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# Effect of an Extended Reality Simulation Intervention on Midwifery Students' Anxiety: Systematic Review

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# Abstract

**Background:** Midwifery students often experience anxiety due to several factors, such as the clinical experiences faced. Simulation-based learning in nursing and midwifery studies using extended reality (XR) tools offers the opportunity to manage better educational processes while reducing this anxiety.

**Objective:** This study aims to evaluate the current knowledge and understanding of how the use of XR gesture-simulation-based tools allows a better understanding of the anxiety levels of midwives and nurses in educational settings.

**Methods:** We conducted a systematic review, a scientific literature search following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Using PubMed, IEEE, Scopus, and Web of Science, up to March 2024, 1005 articles were found to identify studies that reported the effectiveness of these technologies for gesture simulation in education and training on nursing and midwifery student anxiety. The inclusion-exclusion criteria were based on the PICO (population, intervention, control, and outcomes) framework. The population included nurses, midwives, and nursing and midwifery students of any kind using any virtual or augmented or mixed reality simulation training tool to perform a procedure aimed at reducing anxiety. In addition, the Cochrane risk of bias tool was used to evaluate the quality of the systematic review and the bias in the included studies. A narrative synthesis was conducted due to the heterogeneity of study designs and outcome measures. Key findings were summarized in a structured table and grouped according to the learning objective, simulating and performing procedures in an educational setting.

**Results:** Overall, 7 articles, involving a total of 428 participants, were included in this review. The findings indicate that XR can effectively reduce anxiety in midwifery and nursing education. However, the limited number of studies highlights a research gap in the field, particularly in the area of mixed reality, which warrants further exploration.

**Conclusions:** This systematic review highlights the potential of XR-based gesture-simulation tools in reducing anxiety among midwifery and nursing students. The included studies suggest that XR-enhanced training provides a more immersive and controlled learning environment, helping students manage stress and improve procedural confidence. However, the limited number of studies, methodological variations, and the underrepresentation of mixed reality applications indicate the need for further research. Future studies should focus on standardized anxiety measurement tools, larger sample sizes, and long-term impact assessments to strengthen the evidence base. Expanding research in this field could enhance the integration of XR technologies into midwifery and nursing education, ultimately improving both learning experiences and clinical preparedness.

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#### **KEYWORDS**

anxiety; extended reality; gesture simulation; nursing education; midwifery education

# Introduction

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Anxiety is an emotion or state characterized by worry, tension, and physical manifestations such as increased blood pressure. Anxiety is often experienced in midwifery students due to heavy course load, high expectations, and the clinical experiences faced [1].

According to a mental health survey conducted by the National French Association of Midwifery Students (ANESF), with responses from 2000 students, 47% of the respondents showed a probable generalized anxiety disorder (as indicated by the



GAD-7 test, General Anxiety Disorder-7, with a score of  $\geq 10$ ) [2,3].

Simulation-based learning is an important education modality because it allows students to learn from mistakes in a risk-free competencies, setting. acquire necessary practice decision-making, and significantly reduce potentially fatal medical errors [4]. More precisely, through gesture simulation, students can interact with virtual reality (VR) environments using hand movements and gestures, thereby reinforcing muscle memory and enhancing kinesthetic learning. This hands-on approach enables students to better grasp complex concepts, refine their motor skills, and simulate real-world scenarios with greater accuracy. In addition, gesture simulation fosters active engagement and participation, allowing students to feel more connected to the learning process and empowering them to take ownership of their education [5].

Extended Reality (XR) is a general term encompassing a range of immersive technologies, including Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR):

- AR overlays digital information, such as images, text, or 3D models onto the real-world environment viewed through a device's camera. The digital content is superimposed on the real world, enhancing the user's perception of reality [6].
- 2. VR completely immerses the user in a synthetic digital environment, replacing the real world with a simulated one. Users experience this artificial 3D environment through a headset that blocks out their physical surroundings [7].
- 3. MR seamlessly blends and anchors digital objects into the real world, allowing users to interact with physical and VR elements in real time. The VR objects in MR are integrated into and responsive to the real environment, creating a unified, interactive experience [8].

These tools blend physical and VR environments and over the last years, they have been in many fields, such as health care education or professional contexts, since they have the potential advantage of scalability, enhanced motivation, and cost savings [9].

By introducing XR simulation tools in midwifery education, the students can better understand complex concepts, practice skills in a safe environment, and build confidence in their abilities, reducing anxiety-inducing situations [10]. However, there is relatively limited research on the specific impact of these tools on factors such as confidence, anxiety, or decision-making capacities. Most studies focus primarily on performance outcomes or knowledge acquisition. Furthermore, while simulation in general has been extensively studied, research specifically addressing the use of XR tools in these contexts remains scarce [11]. This review aims to address these gaps by systematically analyzing the effectiveness of XR gesture-simulation tools in analyzing anxiety levels during educational training for midwives and nurses.

# Methods

# **Research Question**

The first step was the formulation of the research question, aiming to explore the impact of extended reality gesture-simulation-based tools on the anxiety levels of midwives and nurses involved in educational training. The research question "How much do we know about the effectiveness of extended reality gesture-simulation-based tools on the anxiety levels of midwives and nurses involved in educational training?" was formulated.

To answer the question, we performed the systematic review using the PICO (population, intervention, control, and outcomes) framework, which is an evidence-based practice to frame and answer a scientific endeavor [12]. The components of the framework applied in our study are as follows:

- 1. Population: Midwives and nurses of any type
- 2. Intervention: Extended reality gesture simulation-based training or simulation education intervention aimed at reducing anxiety
- 3. Comparison: Standard training methods or absence of specific anxiety-reduction interventions. Pre and postintervention anxiety levels
- 4. Outcome: Assessing anxiety levels or anxiety-related outcomes

The second category of keywords, related to the intervention, included: "extended reality" OR "XR" OR "augmented reality" OR "AR" OR "virtual reality" OR "VR" OR "mixed reality" OR "3D."The third and last category was related to the desired outcome, including: "anxiety" OR "anxious." The combination of all these keywords resulted in the final query:

("midwife" OR "obstetrics" OR "nurse" OR "nursing") AND ("mixed reality" OR "MR" OR "extended reality" OR "XR" OR "augmented reality" OR "AR" OR "virtual reality" OR "Simulation" OR "Simulated" OR "3D") AND ("anxiety" OR "anxious")

# **Screening Criteria**

Different search tools, including PubMed, IEEE, Scopus, and Web of Science, were used to perform the systematic research with the previously defined keywords. The database search and extraction were performed on March 25, 2024. Besides, the articles retrieved from another similar systematic review were analyzed to see whether they could be included [13].

In total, 1005 articles were found; the decision to include or exclude a study was based on the inclusion and exclusion criteria and quality assessment. A single author screened the articles, and the selection process and rationale were subsequently discussed with the other authors to finalize inclusion. Any disagreement between the reviewers regarding inclusion was resolved with discussion and a majority vote. After applying these criteria, 7 articles were selected for the review.

#### **Search Strategies**

The search strategy focused on databases most relevant to health care and XR research, including PubMed, IEEE, Scopus, and Web of Science. These information sources were selected to ensure coverage of both medical and technological aspects of XR interventions in anxiety analysis during midwifery and nursing gesture simulation activities. Gray literature and conference proceedings were excluded due to resource constraints and difficulty in quality assessment. By not including gray literature and unpublished studies, there is a risk of publication bias, as studies with nonsignificant findings may be underrepresented.

A PubMed MeSH search was conducted to ensure the inclusion of relevant studies using the previously identified keywords to enhance the completeness of the findings. MeSH (Medical Subject Headings) is the National Library of Medicine's controlled vocabulary thesaurus, used for indexing articles for the MEDLINE/PubMED database [14]:

(("students, nursing"[MeSH Terms] OR "Obstetric Nursing"[MeSH Terms] OR "nursing students"[Title/Abstract] OR "midwifery"[MeSH Terms] OR "midwifery students"[Title/Abstract]) AND ("virtual reality"[MeSH Terms] OR

Table . Inclusion and exclusion criteria for article screening.

"augmented reality"[Title/Abstract] OR "extended reality"[Title/Abstract]) AND ("anxiety"[MeSH Terms] OR "anxious"[Title/Abstract]))

A total of 3 articles were found, the first one was focused on the discovery and visit to places, the second was a systematic review, and the third used VR to reduce anxiety by singing calming environments. Therefore, none of the articles were included in this systematic review.

# **Relevance and Topic Proximity: Inclusion and Exclusion Criteria**

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was used to search and screen articles [15]. In addition, the PRISMA checklist was completed to provide transparency and rigor in the systematic review process, in Checklist 1.

The initial choice was to narrow down the results by only selecting articles in English published in a peer-reviewed journal, randomized controlled trials (RCTs), nonrandomized, noncontrolled trials.

The second selection phase encompassed screening titles, keywords, and abstracts, followed by the removal of duplicate articles. Throughout the process, the inclusion and exclusion criteria explained in Table 1 were applied.

6							
Element of the research question	Inclusion criteria	Exclusion criteria					
Population	Nurses, midwives, and nursing and midwifery students of any kind	Any type of health care professional or other students, any other population such as patients					
Intervention	Any virtual or augmented or mixed reality simu- lation training tool to perform a procedure (VR <sup>a</sup> glasses such as HoloLens, Oculus Rift, or any other type of device as the CAVE) <sup>b</sup> used to re- duce <i>anxiety</i>	Any other tool or simulator not used in this set- ting					
Comparator	XR <sup>c</sup> simulation vs other standard training methods, or pre and postintervention anxiety levels	N/A <sup>d</sup>					
Outcome	Anxiety assessment	N/A					
Study design, type of publication	Articles in English, French, and Spanish pub- lished in a peer-reviewed journal, randomized controlled trials (RCTs), non-randomized, non- controlled trials	Journal articles in other languages, conference papers, book chapters, reviews, meta-analysis pilot studies, proof of concept					

<sup>a</sup>VR: virtual reality.

<sup>b</sup>CAVE: Cave Automatic Virtual Environment.

<sup>c</sup>XR: extended reality.

<sup>d</sup>N/A: Not available

#### **Quality Assessment**

The Cochrane Collaboration's Risk of Bias 2.0 tool [16,17] was used to evaluate the quality of the systematic review and assess the risk of bias in the included studies. The tool assesses five specific domains of bias: bias in the randomization process, bias in deviation from intended interventions, bias due to missing outcome data, bias in outcome measurement, and bias in the selection of the reported result. Items were classified as "Low risk," "High risk," or "Some concerns." The overall risk was "Low risk" if all five domains were rated as low risk, "High risk" if any domain was rated as high risk, and "Some concerns" for all other cases.

#### **Result Analysis**

To extract and analyze the resulting articles, data was extracted and collected systematically in a data collection form. A narrative synthesis was conducted due to the heterogeneity of study designs and outcome measures across included studies. Key findings were summarized in a structured table and grouped



according to the learning objective (simulating and performing procedures using XR tools). A thematic analysis was used to identify common patterns in anxiety analysis across studies.

# Results

# Summary of the Chosen Articles

The systematic review of the literature is outlined in Figure 1. Table 2 and Table 3 summarize the results of the systematic review. Below is a brief summary of each of the articles included in the review.

#### Figure 1. PRISMA flow diagram. XR: extended reality.

# Identification of studies via databases and registers





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Table . Systematic review results.

Ttitle	Year	Author	Journal	Location	Risk of bias	Learning ob- ject	Study design / Intervention assignment	Population
The effects of neonatal resus- citation gamifi- cation pro- gram using immersive vir- tual reality: A quasi-experi- mental study	2022	Yang and Oh [18].	Nurse Educa- tion Today	Daejeon, South Korea	Some concern	Simulating and perform- ing procedures	Pre and post- comparison, non random- ized study	Nursing stu- dents (n=88)
Immersive vir- tual reality (VR) training increases the self-efficacy of in-hospital healthcare providers and patient fami- lies regarding tracheostomy- related knowl- edge and care skills A prospective pre-post study	2022	Chiang et al [19].	Medicine Open	Taipei, Tai- wan	Some concern	Simulating and perform- ing procedures	Prospective, randomized controlled, pre and postcom- parison study	Health care providers (n=60)
Pediatric Chest Com- pression Im- provement Via Augmented Reality Car- diopulmonary Resuscitation Feedback in Community General Emer- gency Depart- ments: A Mixed-Meth- ods Simula- tion-Based Pi- lot Study	2023	Kleinman et al [20].	The Journal of Emergency Medicine	Baltimore, United States	Some concern	Simulating and perform- ing procedures	Unblinded, randomized, crossover sim- ulation-based study	Nurses (n=36)
Effects of vir- tual reality training on de- creasing the rates of needlestick or sharp injury in new-coming medical and nursing interns in Taiwan	2020	Wu et al [21].	Journal of Edu- cational Evalu- ation for Health Profes- sions	Taipei, Tai- wan	Some concern	Simulating and perform- ing procedures	Prospective cohort pre and postcompari- son study	Medical and Nurses Interns (n=109)



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Ttitle	Year	Author	Journal	Location	Risk of bias	Learning ob- ject	Study design / Intervention assignment	Population
A mixed- methods feasi- bility study to assess the ac- ceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing educa- tion	2021	Adhikari et al [22].	Nurse Educa- tion Today	Edinburgh, Scotland	Some concern	Simulating and perform- ing procedures	Two-stage se- quential mixed-meth- ods feasibility study	Nursing stu- dents (n=19)
Virtual versus face-to-face clinical simula- tion in relation to student knowledge, anxiety, and self-confi- dence in mater- nal-newborn nursing: A randomized controlled trial	2016	Cobbett and Snelgrove- Clarke [23].	Nurse Educa- tion Today	Halifax, Cana- da	Some concern	Simulating and perform- ing procedures	Controled, randomized pretest- posttest study	Nursing stu- dents (n=56)
Evaluation of practical exer- cises using an intravenous simulator in- corporating virtual reality and haptics de- vice technolo- gies	2012	Jung et al [24].	Nurse Educa- tion Today	Seoul, Korea	Some concern	Simulating and perform- ing procedures	Randomized control trial	First-year nursing stu- dents (n=60)



Table . Study characteristics vs study intervention characteristics

Studies	Software and devices	Intervention activities/ duration	Variables	Intervention outcomes	Anxiety evaluation
Yang and Oh [18]	HMD: <sup>a</sup> Oculus Rift S (VR <sup>b</sup> )	Neonatal resuscitation gamification-50 min	Knowledge, problem- solving, clinical reason- ing ability, self-confi- dence, anxiety, and learning motivation	Anxiety decreased post intervention, no differ- ence between groups	STAI <sup>c</sup>
Chiang et al [19]	HMD-VR Web-based VR Desktop Tablet Smartphone	Tracheostomy-related knowledge and care skills-2-h training; 15- min VR	Familiarity Confidence Anxiety Knowledge Skills	Improved comprehen- sion and reduced anxi- ety at follow-up	Personalized Likert scale questionnaires
Kleinman et al [20]	HMD (AR <sup>d</sup> )	Pediatric chest compres- sions-18 min course	Performance and anxi- ety (qualitative assess- ment)	Reduced anxiety	Qualitative invdividual interviews post intervention
Wu et al [21]	Game-based VR train- ing	Training on needlestick or sharp injury time to finish the game	Performance and Anxi- ety (qualitative asses- ment)	Anxiety reduction, in- crease in confidence	Personalized Likert scale questionnaires
Adhikari et al [22]	3D computer-based simulation (VR)	Sepsis serious game - 20 - 30 min	Anxiety (NASC- CDM) <sup>e</sup> , self-efficacy, acceptability, and appli- cability	Decreased anxiety	NASC-CDM before and after intervention
Cobbett and Snelgrove- Clarke [23]	F2F <sup>f</sup> high-fidelity manikin simulation. VCS <sup>g</sup> with a computer.	Newborn nursing - 2×45 min VR sessions	Simulation Completion Questionnaire, anxiety (NASC-CDM), knowl- edge	Higher anxiety for VR	NASC-CDM before and after intervention
Jung et al [24]	VR IV <sup>h</sup> training simula- tor using haptic skills.	Venipuncture training- 10 min session	State trait anxiety, VAS <sup>i</sup> , performance, and satisfaction	No difference between groups and anxiety de- creased for all of them	Evaluated State-Trait Anxiety using a VAS before and after inter- vention

<sup>a</sup>HMD: head-mounted device

<sup>b</sup>VR: virtual reality

<sup>c</sup>STAI : State-Trait Anxiety Inventory
<sup>d</sup>AR: augmented reality
<sup>e</sup>NASC-CDM: Nursing Anxiety and Self-Confidence with Clinical Decision-Making Scale
<sup>f</sup>F2F: face-to-face
<sup>g</sup>VCS: Virtual Clinical Simulation
<sup>h</sup>IV: intravenous
<sup>i</sup> VAS: Visual Analogue Scale

#### **Short Summary of Each Article**

#### The Effects of Neonatal Resuscitation Gamification Program Using Immersive Virtual Reality: A Quasi-Experimental Study

This nonrandomized controlled simulation study with a pretest-posttest design evaluated a neonatal resuscitation gamification program using immersive VR [18]. Prelicensure nursing students were divided into intervention and control groups. The study assessed outcomes such as neonatal resuscitation nursing knowledge, problem-solving skills, clinical reasoning ability, self-confidence in practical performance, anxiety levels, and learning motivation. The simulation group presented lower anxiety levels, compared to the VR and control groups. Anxiety was measured with the STAI (State-Trait Anxiety Inventory), a commonly used questionnaire to assess an individual's tendency to suffer anxiety. Limitations include the inability to assess long-term effects through follow-up

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surveys and the lack of measurement for actual intervention competency reinforcement, relying solely on self-reported questionnaires.

#### Immersive VR Training Increases the Self-Efficacy of In-Hospital Health Care Providers and Patient Families Regarding Tracheostomy-Related Knowledge and Care Skills a Prospective Pre-Post Study

This prospective pre-post study compared health care providers' tracheostomy care training using immersive VR with head-mounted displays and web-based modules versus traditional text materials [19]. According to a personalized Likert-scale questionnaire, most providers in the VR group found that interactive visual demonstrations improved comprehension and reduced anxiety. Limitations included a small sample size, a short follow-up period, and reliance on self-reported feedback rather than quantitative measures of skill acquisition and patient outcomes. Larger, long-term studies

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with objective assessments are needed to evaluate the efficacy of VR training in improving tracheostomy care competency.

# Pediatric Chest Compression Improvement Via Augmented Reality Cardiopulmonary Resuscitation Feedback in Community General Emergency Departments: A Mixed-Methods Simulation-Based Pilot Study

An unblinded, randomized, crossover simulation-based study evaluated whether augmented reality cardiopulmonary resuscitation (AR-CPR) improves chest compression performance in nonpediatric-specialized community emergency departments [20]. Participants performed chest compression with and without AR-CPR guidance in random order. Qualitative interviews suggested AR-CPR could be usable without device orientation, effective at cognitive offloading, and capable of reducing anxiety while boosting confidence. However, limitations included not excluding individuals with corrective eye lenses, which might affect the AR experience and the lack of feedback during non-AR-CPR cycles, unlike real-world scenarios where feedback devices are common.

# Effects of Virtual Reality Training on Decreasing the Rates of Needlestick or Sharp Injury in New-Coming Medical and Nursing Interns in Taiwan

The prospective cohort pre and post study evaluated a new VR game, designed to teach safe and unsafe behaviors regarding universal precautions on needlestick and sharp injury prevention among incoming medical and nursing interns in Taiwan [21]. The game focused on making correct safety choices. Many participants reported reduced anxiety about preventing these injuries in the personalized Likert-scale questionnaires. However, the study's reliance on self-reported questionnaires could introduce reporting bias, and trainees might report behaviors aligning with their training, potentially skewing results.

#### A Mixed-Methods Feasibility Study to Assess the Acceptability and Applicability of Immersive Virtual Reality Sepsis Game as an Adjunct to Nursing Education

A 2-stage sequential mixed-methods feasibility study assessed the impact of an immersive VR sepsis game on preregistration nurses [22]. The study examined its effect on self-efficacy and perceptions of its acceptability and applicability in nursing simulation education. In the first stage, pre and postintervention self-efficacy scores were collected from 19 preregistration nurses using the Nursing Anxiety and Self-Confidence with Clinical Decision-Making Scale (NASC-CDM). The second stage used a descriptive qualitative approach to explore perceptions of the game. Results showed a significant 23.4% decrease in anxiety. Limitations included the small sample size, the novelty of the educational approach, and the measurement of self-efficacy at a single time point.

#### Virtual Versus Face-To-Face Clinical Simulation in Relation to Student Knowledge, Anxiety, and Self-Confidence in Maternal-Newborn Nursing: A Randomized Controlled Trial

This randomized pretest-posttest study compared the effectiveness of 2 maternal newborn clinical simulation scenarios: VR clinical simulation and face-to-face high-fidelity manikin simulation [23]. Although no statistically significant differences were found in student knowledge and self-confidence between the 2 modalities, anxiety scores, measured by the NASC-CDM, were higher for students in the VR simulation. Limitations included a small sample size, potential intervening variables, such as student motivation, interest, and technological competence, and a lack of orientation to the VR platform, which may have influenced their responses.

# Evaluation of Practical Exercises Using an Intravenous Simulator Incorporating Virtual Reality and Haptics Device Technologies

This randomized control trial assessed the educational effectiveness of practical exercises using intravenous simulators with VR/haptics technologies [24]. First-year nursing students were assigned randomly to three groups: Group A (conventional intravenous arm), Group B (VR/haptics intravenous simulator), and Group C (both intravenous arm and simulator). Group C scored highest in venipuncture procedures, while Group B excelled in injections. Group C completed venipuncture faster than Group B and slightly quicker than Group A. State-trait anxiety was measured using a Visual Analogue Scale (VAS) before and after the intervention. All groups showed reduced anxiety postvenipuncture, with no significant differences. Limitations included insufficient practice time due to curriculum constraints and the study's single-school, single-country setting, which limits generalizability and cultural diversity.

# Analysis of the Chosen Articles

# Risk of Bias

After analyzing the risk of bias of the 7 articles included in the systematic review, summarized in Table 4, 1 [18] had a high risk in the randomization process because the participants were assigned systematically to the intervention and control groups. In total, 2 studies [21,22] lacked a control group and conducted pre and postintervention evaluations. The remaining 4 studies [19,20,23,24] demonstrated a low risk of bias.



Table . Risk of bias of the included studies.

Author	Year	Randomization process	Deviations from intended inter- ventions	Missing out- come data	Measurement of outcome data	Selection of the reported result	Overall bias
Yang et al [18].	2022	High risk	Low risk	Low risk	Some concern	Low risk	Some concern
Chiang et al [19].	2022	Low risk	Some concern	Low risk	Low risk	Low risk	Some concern
Kleinman et al [20].	2023	Low risk	Low risk	Low risk	Some concern	Low risk	Some concern
Wu et al [21].	2020	Not applicable	Low risk	Low risk	Some concern	Low risk	Some concern
Adhikari et al [22].	2021	Not applicable	Low risk	Low risk	Some concern	Low risk	Some concern
Cobbett and Snelgrove- Clarke [23].	2016	Low risk	Some concern	Low risk	Low risk	Low risk	Some concern
Jung et al [24].	2012	Low risk	Some concern	Low risk	Low risk	Low risk	Some concern

The risk of deviations from the intended intervention raised some concerns in 3 studies due to the motivation of the intervention group related to their interest in the technology [19,23,24]. No risk was detected due to missing outcome data. However, some concerns arose in studies [18,20,21], regarding outcome measurement, as only the intervention group was evaluated in certain aspects. Finally, no risk was identified in any of the studies concerning the selection of reported results. In conclusion, all studies presented some concerns, but none was deemed to have a high risk of bias overall.

#### Learning Object

All of the papers had a common general learning objective: simulating and performing procedures. However, the clinical foci covered in the selected papers differed.

Overall, 2 of the studies focused on reducing anxiety around newborn care. The first was with an immersive VR neonatal resuscitation gamification program, enabling hands-on experience in a VR environment [18]. The second, a simulation-based pilot study used AR to teach pediatric chest compression [20].

In total, 2 studies used serious games to teach and reduce anxiety in students. Occupational needle stick or sharp injury prevention was sought through a game of right and wrong choices for safe or unsafe universal precaution behaviors [21]. The other used a 3D, computer-based simulation sepsis game [22].

In 3 studies, they opted for a procedure-specific training, Cobbett and Snelgrove-Clarke [23], evaluated VR clinical simulation in preeclampsia and Group B *Streptococcus* scenarios. Another study divided the first-year nursing students into 3 groups, learning how to practice injections. A VR intravenous training simulator using haptic skills was evaluated, along with its effect on reducing students' anxiety toward this procedure [24]. Finally, in [19] used a combination of head-mounted display VR and smartphone application VR in an environment for tracheostomy-related materials. The VR teachings on how to dress the stoma or handle emergencies such as aspiration, aimed to reduce anxiety among health care providers.

#### Study Design

This analysis reveals significant methodological differences among the articles, particularly in their approaches to study design, including quasi-experimental, randomized controlled trials (RCTs), mixed methods, pre-post, and crossover designs.

RCTs ([20,23,24]) provide stronger evidence due to their randomization and ability to control the relationship between the XR interventions and outcomes. Quasi-experimental ([18]) and pre-post ([20,22,23]) designs are valuable for exploratory or feasibility research, but are less robust due to biases and limitations in establishing causality. Mixed-methods designs ([20,22]) add depth to the analysis by incorporating qualitative perspectives but lack the quantitative generalizability of RCTs. Finally, crossover designs ([20]) offer a unique advantage by enabling within-subject comparisons, which may result in more reliable conclusions about XR effectiveness.

The studies demonstrate that the choice of study design is dependent on the research goals, feasibility, and the need to balance internal validity, external validity, and depth of analysis. RCTs are the most robust and reliable for establishing causality, making them the gold standard for intervention studies. However, quasi-experimental designs and cohort studies provide practical alternatives for real-world contexts where randomization is not feasible. Meanwhile, mixed-methods designs offer depth and insights into user experiences, making them ideal for exploratory and feasibility studies, though their findings may be less generalizable. Finally, crossover designs effectively reduce variability and improve validity but require careful management to avoid carryover effects.

#### **Participants**

All the selected articles included nurses, midwives, or nursing and midwifery students of any kind. In total, 428 individuals participated in the studies, and 332 were nursing students, mixed with other medical students. Only 2 studies included 96 professional health care providers [19,20].

Exclusion criteria varied across the studies. In one case, they excluded those with previous clinical or VR experience,

recruiting 88 prelicensure nursing students (VR group=31, simulation group=28, control group=29) [18]. The groups were homogeneous in sex, satisfaction with the nursing major, clinical practice training, and demand for XR education, but differed in anxiety levels.

Notably, 2 studies included third-year nursing students, with 56 and 19 participants, respectively [22,23]. The age ranges and gender proportions were similar: 20 - 44 years, mostly female (84%), with no previous degree (81%) in the former study, and 25 - 45 years, with 74% female in the latter. No statistical differences were found between the types of simulation groups.

One invited both 50 medical and 59 nursing interns [21]. Nursing interns were aged 17 - 22 years, and medical interns were 20 - 29 years. Female representation was 85% in nursing and 52% in medicine. The previous deep occupational experience was 34% in nursing and 61% in medicine.

In one study, 36 professional nurses (18 per group, AR and no AR) evenly distributed by age, sex, clinical role, and experience participated, with participants excluded based on their medical specialty [20]. Also involving 60 professional health care providers, including physicians, nurses, and respiratory therapists, in the study they randomly divided participants into regular and intervention groups, excluding those with incomplete training or questionnaires [19]. A similar exclusion criteria was applied to the same number of nursing students, ensuring homogeneity in age, gender, anxiety, and intravenous knowledge [24].

#### Devices Used to Create the Extended Reality Scenarios and Duration of the Intervention

In total, 6 articles used VR interventions, while one used AR [20]. Among included studies, 3 used a Head-Mounted device [18-20], 3 relied on computer-based simulations [22-24], and 1 used a mobile device app.

The duration of the training sessions varied minimally across the studies, ranging from a 10-minute VR session [24], to a 50-minute gamification program [18]. Notably, only one conducted two sessions [23], while the others performed a single XR experiment.

#### Analysis and Anxiety Assessment Methods, Variables Evaluated

Throughout the studies, common elements were analyzed. The 7 articles evaluated anxiety using various methods, such as

personalized Likert scale questionnaires [19,21]. Among them, 2 of the articles [22,23] useda specific tool to measure anxiety pretest and posttest, the NASC-CDM, which aims to provide insight into the emotional aspects of clinical decision-making, which can impact nursing performance and patient care outcomes [25].

A total of 2 studies assessed state-trait anxiety. One study distinguished between temporary anxiety influenced by environmental factors and the more stable, underlying trait anxiety [24]. Transient anxiety was measured using a Visual Analogue Scale, which consists of a 10-cm horizontal line with marked points corresponding to different levels of worry, such as "Not worried at all," "Worried a little bit" and "Very worried,". The chosen point on the VAS was converted to a numerical score for pre and posttest comparison. This analysis was performed and compared pre and post test. The other study [18] used the STAI, a 20-item questionnaire assessing state anxiety. Each item is rated on a 4-point Likert scale (1=not at all; 4=very much so), with a total score ranging from 20 to 80 (not 15 to 75 as stated in the original). Scores of 30 or lower indicate low or no anxiety, while scores of 31 or higher indicate high anxiety. The STAI's Cronbach  $\alpha$  was 0.93 at its development and 0.90 in this study.

Finally, in [20] they assessed anxiety by performing qualitative individual interviews while evaluating the rate and depth of chest compressions to provide AR feedback and therefore measure performance simultaneously.

Other aspects of the studies were evaluated, including knowledge pre and post test related to preeclampsia and group B strep, a Simulation Completion Questionnaire [23], knowledge related to neonatal resuscitation [18], or an multiple choice questionnaire on tracheostomy care and skills [19]. Another qualitative approach explores student nurses' perceptions of the game [22], while others evaluated only the performance of the subjects, regardless of the knowledge acquisition [20,21].

#### Anxiety Outcomes After XR Intervention

After assessing and analyzing the results, most of the articles reported positive outcomes concerning anxiety reduction, as seen in the summary of anxiety outcomes in Table 5.



Table . Anxiety outcomes in the included studies.

Author	Intervention	Assessment tool	Population	Outcome
Yang et al [18]	Intervention vs control; pre vs post test	STAI <sup>a</sup>	N=88; Intervention=31	Intervention: 59.14 (SD 9.62) to 56.72 (SD 7.50)
				Control: 59.50 (SD 8.35) to 57.65 (SD 6.86)
Chiang et al [19]	Intervention vs control; pre vs post test	Likert scale	N=60 ; Intervention=30	Intervention: reduced anxi- ety (mean 93%, SD 2%; <i>P</i> =.002
				Control: reduced anxiety (mean 75% SD 6%; <i>P</i> =.002
Kleinman et al [20]	Interview postintervention	Qualitative interviews	N=36	Qualitative answers about decrease of anxiety
Wu et al [21]	Pre- post-intervention	Likert scale questionnaire	N=109	63.3% reported a decrease in anxiety
Adhikari et al [22]	Pre- post- intervention	NASC-CDM	N=19	23.4% decrease in anxiety 77.4 (SD 12.5 vs 59.3, SD 15.9; <i>P</i> <.001)
Cobbett et al [23]	Intervention vs control	NASC-CDM <sup>b</sup>	N=56 Intervention=27	Intervention: anxiety (mean 73.26, SD 19.95, SE mean 3.84)
				Control: anxiety (mean 57.75, SD 15.25, SE mean 2.88)
Jung et al [24]	Intervention versus control; Pre vs post test	STAI	n=60 Intervention =38	Intervention: pretest (mean 41.63, SD 9.30) and posttest (mean 39.52, SD 10.05) <i>P</i> =.29
				Control: pretest (mean 46.97, SD 11.99) and posttest (mean 39.26, SD 10.90) <i>P</i> =.004

<sup>a</sup>STAI: State–Trait Anxiety Inventory

<sup>b</sup>NASC-CDM: Nursing Anxiety and Self-Confidence with Clinical Decision-Making Scale

In total, 4 studies reported decreased anxiety levels after the XR intervention. In [20], participant feedback supported that AR-CPR could be effective for cognitive offloading, reduction in performer anxiety, and increase in performer confidence in the care delivered. In the case of [21], 68% of nursing and 58% of medical interns reported that the extended reality intervention significantly decreased their anxiety about occupational needle injury prevention, and also in [22] the participants reported a 23.4% decrease in anxiety. In addition, in [19] at baseline, there were no significant differences between the intervention and regular groups. However, at follow-up, the intervention group showed significantly higher agreement with statements about increased familiarity (83% vs 76%, P=.04), enhanced confidence (92% vs 74%, P=.001), and reduced anxiety (93% vs 75%, P=.002). The VR intervention effectively improved familiarity, boosted confidence, and reduced anxiety in tracheostomy-related skills compared to the regular training.

One study [24] reported no statistical differences among the 3 groups. State anxiety and VAS for anxiety decreased in all groups after venipuncture.

A total of 2 studies reported higher anxiety in the intervention group. In [18] the anxiety score of the 3 groups decreased from

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pre-intervention to post-intervention (VR group: 59.14 (SD 9.62) to 56.72 (7.50); simulation group: 66.46 (8.60) to 57.65 (SD 10.35); and control group: 59.50 (8.35) to 57.65 (6.86). However, the VR group did not show significant improvement compared to the simulation and control groups, with the highest difference observed in the simulation one.

Also, anxiety scores were higher for students in the VR clinical simulation than for those in the face-to-face simulation [23]. However, the new technology rather than the VR simulation itself might have caused the increased anxiety. In addition, students were more comfortable with the mannequin, as they had previous exposure to this type of exercise.

#### Authors' Opinions and Main Limitations of the Studies

The authors consider that the studies provided improvement in knowledge [18], demonstrated feasibility [19], improved educational quality [20], presented a promising pedagogical approach [22], and were educationally and cost-effective, as they allowed for repeated simulations [23]. This characteristic among others, contributes to the reduction of anxiety [24].

Nevertheless, even if the results were positive, all the studies included in this review performed a small sample, single-school or medical center, single-country sessions, which is a significant

limitation as it is not very representative. The authors suggest using larger sample sizes with random selection to increase generalizability and conducting multicenter studies.

Furthermore, in 3 studies, the evaluation method was qualitative and self-reported, which might also lead to report bias [19-21]. In addition, the long-term effect was not evaluated in any of the articles and often the evaluation was only made at one-time point [22].

Several limitations were related to the use of new technologies, in the study by [23], students preferred face-to-face simulations, citing the similarities to practicing in a "real" situation and the immediate debriefing. Students who did not like the VR clinical simulation often cited technological issues, such as "online program was slow", or "didn't know where to find things. Similarly, in [24] they noted that the results might have been affected by the students' IT expertise, while [18] pointed out that the unfamiliar VR environment could be a factor. In [22], they suggested that students more comfortable with technology might have been more willing to participate in the experiments.

An orientation activity built into the study design would be useful so that when the XR scenario is presented, students will not be focused on learning the software. Furthermore, the studies were often performed in a single session; multiple sessions would increase students' familiarity with the tools. On the other hand [18], suggests that it would be better to establish an MR environment, using hand tracking and physically practicing the skills, rather than using the HMD controllers. This approach would also reduce the learner's burden owing to unfamiliar environments, enabling experiences similar to reality.

Finally, none of the studies they engaged with the focus group (nurses and midwives) to identify and prioritize their real needs. A better approach would have been to perform a systematic conception method to translate their needs into tangible project objectives and features aligned with user expectations, rather than imposing the technological approach without working and thinking about the solution with them first.

# Discussion

# Limitations

The systematic review had several limitations. The research results could vary depending on the databases, languages, or types of articles included. Furthermore, the review focused on the use of extended reality for gesture simulation to reduce anxiety. Not many articles were found on this specific topic, highlighting a research gap. The results would differ if we included the use of these tools in other procedures, such as the management of medical situations or the treatment of anxiety with calming scenarios.

# **Future Research Directions**

This systematic review was conducted in preparation for a follow-up study on XR gesture simulation educational training for midwifery students' anxiety management in the Midwifery Department at Grenoble Alpes University during the next academic year. The limited articles found in this review and their positive results highlight the research gap and underscore the importance of further exploring gesture simulation using XR tools to reduce student anxiety. Furthermore, the limitations found in the studies could be addressed by implementing a long-term follow-up with questionnaires, choosing a larger sample size, including diversity by testing in different centers, using MR, or engaging with the focus group.

The next intended study will focus on MR gesture simulation in an educational midwifery or nursing procedure. Collaboration with educators and users is essential to make an appropriate demonstrator, and the use a pre and post-test evaluation with diverse, evenly distributed participants from different centers and countries, to measure anxiety levels will be evaluated.

The first demonstrator prototype will be as follows:

- 1. Learning object: The learning object will be defined later on the development of the project, after discussing with the educators and students of the midwifery course.
- 2. Study design: RCT could be the primary methodology as it provides a more robust evidence by minimizing bias.
- 3. Participants: All of the 147 students at the Midwifery Department of the Grenoble Alpes University will be invited to participate in the study. The exclusion criteria will be incomplete training or questionnaires. Furthermore, depending on the learning object, only the promotion following the specific course will be included in the study, excluding the rest of the students. A posterior international demonstrator will be performed to validate the results obtained.
- 4. Device: To interact with the VR environment, Microsoft HoloLens 2 will be used, as the goal is to develop an MR tool. By seeing their hands, the students can physically practice the gestures to simulate and learn the procedure.
- 5. Anxiety Assessment Methods, Variables: Before and after the intervention, anxiety will be evaluated with the NASC-CDM [25,26], as it is specially designed for nursing students to measure stress and anxiety related to clinical procedures and academic responsibilities. n addition, slight modifications specific to our learning object will be added to the questionnaire.

#### Conclusions

The results of the systematic review encourage the development of an extended reality gesture or procedure simulation system to evaluate and manage anxiety for nurses and midwives. Positive outcomes have been achieved as an improved learning experience, educational effectiveness, feasibility examples, and anxiety reduction. However, the search revealed limited research addressing this issue globally and a potential gap in the MR field, since it has not been used in any of the studies, and could meet the requirements and needs of midwifery and nursing students.

Furthermore, there were some limitations to the systematic review, including variability in results due to database selection and a narrow focus on gesture simulation. Expanding the scope to include other uses of XR, such as in medical procedures or calming scenarios could provide broader insights.

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# **Conflicts of Interest**

None declared

#### Checklist 1

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Checklist [PDF File, 61 KB - nursing\_v8i1e68984\_app1.pdf]

#### References

- 1. Aloufi MA, Jarden RJ, Gerdtz MF, et al. Reducing stress, anxiety and depression in undergraduate nursing students: systematic review. Nurse Educ Today 2021 Jul;102:104877. [doi: <u>10.1016/j.nedt.2021.104877</u>] [Medline: <u>33905898</u>]
- 2. Frajerman A, Colle R, Jollant F, et al. Mental health in midwifery students: a French nationwide survey. Midwifery 2024 Dec;139:104165. [doi: 10.1016/j.midw.2024.104165] [Medline: 39260125]
- 3. ANESF Association Nationale des Etudiants Sages-Femmes. URL: https://anesf.com/ [accessed 2024-04-16]
- Changuiti O, Moustarhfir N, Marfak A, et al. Simulation based-learning from simple to complicated clinical situations for midwifery students. Adv Med Educ Pract 2021;12:881-886. [doi: <u>10.2147/AMEP.S318560</u>] [Medline: <u>34408529</u>]
- 5. Yeung AWK, Tosevska A, Klager E, et al. Virtual and augmented reality applications in medicine: analysis of the scientific literature. J Med Internet Res 2021 Feb 10;23(2):e25499. [doi: <u>10.2196/25499</u>] [Medline: <u>33565986</u>]
- Mujumdar O. Augmented Reality. Int J Res Appl Sci Eng Technol 2022 Dec;10(12):487-495. [doi: 10.22214/ijraset.2022.47902]
- Saju S, Babu A, Kumar AS, et al. Augmented Reality VS Virtual Reality. Int J Eng Technol Manage Sci 2022 Sep 28;6(5):379-383. [doi: <u>10.46647/ijetms.2022.v06i05.057</u>]
- 8. Liu J. Characteristics of mixed reality technology and its application in engineering fields. Highl Sci Eng Technol 2022 Dec;28:213-219. [doi: 10.54097/hset.v28i.4109]
- 9. Logeswaran A, Munsch C, Chong YJ, et al. The role of extended reality technology in healthcare education: towards a learner-centred approach. Future Healthc J 2021 Mar;8(1):e79-e84. [doi: <u>10.7861/fhj.2020-0112</u>] [Medline: <u>33791482</u>]
- 10. Tang YM, Chau KY, Kwok APK, et al. A systematic review of immersive technology applications for medical practice and education Trends, application areas, recipients, teaching contents, evaluation methods, and performance. Educ Res Rev 2022 Feb;35:100429. [doi: 10.1016/j.edurev.2021.100429]
- Silva GO, Oliveira F, Coelho ASG, et al. Effect of simulation on stress, anxiety, and self-confidence in nursing students: systematic review with meta-analysis and meta-regression. Int J Nurs Stud 2022 Sep;133:104282. [doi: 10.1016/j.ijnurstu.2022.104282] [Medline: 35679634]
- Eriksen MB, Frandsen TF. The impact of patient, intervention, comparison, outcome (PICO) as a search strategy tool on literature search quality: a systematic review. J Med Libr Assoc 2018 Oct;106(4):420-431. [doi: <u>10.5195/jmla.2018.345</u>] [Medline: <u>30271283</u>]
- 13. Jallad ST, Işık B. The effectiveness of virtual reality simulation as learning strategy in the acquisition of medical skills in nursing education: a systematic review. Ir J Med Sci 2022 Jun;191(3):1407-1426. [doi: 10.1007/s11845-021-02695-z]
- 14. Home mesh NCBI. URL: https://www.nlm.nih.gov/mesh/meshhome.html [accessed 2025-02-07]
- Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021 Mar 29;372:n71. [doi: <u>10.1136/bmj.n71</u>] [Medline: <u>33782057</u>]
- 16. RoB 2: A revised Cochrane risk-of-bias tool for randomized trials | Cochrane Bias. URL: <u>https://methods.cochrane.org/bias/resources/rob-2-revised-cochrane-risk-bias-tool-randomized-trials</u> [accessed 2024-12-18]
- Babić A, Barcot O, Visković T, et al. Frequency of use and adequacy of Cochrane risk of bias tool 2 in non-Cochrane systematic reviews published in 2020: Meta-research study. Res Synth Methods 2024 May;15(3):430-440. [doi: 10.1002/jrsm.1695] [Medline: 38262609]
- Yang SY, Oh YH. The effects of neonatal resuscitation gamification program using immersive virtual reality: a quasi-experimental study. Nurse Educ Today 2022 Oct;117:105464. [doi: <u>10.1016/j.nedt.2022.105464</u>] [Medline: <u>35914345</u>]
- 19. Chiang DH, Huang CC, Cheng SC, et al. Immersive virtual reality (VR) training increases the self-efficacy of in-hospital healthcare providers and patient families regarding tracheostomy-related knowledge and care skills: a prospective pre-post study. Medicine (Baltimore) 2022 Jan 14;101(2):e28570. [doi: 10.1097/MD.00000000028570] [Medline: 35029229]

- Kleinman K, Hairston T, Smith B, et al. Pediatric chest compression improvement via augmented reality cardiopulmonary resuscitation feedback in community general emergency departments: a mixed-methods simulation-based pilot study. J Emerg Med 2023 Jun;64(6):696-708. [doi: 10.1016/j.jemermed.2023.03.058] [Medline: <u>37438023</u>]
- Wu SH, Huang CC, Huang SS, et al. Effect of virtual reality training to decreases rates of needle stick/sharp injuries in new-coming medical and nursing interns in Taiwan. J Educ Eval Health Prof 2020 Jan;17:1. [doi: <u>10.3352/jeehp.2020.17.1</u>] [Medline: <u>31955547</u>]
- Adhikari R, Kydonaki C, Lawrie J, et al. A mixed-methods feasibility study to assess the acceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing education. Nurse Educ Today 2021 Aug;103:104944. [doi: 10.1016/j.nedt.2021.104944] [Medline: 34015677]
- 23. Cobbett S, Snelgrove-Clarke E. Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: a randomized controlled trial. Nurse Educ Today 2016 Oct;45:179-184. [doi: 10.1016/j.nedt.2016.08.004] [Medline: 27537670]
- 24. Jung EY, Park DK, Lee YH, et al. Evaluation of practical exercises using an intravenous simulator incorporating virtual reality and haptics device technologies. Nurse Educ Today 2012 May;32(4):458-463. [doi: 10.1016/j.nedt.2011.05.012] [Medline: 21664014]
- 25. White KA. Development and validation of a tool to measure self-confidence and anxiety in nursing students during clinical decision making. J Nurs Educ 2014 Jan 1;53(1):14-22. [doi: <u>10.3928/01484834-20131118-05</u>] [Medline: <u>24256004</u>]
- 26. Van de Weyer G, White K, Franck E, et al. Evaluating anxiety and self-confidence in nursing students: adaptation and validation of the NASC-CDM scale for high-fidelity simulation training. Clin Simul Nurs 2024 Nov;96:101618. [doi: 10.1016/j.ecns.2024.101618]

#### Abbreviations

ANESF: National French Association of Midwifery Students AR: augmented reality AR-CPR: augmented reality cardiopulmonary resuscitation GAD-7: General Anxiety Disorder-7 MeSH: Medical Subject Heading MR: mixed reality NASC-CDM: Nursing Anxiety and Self-Confidence with Clinical Decision-Making Scale PICO: population, intervention, control, and outcomes PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses RTCs: Randomized Controlled Trials STAI: State-Trait Anxiety Inventory VR: virtual reality XR: extended reality

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# Delivering an Electronic Health Record Based Educational Intervention Promoting Peri-Operative Non-Pharmacological Pain Care as Part of a Randomized Controlled Trial: Mixed Method Evaluation of Inpatient Nurses' Perspectives

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# Abstract

**Background:** Best practice guidelines recommend educating surgical patients about non-pharmacological pain care (NPPC) techniques that can be used in addition to pain medication for perioperative pain management, given the risks for opioid misuse following surgery. As part of the parent non-pharmacologic options in postoperative hospital-based and rehabilitation pain management (NOHARM) clinical trial, we implemented the Healing After Surgery initiative, which leveraged the Epic electronic health record (EHR) to provide patients with education on NPPC techniques perioperatively. We disseminated educational materials directly to patients via the EHR patient portal and prompted patients to select the techniques they were most interested in using, which auto-populated the EHR so that their care team could view their preferences. We also built clinical decision support elements in the EHR to prompt and support inpatient nurses in providing patients with education and reinforcement for using their preferred NPPC techniques. Print materials, a website, a DVD, videos on hospital televisions, a toll-free number, and Zoom-based group calls provided additional education on NPPC techniques.

**Objective:** This study evaluated nurses' perceptions of barriers and facilitators to implementing the EHR-based Healing After Surgery initiative.

**Methods:** We invited inpatient nursing leaders and bedside nurses to participate in a semistructured interview. Inpatient nursing leaders were invited to complete a brief survey that asked them to rate their agreement with 7 items using a numeric rating scale (1=not at all, 10=a great deal).

**Results:** Interview findings from 29 nurses revealed: (1) nurses gravitated towards providing NPPC techniques they were familiar with, (2) the initiative was patient-centric with opportunities to better engage patients, and (3) nurses experienced challenges implementing and prioritizing the intervention in the inpatient setting due to competing demands in a pandemic and postpandemic environment. Interviews revealed mixed effectiveness of implementation strategies. We received survey responses from 47 nursing leaders who indicated that their staff knew about the Healing After Surgery initiative (mean=7.53, SD=1.77) and what they were expected to do (mean=7, SD=1.88). They thought the Healing After Surgery initiative supported patients' pain management needs (mean=6.76, SD=2.24), endorsed it as a priority (mean=7.02, SD=2.56), and encouraged staff to support it (mean=5.98, SD=2.78). They indicated staff experienced some burden supporting the initiative (mean=3.93, SD=2.47), but supported some variation of the initiative continuing once the parent trial ended (mean=7.72, SD=2.62).

**Conclusions:** Nurses understood the intervention's benefit but struggled to implement unfamiliar NPPC techniques and prioritize the initiative due to other clinical demands. Additional implementation strategies may be needed to better engage patients and facilitate intervention delivery.

**Trial Registration:** ClinicalTrials.gov NCT05166356; https://clinicaltrials.gov/study/NCT05166356 **International Registered Report Identifier (IRRID):** RR2-10.1007/s40122-022-00393-x

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#### **KEYWORDS**

non-pharmacological pain care; clinical decision support; electronic health record; nurse perspectives; pain management; patient education

# Introduction

Patients undergoing a surgical procedure in the United States are often prescribed, and at times overprescribed, opioids for managing peri-operative pain [1,2]. Recent guidelines suggest a conservative approach to opioid prescribing and dosing [3] given the risk of improper opioid use post-operatively [4,5]. Other research suggests that limiting the duration of post-operative use may be more important than limiting dosage [6].

As the risks of addiction have become increasingly publicized, patients may be concerned about the risks associated with taking opioids [7]. A survey of patients who had undergone surgery found 30% endorsed concerns about developing an opioid addiction [8]. As a result, patients may desire information about appropriate medication use and how and when to discontinue use [9]. Preoperative education in this area has been found to be effective at reducing patients' opioid consumption [10-12].

When encouraging patients to limit opioid use, offering alternative strategies for managing postoperative pain becomes increasingly important [13]. In addition to nonopioid pain medications, nonpharmacologic pain management techniques may offer another means of pain management [14-17]. Patients may also benefit from having their care teams introduce nonpharmacological pain care (NPPC) during their postoperative recovery, as patients may be unlikely to incorporate these techniques on their own [18]. However, these techniques may not be routinely provided to patients [8,18].

Some nurses may not feel equipped to advise patients on the full spectrum of nonpharmacologic options [7]. Deficits in knowledge about and training in nonpharmacologic techniques and lack of time may prevent nurses from using them [19,20]. Oncology nurses, for example, were more likely to use nonpharmacologic techniques with patients if they thought those strategies were effective and they had institutional support (eg, time, equipment, knowledge, and peer, colleague, and administration support) for doing so [21]. Critical care nurses used techniques they possessed knowledge and training in, personally used, and perceived as legitimate and beneficial [19]. Importantly, nurses' beliefs of legitimacy and training may vary greatly for different non-pharmacological techniques [19]. Education on pain management in nursing school is sparse, and specifics of what to cover are determined by programs [22]. Nursing curricula may provide nurses with deficient knowledge of pain management, including NPPC [23], but providing specific training on NPPC can increase nurses' intentions to incorporate these techniques into their practice [24].

The Healing After Surgery initiative, evaluated in the nonpharmacologic options in postoperative hospital-based and rehabilitation pain management (NOHARM) clinically-embedded, pragmatic clinical trial [25], was designed to provide patients with education and support for incorporating NPPC techniques into their individualized perioperative pain

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management plans. Inpatient nurses played a large role in supporting the Healing After Surgery initiative by providing patients with educational resources on their preferred NPPC techniques (including directing them to interactive resources), delivering NPPC as feasible, and discussing NPPC as part of the discharge conversation. We received strong support and endorsement for nursing's involvement from enterprise nursing leadership. This mixed methods analysis explores inpatient nursing leaders' and bedside nurses' perceptions of barriers and facilitators to implementing the Healing After Surgery initiative. The goal was to understand aspects of the intervention and implementation strategies that promoted implementation and challenges nurses encountered with implementation to inform similar future efforts implementing large-scale EHR-based educational initiatives that rely heavily on nurses to support implementation. This manuscript was prepared in accordance with the consolidated criteria for reporting qualitative research (COREQ) guidelines [26].

# Methods

#### **Study Design**

For this study, we conducted individual, semistructured interviews with nursing leaders and bedside nurses to obtain detailed feedback about facilitators and barriers to implementing the Healing After Surgery initiative in inpatient settings. We also conducted a brief, investigator-developed web-based survey, which was completed by inpatient nursing leaders to evaluate barriers and facilitators to the implementation of NPPC as part of the Healing After Surgery initiative.

# The NOHARM Clinical Trial and Healing After Surgery Initiative

The NOHARM pragmatic clinical trial [25] used a stepped-wedge cohort cluster-randomized design. The trial was conducted in 31 surgical practices across six sites belonging to the Mayo Clinic Enterprise: Rochester, Minnesota; Phoenix, Arizona; Jacksonville, Florida; Mankato, Minnesota; Eau Claire, Wisconsin; and La Crosse, Wisconsin. Practices comprised the following surgical specialties: lung, cardiac, gynecology, obstetrics, transplant, colorectal, orthopedics. Practices were randomly assigned to clusters defined by site and surgical practice to initiate the Healing After Surgery initiative during one of five sequences (steps in the wedge) at seven-month intervals. The control comparator condition was usual care. At the start of the trial, all surgical practices underwent a seven-month control interval. The first group of surgical practices began delivering the intervention in March 2021, the second group began delivering the intervention in October 2021, the third group began delivering the intervention in May 2022, the fourth group began delivering the intervention in December 2022, and the fifth group began delivering the intervention in July 2023. Patient outcomes of the NOHARM trial comparing patients undergoing the intervention to those who received usual care and qualitative research on patients' perceptions of their

experiences with the intervention will both be reported elsewhere. The present manuscript focuses on nurses' experiences delivering the Healing After Surgery initiative.

The Healing After Surgery initiative introduced surgical patients to 13 evidence-based NPPC techniques via a Healing After Surgery guide that was automatically sent to their EHR patient portals when they were identified as having a qualifying surgery within the next 30 days. The 13 NPPC techniques included movement techniques (walking, yoga, tai chi), physical techniques (transcutaneous electrical nerve stimulation (TENS), massage, acupressure, cold or heat), and relaxation techniques (meditation, guided imagery, aromatherapy, relaxing breathing, muscle relaxation, and music listening). Patients were encouraged to select up to three NPPC techniques of greatest appeal using the guide, which created discrete structured EHR data elements, which drove clinical decision support (CDS) including provider interfaces. Patients' NPPC choices were viewable in discipline-specific EHR workflow. These interfaces allowed inpatient care teams (eg, inpatient nurses, physical and occupational therapists) to view and support patients' preferences. If a patient had not indicated their NPPC preferences or their preferred techniques were not appropriate, inpatient nurses were instructed to share educational resources on the different NPPC techniques and encourage the patient to choose (other) NPPC techniques and enter the patient's preferences into the EHR. Inpatient nurses were encouraged to provide patients with educational materials on their preferred NPPC techniques and deliver NPPC for pain relief as feasible and compatible with existing nursing workflows. Healing After Surgery videos on hospital televisions, print materials stocked on inpatient floors, and information about NPPC techniques that auto-populated the patient's discharge summary supported inpatient nurses' educational efforts.

Epic CDS tools included best practice advisories for the provision of preferred NPPC for elevated pain, education points for preferred NPPC, a clickable Healing After Surgery banner at the top of the patient's chart to indicate Healing After Surgery initiative participation, and task reminders to educate the patient on NPPC [25] were built into the EHR to support inpatient nurses in delivering the initiative. There was also a designated pager nurses could call with questions. Nurses were encouraged to direct patients to interactive resources staffed by the research team (eg, Healing After Surgery patient toll-free number, Healing After Surgery Zoom-based group calls held three times a week) and a Healing After Surgery website, if they did not have the time or knowledge for more in-depth discussions of the patient's preferred NPPC techniques.

Inpatient nurses were onboarded to this program via an online educational module. The study's implementation team worked with nursing unit leaders to determine the best way to provide additional education and support to nurses. The implementation team was comprised of a diverse group of study team members including implementation researchers, physicians, nurses (eg, nurse scientist, clinical nurse specialist, and nurse manager), physical therapists, a physical therapy assistant, an occupational therapist, and study coordinators who cumulatively possessed implementation research and clinical expertise. Examples of additional education and support provided by the implementation

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team included presenting at staff meetings or professional development days or holding drop-in sessions with lunch or snacks for staff. We also offered in-person and online TENS training to teach nurses how to use the TENS machines we provided to their units. Nurses who started their job after this initial onboarding had access to the online educational module, but this was not required education for all new employees.

Upon implementation, members of the implementation team intermittently stopped by units to provide additional support. The implementation team also used secure messaging (available through the EHR) to offer nurses one-on-one support and to encourage them to ask questions. However, these supports were only available to day shift nurses. Our team also held wellness events for staff about midway through the trial, in which staff could stop by a room where members of our team offered some of the NPPC techniques.

#### **Interview Design**

Interviews were semistructured, using an interview guide developed by the study team, including those with clinical and research expertise. Interview questions were informed by the Consolidated Framework for Implementation Research (CFIR) 2.0 [27], which is a well-known implementation framework consisting of 5 domains (innovation, outer setting, inner setting, individuals, and implementation process) that contain related constructs. This framework can help elucidate what helped or hindered implementation. Interview questions were developed before, and independently of, survey development.

#### **Survey Design**

The brief survey, housed in the web-based platform, RedCap, had 2 questions that asked about participants' general characteristics (eg, work site and nursing role). In total, 7 additional items asked participants to indicate the extent to which staff knew about the initiative and what was expected of them to support the initiative; the extent to which the initiative helped support patients' pain management needs; how burdensome it was for staff to support the initiative; how big of a priority it was for their staff to support the initiative; how much they continued to encourage and remind staff to support the initiative; and to what extent they would support a variation of the initiative becoming part of standard care after the trial ended. These 7 questions were rated on a 10-point numeric rating scale, and participants were provided the anchors, 1=not at all, 10=a great deal. Participants could also select "unable to assess" as a response. Survey items were generated by members of the study team (including nursing professionals, a researcher, and physicians), whose experience helping implement the intervention informed key questions for nursing leadership to assess how implementation was going. The survey was reviewed by a member of the study team with expertise in survey research but was not pilot tested.

#### Sample

Nursing leaders (eg, supervisors, administrators, interim managers, clinical nurse specialists, and nursing education specialists) from inpatient floors that regularly cared for Healing After Surgery patients from each of the 31 surgical practices included in the NOHARM trial were invited to participate in a

brief survey and interview. Inpatient nurses who regularly delivered bedside care to Healing After Surgery patients from the 31 surgical practices were also eligible to participate in interviews.

#### Recruitment

We had originally planned to invite nursing leaders to participate in an interview approximately one year after their unit had begun delivering the Healing After Surgery initiative to give their unit time to adopt the intervention. This meant nursing leaders would be recruited at different timepoints depending on which of the 5 timepoints their surgical practice had been randomized to begin delivering the intervention as part of the parent trial. Our goal was to recruit 2 - 3 key inpatient nursing stakeholders from all 31 surgical practices. (Sometimes inpatient units cared for patients from multiple surgical practices or patients from a single surgical practice were cared for across multiple surgical floors with different nursing leadership and staff).

We emailed inpatient nursing leaders from the first group of surgical practices to begin delivering the Healing After Surgery initiative approximately 15 months later and invited them to participate in a 30-minute interview. The email informed nursing leaders they could also identify a representative for their unit (eg, charge nurse) who may be interested in participating. We emailed nursing leaders from the second group of surgical practices to begin delivering the Healing After Surgery initiative approximately one year after their units had begun intervention delivery. We also included information about the opportunity for bedside nurses to participate in an interview in study newsletters sent to inpatient nursing leaders from the first 2 groups of practices to begin delivering the intervention. However, recruitment was challenging, likely due to the COVID-19 pandemic environment and high rates of nursing leadership and staff turnover. Thus, we modified our recruitment email to more clearly state we were seeking 1 nursing leader and 1 bedside nurse from each surgical practice to participate in an interview and recontacted nursing leaders from the first 2 practice groups. Bedsides nurses were instructed to contact the study team if interested in participating in a research interview. Including both a nursing leader and bedside nurse from each practice increased the likelihood of achieving broad representation from the 31 surgical practices. In addition, because bedside nurses were directly involved in delivering the Healing After Surgery initiative to patients, their perspectives on facilitators and barriers to implementation complement the perspectives of nursing leaders, who oversaw implementation of the Healing After Surgery initiative on their unit but were not directly involved in its delivery to patients.

The third group of practices to begin delivering the intervention received the updated recruitment email approximately 1 year after they began delivering the intervention. However, because of ongoing challenges with recruitment and high rates of leadership and staff turnover, we recruited nurses from the fourth group of practices approximately six months after they began delivering the initiative and recruited nurses from the fifth group of practices approximately three months after they began delivering the initiative. These shorter intervals between beginning delivery of the initiative and recruitment were

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intended to minimize the likelihood of turnover while providing enough time for practices to adopt the initiative. For surgical practices that experienced leadership turnover and for which we had not met our recruitment goal, we invited new leaders to participate in interviews.

Ultimately, we invited 113 nursing leaders and bedside nurses to participate in an interview. We contacted bedside nurses about participating in an interview after they emailed us to express interest. The total number of nurses eligible to participate in an interview therefore exceeded 113, but it was impossible to determine how many additional bedside nurses may have become aware of the opportunity to participate via newsletter or heard about it from their leadership but never contacted us. A maximum of three recruitment attempts were made.

To offer nursing leaders a less time-consuming way to provide their feedback on the initiative and allow us to evaluate facilitators and barriers to implementation, we invited 78 nursing supervisors, administrators, managers, nursing education specialists, and clinical nurse specialists that represented the 31 surgical practices to complete a brief survey between July and December 2023. Recruitment was conducted via in-person outreach, email, or telephone. Nursing leaders from the fifth group of practices to begin delivering the initiative were not recruited to complete the survey until at least approximately three months since they had begun delivering the intervention, to ensure adequate exposure to the initiative. A maximum of 3 recruitment attempts were made.

#### Procedure

Print surveys were delivered with pre-addressed envelopes. Surveys returned through the health care enterprise's internal mail system were entered into Qualtrics by the study coordinator. Those who preferred to complete the survey online were emailed a link to the Qualtrics survey. A study coordinator entered responses into Qualtrics for any participants who preferred to complete the survey via phone.

For the interviews, two female, PhD-level researchers (SAM and CT) conducted the interviews. SAM is a research associate, and CT is a nurse scientist. Both had extensive interview and qualitative research experience from other research projects. SAM has also attended a workshop on rapid qualitative analysis and a workshop on qualitative analysis in implementation science. SAM and CT helped implement the Healing After Surgery initiative, so some participants were familiar with them from study implementation activities. Participants were informed at the start of the interview that the interviews were being conducted for the purpose of understanding what went well and what did not in terms of implementation. Interviews were conducted via telephone or a web-based video platform, Zoom, and only attended by the interviewer and participant. All interviews were recorded, and the audio was transcribed verbatim.

#### **Ethical Considerations**

For the survey, completion of the survey was taken as assent to participate, and those who did not wish to participate could choose not to. Participants provided verbal consent for

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participating in an interview. Respondents received \$35 remuneration for completing a survey and \$50 remuneration for completing an interview. Survey data were reported in aggregate. Exemplary quotes were attributed to a participant ID number assigned by the study team to protect participants' identities. The Mayo Clinic Institutional Review Board approved all procedures, #21 - 007898.

#### **Analytic Strategy**

We calculated descriptive statistics for responses gathered from the leadership surveys. Numeric responses were averaged across survey respondents as a whole and by site.

For the nurse interviews, we used Rapid Analysis [28,29] to summarize interview transcripts. Rapid analysis is a technique that can be used when the results are needed to modify implementation strategies of evidence-based interventions [30]. Consistent with the rapid analytic approach which follows a deductive process, SM developed a Summary Template containing domain labels based on the interview guide questions to facilitate summarizing and organizing key information from interview transcripts. For the first three interviews, SAM, CT, and KS (a Senior Clinical Research Coordinator) independently completed summaries by summarizing information from the interview transcripts as bullet points under the appropriate domain. They met to discuss their summaries after each of these three interviews to establish consensus for completion. Remaining interview transcripts were summarized by either SAM, CT, or KS, independently. SAM reviewed all completed summaries, making minor edits, before uploading them into Nvivo software by Lumivero [31]. In Nvivo, the text for each summary was coded to the corresponding domain on the summary template, and the text for each domain was queried. SAM and CT created analytic memos for queried domains, identifying key themes and how they fit within CFIR 2.0. SAM and CT met to discuss key themes and their correspondence with CFIR 2.0 constructs and arrived at consensus via discussion. CT and SAM further consolidated key themes within CFIR 2.0 via independent preparation of memos and discussion.

# Results

# **Qualitative Findings**

We interviewed 29 of the 113 inpatient nurses (26% response rate) invited to participate between June 2022 and November 2023. Of those interviewed, 13 were in leadership roles and 16 were in clinical, direct patient care roles; 27 were female and 2 were male. Participants worked in Rochester, Minnesota (n=10); Phoenix, Arizona (n=7); Jacksonville, Florida (n=4); Eau Claire, Wisconsin (n=3); La Crosse, Wisconsin (n=2); and Mankato, Minnesota (n=3). They cared for the following types of surgical patients: colorectal (n=3), obstetrics (cesarean section; n=5), gynecological (n=3), orthopedic (n=5), cardiac and lung (n=4), gynecological and orthopedic (n=1), and colorectal and gynecological (n=1). Interviews lasted 32 minutes on average (minimum=20 minutes, maximum=47 minutes).

Interviews revealed the following three themes related to barriers and facilitators to the implementation of the Healing After Surgery initiative: (1) nurses tended to gravitate towards NPPC techniques they were familiar with, (2) the initiative was patient-centric, but opportunities remained to better engage patients via increased care team communication, and (3) nurses experienced challenges implementing and prioritizing the intervention in the inpatient settings due to competing demands experienced in the pandemic and postpandemic environment. CFIR 2.0 constructs that correspond to each theme are shown in parentheses.

#### Nurses Tended to Gravitate Toward NPPC Techniques They Were Familiar With (Compatibility, Innovation Deliverers–Capability, and Available Resources–Materials & Equipment)

The initiative's focus on pain management incorporating non-pharmacologic techniques broadly aligned with the Health Care System's current approach to patient care. However, nurses varied in their receptiveness towards (eg, thoughts about appropriateness of inpatient use) and familiarity with different NPPC techniques and perceived the availability of resources to vary. More specifically, walking, application of ice, music, and relaxation techniques were available in current practice, while techniques such as yoga, tai chi, and acupressure were not. There were mixed impressions regarding the compatibility of TENS (transcutaneous electrical nerve stimulation), aromatherapy, and massage with nursing practice. Some nurses were concerned they may be asked to deliver techniques for which they felt they lacked the training or resources (eg, extra time or special equipment) to deliver. As one participant described it,

"it's just that it's time, massage is time, TENS unit is time...and unfortunately, I feel like that has been very short lately." [(P18, lines 531 - 532).]

There was a tendency for nurses to discuss NPPC techniques with patients that they were personally familiar with and avoid discussing techniques they were less familiar with or lacked resources to provide. One nurse stated,

"I don't know the first thing about tai chi, or...how we would be able to implement that in the inpatient setting at least. Maybe once they go home, they could utilize that more." [(P1, lines 38 - 40).]

However, some units were resourceful with figuring out how to get the supplies they needed, such as ordering essential oils to support aromatherapy.

#### Initiative Viewed as Patient-Centric, but Opportunities Remained to Better Engage Patients via Increased Care Team Communication (Recipient-Centeredness, Assessing Needs–Innovation Recipients, and Engaging Innovation Recipients)

Offering options for nonpharmacologic pain management empowered patients by offering pain management solutions that extend beyond the scope of medications, allowing patients to be active participants in their pain management plan. One nurse shared,

"I feel like this is just another part of nursing, and we should have, to be honest, probably been doing this all along... I think patients are very receptive to

it, very thankful for it, and I feel like it makes a significant difference when it's done". [(P13, lines 776 - 782).]

NPPC was viewed as particularly helpful for patients who were reticent to take opioids and for use in conjunction with medications for individuals experiencing severe pain. Patients tended to gravitate toward more familiar techniques such as walking, application of cold or heat, or relaxed breathing; however, there were medical situations and priorities that made engaging in NPPC impractical. For instance, persons with serious, acute needs, those who had emergency surgery, new mothers who had a cesarean section, and patients who were intubated were not good candidates for the intervention.

Nurses also identified missed opportunities to increase patient engagement and felt strongly that conversations about NPPC use should be initiated before surgery. They emphasized that patients would likely be more engaged if they had heard about the Healing After Surgery program from their providers in advance, as an example:

I don't know if this is something that they're currently doing, but I do think that having providers share the same message....really helps...and not just in those times where... nursing can't necessarily do it because of timing... but... have that as part of their normal kind of workflow or discussion points with patients. [(P21, lines 363 - 371).]

While it fell within the scope of nursing practice to support NPPC, there were suggestions to engage others in delivery, including physicians, virtual RNs, and nurse technicians. Nurse technicians are members of the health care team that function under the direct supervision of a registered nurse, performing basic patient care tasks such as vital signs and assistance with activities of daily living.

# Challenges Implementing and Prioritizing the Intervention in the Inpatient Setting (Physical Infrastructure, Relative Priority, Critical Incidents, Work Infrastructure, Individuals–Mid-Level Leaders–Capability, Motivation, Deliverer-Centeredness,

The intervention was introduced during the COVID-19 pandemic, and although the elective surgical patient population targeted by the intervention did not typically have a COVID-19 infection, the pandemic indirectly impacted the delivery of the intervention due to staff burnout and changes to work infrastructure. Nurses noted bed shortages, higher patient to staff ratios, and caring for higher acuity patients as barriers to delivering the intervention and NPPC. Patients also had shorter hospital stays than in years prior. One nurse shared:

just five years ago, a knee or a hip would be in the hospital for probably a minimum of three days. Now...we got about one and a half to two days maybe. And that's from the time they check in down at the desk.... So when I say that 1.5, we're really getting about 24 hours with the patient to do this education...that's probably our biggest challenge, but that's across the board... [(P7; 501 - 521).]

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and Mission Alignment)

The COVID-19 pandemic also created an environment of increased staff and leadership turnover. New leaders were unfamiliar with what training on the intervention staff had received. With leadership turnover, the intervention got deprioritized, and many leaders did not do much to convey support for the initiative, particularly after the initial roll-out:

...we've...had a lot of leadership turnover in the last couple of years... and we're... in the limbo of interim managers and all of that right now. So it's... hard because I feel like we've missed a lot of that solidarity of the same person and that support just 'cause everyone's trying to pick up the pieces and just get us through until the next manager takes over... right when they rolled out, they were super supportive...since then, we've...been in this limbo [(P24; 385 - 400).]

Many saw this initiative as something extra and deprioritized it when faced with short staffing and other tasks. One nurse stated:

...the way that they staff us for... our floors ...you don't have extra time to do...the education that you want to be able to do...these extra interventions that you wanna do. You have enough time to do ...the bare minimum stuff...if it's a really good day, and everything is going perfectly, sometimes you get those extra moments [(P18; 175 - 180).]

For new nurses joining units, the priority was on developing their basic nursing skills. One nurse shared,

... when your staff... is stretched and they're new you have to go back to the basics to make sure that everyone has the basic skills...and NOHARMs is... very important, but it's not a basic skill. So it doesn't go to the top of my list [laughter].

(P5; 346 - 354).

In this context, some nurses tended to look towards medications first for faster results.

A few nurses thought that this initiative should be prioritized, and it was a reasonable ask. A few leaders also communicated the importance of the initiative or how it aligned with broader goals for patient care and opioid reduction. One nurse manager stated,

...we have to realize that we are... hurting people more than helping them with our heavy-handed narcotic passing. And so just knowing that importance and expressing that to the team, I felt like it is a high-priority item...you're always gonna be able to make an excuse about something being a low-priority problem, you know?...—as a nurse manager, it can be overwhelming to decide what you fit where, but it doesn't mean that you can't fit it. [(P2; lines 483 - 501).]

Leaders who conveyed support did so via existing communication channels (eg, email and huddle), and some went out of their way to make sure staff were informed (eg, posting fliers in the breakroom). Interviewees suggested getting support

from additional councils and quality and practice committees might have enhanced support.

Mixed Effectiveness of Implementation Strategies (Design, Access to Knowledge & Information,

# Implementation Leads, Engaging Innovation Deliverers, and Tailoring Strategies)

Nurses reflected on several evidence-based implementation strategies used by the research team or units themselves to facilitate implementation of the intervention, which had varied success. Implementation strategies were part of the Expert Recommendations for Implementing Change (ERIC) list of strategies [32]. These are summarized in Table 1.



have done so many MyLearning on it. [Laughter] don't remember if as there one? I don't even know' P8; lines 227 - 230 ause of the turnover on the floor that the initial education was just e we got there, a lot of us. I think that might be a barrier.'' P17; 119
have done so many MyLearning on it. [Laughter] don't remember if as there one? I don't even know' P8; lines 227 - 230 ause of the turnover on the floor that the initial education was just e we got there, a lot of us. I think that might be a barrier.' P17; 119
nk everyone's pretty good at like trying to bounce ideas off each and things like that. And I think everyone's pretty open to trying natives butI'm not aware of somebody it's kind of hard right with the staff turnover. We have so many young staff members. So, having a hard time filling positions on unit council, and filling ions on all the different things like that. But we do have a falls pion, and a pressure ulcer champion we have two wellness cham- . But it's not always super easy to get those positions filled." <i>P18;</i> 586
echose to make our team lead groups, so we've got 12 team leads, i're core, that's their primary job, and 6 that're relief, which means fill in as needed our super-user group, just because there's always of them on either day shift or night shift. And they can be thatgo- rson if somebody has questions." <i>P15; 423 - 428</i>
ned very straightforward and similar to what we had previously with other educational elements." P3; 386 - 390
inders emails, huddlesthe little daily interactions to say have you guys been doing this?' Or, 'What's been working? What's I think they're pretty good about reminding us that we're part of that and our goal is to do this it's become a part of my ice that, even if I have a patient that's not a NOHARM patient, I'm . talking about those same points with them." P19; 315 - 323
rough secure chat is very beneficial 'cause I do know that there been times where you guys have noticed that maybe we weren't wing through with the plan the way we should, and there's that, 'Hey, e remember this patient wants to do X, Y, and Z.' it's a gentle way ting us know that, "Hey, there's this other thing out there," without waiting by the door, waiting for that nurse to come out and then ting them in the hallway, so to speak." P7; 460 - 473
nk definitely having someone on the unit to be there to answer ions, to actually physically show you the chart is definitely more ul than a MyLearning. [Laughter] I think that you just hafta click gh 'cause it's another required education." P12; 266 - 270 personally work a lot of night shifts so I haven't seen anybody
No Harm come around besides the one-day shift when they rolled but and gave us information" P24; 568 - 576



Description of implementation strategies	Exemplary quotes
Some nursing leaders shared report data provided by the research team on how their unit was doing with intervention delivery in emails/newsletters.	" when you give us updates of where we're at as far as meeting the percentages of patients that have done their selectionI'm trying to remember if it also talks about the discharge teachingwe share those results in our newsletters. We do a weekly newsletter, so when you guys send us that, then we share that in our newsletter that we send out to the staff." P5; 390 - 405
ERIC implementation strategy: Change physical structure and equipment	
Few nurses reported tailoring implementation of the intervention but modifications that were reported were mostly related to changing the loca- tion of Healing After Surgery-related resources to make them more acces- sible.	"we started putting on each individual pod—so it's more accessible— aromatherapy kits. Where it was in one central location behind the team lead's, it is now available to every pod in our med room As well as printouts right there of the list, so it's easily accessible rather than trying to dig through a drawer or look it up on the intranet to try to print some- thing out. It's just right there and available" P19; 523 - 532

<sup>a</sup>ERIC: Expert Recommendations for Implementing Change [32].

#### **Survey Findings**

We received survey responses from 47 of the 78 (60% response rate) nursing leaders invited. See Table 2 for respondents' work site and professional role. Overall, leaders thought their staff knew what the Healing After Surgery initiative was (mean=7.53, SD=1.77), and that their staff knew what they were expected to do to support the initiative (mean=7, SD=1.88). The initiative was perceived to support patients' pain management needs (mean=6.76, SD=2.24), but added some burden to staff (mean=3.93, SD=2.47). Leaders endorsed the Healing After Surgery initiative as a priority (mean=7.02, SD=2.56) and rated their ongoing encouragement of staff to support the initiative slightly lower (mean=5.98, SD=2.78). Generally, nursing leaders supported the Healing After Surgery program becoming part of standard care once the clinical trial ended (mean=7.72, SD=2.62).

Respondents from the hospital located in Rochester, Minnesota, rated burden from this initiative the highest (mean=5, SD=2.68), and their ongoing encouragement for staff to support this
initiative (mean=4.73, SD=2.24) and support for this initiative
to continue (mean=6.09, SD=2.63) the lowest of all sites.
Respondents from the hospital in Phoenix, Arizona, rated the
ability of the initiative to help them better meet patients' pain
management needs (mean=8.25, SD=1.60) and their interest in
having the initiative continue in some form (mean=8.75,
SD=1.76) the highest of all sites. Respondents from the hospital
in La Crosse, Wisconsin, rated staff's knowledge of what the
initiative was (mean=9.33, SD=1.15) and staff's knowledge of
what was personally expected (mean=8.6, SD=2.31) of them
highest of all sites. See Table 3 for nursing leaders' responses
by site (and to view the survey questions).

Table .	Survey	participants	by role	and site.
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Site	Nurse administra- tor	Nurse manager	Interim nurse manager	Clinical nurse specialist	Nursing educa- tion specialist	Other	Total
Rochester, Min- nesota	1	7	a	2	1	_	11
Phoenix, Ari- zona	_	4	1	1	3	3	12
Jacksonville, Florida	_	7	_	1	1	_	9
Eau Claire, Wis- consin	_	4	_	1	2	_	7
La Crosse, Wis- consin	_	2	_	_	1	_	3
Mankato, Min- nesota	_	2	_	2	1	_	5

<sup>a</sup>Not applicable.



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Table . Mean (SD) responses to individual survey items by site.

Question	Rochester, MN	Phoenix, AZ	Jacksonville, FL	Eau Claire, WI	La Crosse, WI	Mankato, MN
To the best of your knowledge, to what extent do your staff know what the Healing After Surgery initiative is?	6.55 (1.51)	8.5 (1.51)	7.22 (2.17)	7.43 (1.51)	9.33 (1.15)	7 (1.41)
To the best of your knowledge, to what extent do your staff know what they are personally expected to do to support the Healing After Surgery initiative?	6.36 (1.50)	8.17 (1.80)	5.89 (1.90)	7.29 (1.38)	8.67 (2.31)	6.2 (1.48)
To what extent has the Healing After Surgery initiative helped you and your staff better support patients' pain management needs?	6.36 (2.62)	8.25 (1.60)	6.44 (2.13)	5.71 (1.89)	5 (2.83) <sup>a</sup>	6.75 (2.22) <sup>a</sup>
How burdensome has it been for your staff to support the Healing After Surgery initiative?	5 (2.68)	3.18 (2.44) <sup>a</sup>	3.89 (2.85)	3.14 (1.46)	4 (3.61)	4.4 (1.95)
How big of a priori- ty is it to you that your staff support the Healing After Surgery initiative?	5.91 (2.34)	7.75 (2.09)	8.56 (1.67)	5.57 (3.60)	7 (2.65)	7 (2.71) <sup>a</sup>
Outside of early implementation ef- forts, how much have you continued to encourage and remind staff to sup- port the Healing After Surgery initia- tive? (eg, email re- minders, discus- sions, etc.)	4.73 (2.24)	5.33 (3.26)	6.78 (2.82)	7.43 (2.51)	7.33 (2.52)	6 (2.55)
To what extent would you support a variation of the Healing After Surgery Program becoming part of standard care once the trial ends?	6.09 (2.63)	8.75 (1.76)	8.44 (2.01)	7.43 (2.51)	7.67 (2.52)	8 (0.71)

<sup>a</sup>One participant from the site selected "unable to assess" so their response is not included in the mean.

# Discussion

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#### **Principal Findings**

This study describes nurses' perceptions of NPPC and implementation of the Healing After Surgery initiative across diverse surgical practices within a single healthcare system

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spanning multiple geographic locations. The Healing After Surgery initiative was developed as a low-touch intervention designed to provide patients with peri-operative education and support for using NPPC for perioperative pain management. This educational initiative was intended to cover the perioperative period and include all members of the surgical care team, addressing inadequacies in education on pain

management and opioid safety and setting of pain expectations previously reported [33]. During the pre-operative period, patients were assigned an educational Healing After Surgery guide upon surgical scheduling. Ambulatory nurses and preoperative evaluation clinic staff encouraged patients to complete the guide and offered additional educational materials during preoperative visits. Surgeons were also encouraged to voice their support of the initiative to patients. Inpatient nurses were designated as having a key role in intervention delivery by providing patients with education on their preferred NPPC techniques and delivering them as feasible during the postoperative inpatient stay.

To minimize the burden of intervention delivery on inpatient nurses, we developed multimodal educational resources (eg, print resources, website, DVD, and videos available on hospital televisions) designed to support patients in self-administration of NPPC. For example, print materials and a brief video guided patients through finding pressure points and applying pressure to facilitate patients' use of acupressure. Videos on the website guided patients through tai chi and gentle yoga movements geared towards a surgical patient population. Moreover, training provided to nurses instructed them to provide patients with these resources (eg, give patients print materials stocked on their floor, navigate to the NPPC educational videos on the hospital television). Nurses were also told that they did not need to be experts in the NPPC techniques. Nurses could discuss NPPC techniques as their knowledge and time allowed and refer patients needing more support to the Zoom-based group calls and toll-free number.

Interview and survey responses revealed that the initiative was thought to be patient-centric and help meet patients' pain management needs. Nursing leaders were supportive of NPPC practice integration and its continuation notwithstanding some burdens in supporting the program. However, challenges to implementing the Healing After Surgery initiative identified via the interviews included nurses' lack of familiarity with some of the NPPC modalities and lack of time to educate patients on NPPC due to other aspects of patient care that took priority. Further, some of the implementation strategies employed could be modified to better support implementation.

Four of the ERIC implementation strategies utilized to support nursing implementation of the Healing After Surgery initiative included developing educational materials, distributing educational materials, conducting educational meetings, and conducting outreach visits [32] with the goal of training nurses how to deliver the intervention. However, these strategies (eg, an assigned web-based educational module, presentations at staff meetings, "drop-in sessions," and at-the-elbow support) may have failed to adequately reach all nurses due to high rates of staff turnover, nursing float coverage (eg, nurses taking shifts on a unit that was not their usual unit), or nurses not being scheduled to work during these supports. Moreover, these efforts made nurses aware of available patient educational resources and CDS developed as a reminder of what to do and to facilitate documentation. Education on the NPPC techniques was a lesser focus. We thought nurses would be familiar with many of the techniques because pain management, including self-management strategies, is an essential competency for

nurses [34-36]. We also thought nurses would be comfortable directing patients to educational materials or the toll-free number and Zoom-based group calls for NPPC techniques while realizing they may have lacked the time or knowledge to educate patients on the techniques. However, most nurses gravitated to those NPPC modalities already integrated into their practice (eg, walking, application of ice) and avoided discussing techniques they were not sure how to use (eg, tai chi and acupressure). Although nurses are likely introduced to NPPC during their training and include basic techniques such as application of cold or heat and walking into their practice, they may benefit from additional training in the use of techniques that they are less familiar with and not comfortable discussing with patients. Similarly, a survey of critical care nurses found that roughly 80% and 59% reported no training or knowledge in tai chi and acupressure, respectively [19]. Furthermore, only roughly 1% of those who reported no training or knowledge in these techniques utilized them as part of their practice [19]. Anecdotal conversation during the implementation of the Healing After Surgery initiative suggested that giving patients materials without being able to discuss them may run counter to nursing practice. This might explain why some nurses avoided mentioning NPPC techniques they were not comfortable with altogether.

To normalize NPPC use in hospitals, it may be important to bolster nurse knowledge and familiarity with relevant, evidence-based pain modalities via additional training [19,37-41], and nursing curriculums should consider integrating more information about NPPC [37,42]. Education could take the form of brief in-services [37], patient stories, hands-on learning, e-learning, lunch-and-learns, education days, and speaking with colleagues [7]. However, it is important to ensure that night shift nurses have the same access to these opportunities as day shift nurses. We only provided implementation support (eg, presentations at huddles and staff meetings, pager support, at-the-elbow support on inpatient floors) during daytime hours. Some practices may have overcome this by having charge nurses or team leads be super users (eg, clinical champions), but this was driven by units themselves and not routinely adopted.

Additional education on NPPC may also help address concerns about the appropriateness and feasibility of some of these techniques that persisted despite emphasizing in the nursing training that our educational materials were created for a surgical patient population. Delivering techniques such as yoga or tai chi to patients in the hospital was perceived to be impractical. Further, although we had not initially planned on educating critical care nurses on how to support the Healing After Surgery initiative, some of the included surgical practices routinely admitted patients to the intensive care unit (ICU) following their procedure, and in cases of high hospital census, patients could spend more time there. Thus, in partnership with ICU nursing leadership, we determined that critical care nurses may be able to introduce NPPC to patients depending on the patient's stage of recovery. However, past studies have described patient-related barriers to pain management in intensive care units [43], and whether the Healing After Surgery initiative was appropriate

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for patients on critical care units varied depending on their status.

Some of the interviewees also described competing patient care priorities and suggested that inpatient units are not ideal for teaching NPPC to patients. For instance, some nurses perceived NPPC as an "extra" and relied on pharmacological pain management as a fast and effective method of alleviating pain. Our findings suggest that current inpatient systems and processes within our hospital enterprise may not allow enough time for nurses to readily deliver NPPC for pain management despite strong endorsement from the enterprise and participating surgical departments for implementing the HAS initiative. Literature has noted that nurse staffing ratios may impede pain management [38,44,45] and NPPC use [40,42], and competing demands on nurses' time may also impede NPPC use [39,41,42,44,45]. The implementation strategies we utilized to prompt, support, and motivate nurses to provide patients with NPPC education (eg, CDS clinician reminders, local technical assistance via EHR-based messaging, and audit and feedback data on completion of NPPC selections and NPPC education) may have limited effectiveness if time and competing priorities remain important barriers. One helpful implementation strategy used by some units was changing the physical location of some Healing After Surgery-related resources to make them more accessible to staff (eg, less time and effort to retrieve materials). However, small modifications like this may be insufficient to overcome time constraints imposed by higher patient to staff ratios and higher acuity patients, exacerbated by the pandemic. The healthcare enterprise in which this initiative was delivered may consider more explicitly voicing prioritization of NPPC provision (and how this should be prioritized compared to other nursing responsibilities) and ensure nurses are given the necessary time [39], if the goal is for this to become a routine part of peri-operative pain management.

Interviews also suggested that patients could benefit from the patient's surgeon also discussing NPPC with patients. We did encourage surgeons to voice their support of the HAS initiative to patients, but it is unclear to what extent this occurred. Moreover, there may be an opportunity for advanced practice providers (APPs) to voice their support of NPPC as well, although we minimally engaged them as part of the initiative. A prior survey of APPs conducted at one of the hospitals in which the present study took place found that APPs held positive beliefs about NPPC, but discussion about the benefits and risks of NPPC occurred inconsistently [46]. However, if surgeons and APPs consistently voice support for NPPC, this may help create an organizational culture in which discussion about NPPC as part of peri-operative pain management is normalized and expected.

#### **Strengths and Limitations**

This study gathered interview data from inpatient nursing leaders and bedside nurses and survey data from inpatient nursing leaders on the barriers and facilitators to implementing a program designed to provide patient education and support for use of NPPC for peri-operative pain management. CFIR 2.0 guided the qualitative data collection and interpretation, adding to its theoretical rigor. Furthermore, our findings add to the

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literature by including inpatient nurses from diverse surgical practices and sites that varied in academic status, rurality, and size. Some site differences did emerge, perhaps due to competing priorities, adequacy of staffing, nursing leaders' own biases, patient volumes, and hospital culture. The variation in the support at different locations may also reflect the overall complexity with size of each facility, surgical volumes, culture, resources, and complexity of care during the time the study was conducted during the COVID-19 pandemic. However, only nurse leaders were offered participation in the survey, and the number of respondents from each site varied, so it is unclear to what extent survey findings reflected the opinions of each site. It is also possible that the opinions and perspectives of the nursing leaders may or may not adequately reflect the opinions and perspectives of all involved bedside nurses. Further, although our response rate was 60% for the survey and 26% for the interviews, we make no definitive claim of representativeness because all hospital sites belong to the same health care enterprise, instead focusing on the range of issues identified in this context. Nonetheless, our findings, particularly from the interviews, were fairly balanced in terms of identifying facilitators and barriers to implementation, suggesting our results were not skewed in one direction.

The study began during the COVID-19 pandemic, which provided a unique implementation context that might have influenced our findings. However, our interviews suggested that the elective surgical nature of this patient population did not seriously impact their experience. Instead, COVID-19 more indirectly impacted inpatient surgical units in terms of staffing and higher rates of staff turnover. It may also be difficult to compare findings from our research to that of other studies that have used validated implementation measures because survey items were generated by the members of the research team and not taken from a validated scale. Nonetheless, the items have face validity and achieved our objective of understanding nursing leaders' perceptions of facilitators and barriers to the implementation of the Healing After Surgery initiative.

#### **Conclusions and Future Directions**

Our findings highlight important lessons learned during the implementation of a novel EHR-facilitated initiative into inpatient nursing practices that incorporate additional education and provision of non-pharmacologic options for managing pain. This trial provides feedback on the use of technology to align care to meet guidelines for comprehensive pain management initiated prior to surgery and during recovery at home. Our findings highlight a need for earlier education and increased availability of resources to support the use of NPPC. Moreover, our findings suggest challenges and opportunities for better engagement of inpatient nurses for any practice change at the inpatient nurse level, given the anticipated persistence of similar complexity of care and short lengths of stay. Our findings also highlight a challenge inherent to large-scale pragmatic trials that require engaging and training a large number of intervention providers to deliver an intervention with fidelity. Future efforts may explore other ways of strategically augmenting implementation resources to effectively engage care teams. There are opportunities to enhance nurses' role in pain management with educational support for NPPC in academic

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programs, through orientation support, virtual nursing roles, and ongoing professional development support.

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#### **Data Availability**

The interview transcript data for this paper will not be made available to protect the privacy of interview participants. De-identified, aggregate level data collected from the web-based survey is available upon reasonable request to the corresponding author.

#### **Authors' Contributions**

SAM, CT, KS, SC, SL, JH, MM, JT, and AC contributed to conceptualization of the study. KS, SC, JH, SL, and MM assisted with study recruitment. SAM, CT, and KS contributed to the analytic methods. SAM and CT prepared the first draft of the paper. All authors reviewed drafts, provided edits, and approved of this final version.

#### **Conflicts of Interest**

None declared.

#### References

- El Moheb M, Mokhtari A, Han K, et al. Pain or no pain, we will give you opioids: relationship between number of opioid pills prescribed and severity of pain after operation in US vs Non-US patients. J Am Coll Surg 2020 Dec;231(6):639-648. [doi: 10.1016/j.jamcollsurg.2020.08.771] [Medline: 32977034]
- Thiels CA, Anderson SS, Ubl DS, et al. Wide variation and overprescription of opioids after elective surgery. Ann Surg 2017 Oct;266(4):564-573. [doi: 10.1097/SLA.0000000002365] [Medline: 28697049]
- 3. Dowell D, Ragan KR, Jones CM, Baldwin GT, Chou R. CDC clinical practice guideline for prescribing opioids for pain -United States, 2022. MMWR Recomm Rep 2022 Nov 4;71(3):1-95. [doi: 10.15585/mmwr.rr7103a1] [Medline: 36327391]
- 4. Barth RJ, Waljee JF. Classification of opioid dependence, abuse, or overdose in opioid-naive patients as a "never event". JAMA Surg 2020 Jul 1;155(7):543-544. [doi: 10.1001/jamasurg.2020.0432] [Medline: 32347906]
- Gil JA, Gunaseelan V, DeFroda SF, Brummett CM, Bedi A, Waljee JF. Risk of prolonged opioid use among opioid-naïve patients after common shoulder arthroscopy procedures. Am J Sports Med 2019 Apr;47(5):1043-1050. [doi: 10.1177/0363546518819780] [Medline: 30735622]
- 6. Brat GA, Agniel D, Beam A, et al. Postsurgical prescriptions for opioid naive patients and association with overdose and misuse: retrospective cohort study. BMJ 2018 Jan 17;360:j5790. [doi: <u>10.1136/bmj.j5790</u>] [Medline: <u>29343479</u>]
- Leegaard M, Watt-Watson J, McGillion M, Costello J, Elgie-Watson J, Partridge K. Nurses' educational needs for pain management of post-cardiac surgery patients: a qualitative study. J Cardiovasc Nurs 2011;26(4):312-320. [doi: 10.1097/JCN.0b013e3181f806bc] [Medline: 21099695]
- 8. Gan TJ, Habib AS, Miller TE, White W, Apfelbaum JL. Incidence, patient satisfaction, and perceptions of post-surgical pain: results from a US national survey. Curr Med Res Opin 2014 Jan;30(1):149-160. [doi: 10.1185/03007995.2013.860019] [Medline: 24237004]
- Kennedy D, Wainwright A, Pereira L, et al. A qualitative study of patient education needs for hip and knee replacement. BMC Musculoskelet Disord 2017 Oct 12;18(1):413. [doi: 10.1186/s12891-017-1769-9] [Medline: 29025397]
- Egan KG, De Souza M, Muenks E, Nazir N, Korentager R. Opioid consumption following breast surgery decreases with a brief educational intervention: a randomized, controlled trial. Ann Surg Oncol 2020 Sep;27(9):3156-3162. [doi: <u>10.1245/s10434-020-08432-7</u>] [Medline: <u>32285282</u>]
- 11. Lee BH, Wu CL. Educating patients regarding pain management and safe opioid use after surgery: a narrative review. Anesth Analg 2020 Mar;130(3):574-581. [doi: 10.1213/ANE.000000000004436] [Medline: 31567320]
- 12. Rucinski K, Cook JL. Effects of preoperative opioid education on postoperative opioid use and pain management in orthopaedics: A systematic review. J Orthop 2020;20:154-159. [doi: 10.1016/j.jor.2020.01.020] [Medline: 32025140]
- 13. Chou R, Gordon DB, de Leon-Casasola OA, et al. Management of postoperative pain: a clinical practice guideline from the American pain society, the American society of regional anesthesia and pain medicine, and the American society of

anesthesiologists' committee on regional anesthesia, executive committee, and administrative council. J Pain 2016 Feb;17(2):131-157. [doi: 10.1016/j.jpain.2015.12.008] [Medline: 26827847]

- 14. Tick H, Nielsen A, Pelletier KR, et al. Evidence-based nonpharmacologic strategies for comprehensive pain care: the consortium pain task force white paper. Explore (NY) 2018;14(3):177-211. [doi: 10.1016/j.explore.2018.02.001] [Medline: 29735382]
- Sezen CB, Akboga SA, Celik A, Kalafat CE, Tastepe AI. Transcutaneous electrical nerve stimulation effect on postoperative complications. Asian Cardiovasc Thorac Ann 2017 May;25(4):276-280. [doi: <u>10.1177/0218492317703838</u>] [Medline: <u>28350210</u>]
- 16. Fan M, Chen Z. A systematic review of non-pharmacological interventions used for pain relief after orthopedic surgical procedures. Exp Ther Med 2020 Nov;20(5):36. [doi: 10.3892/etm.2020.9163] [Medline: 32952627]
- 17. Good M, Anderson GC, Stanton-Hicks M, Grass JA, Makii M. Relaxation and music reduce pain after gynecologic surgery. Pain Manag Nurs 2002 Jun;3(2):61-70. [doi: 10.1053/jpmn.2002.123846] [Medline: 12050837]
- Keast M, Hutchinson AF, Khaw D, McDonall J. Impact of pain on postoperative recovery and participation in care following knee arthroplasty surgery: a qualitative descriptive study. Pain Manag Nurs 2022 Aug;23(4):541-547. [doi: 10.1016/j.pmn.2021.11.011] [Medline: 34972657]
- 19. Tracy MF, Lindquist R, Watanuki S, et al. Nurse attitudes towards the use of complementary and alternative therapies in critical care. Heart Lung 2003;32(3):197-209. [doi: 10.1016/s0147-9563(03)00040-2] [Medline: 12827105]
- 20. Kidanemariam BY, Elsholz T, Simel LL, Tesfamariam EH, Andemeskel YM. Utilization of non-pharmacological methods and the perceived barriers for adult postoperative pain management by the nurses at selected national hospitals in Asmara, Eritrea. BMC Nurs 2020;19:100. [doi: 10.1186/s12912-020-00492-0] [Medline: 33110397]
- 21. Kwekkeboom KL, Bumpus M, Wanta B, Serlin RC. Oncology nurses' use of nondrug pain interventions in practice. J Pain Symptom Manage 2008 Jan;35(1):83-94. [doi: <u>10.1016/j.jpainsymman.2007.02.037</u>] [Medline: <u>17959348</u>]
- 22. Compton P, Blacher S. Nursing education in the midst of the opioid crisis. Pain Manag Nurs 2020 Feb;21(1):35-42. [doi: 10.1016/j.pmn.2019.06.006] [Medline: 31358464]
- 23. Latchman J. Improving pain management at the nursing education level: evaluating knowledge and attitudes. J Adv Pract Oncol 2014 Jan;5(1):10-16. [Medline: 25032029]
- 24. Murphy-Smith MT, Samawi Z, Abbott P. Teaching strategies for nonpharmacological pain management to nursing students. Pain Manag Nurs 2024 Oct;25(5):474-479. [doi: 10.1016/j.pmn.2024.04.006] [Medline: <u>38714423</u>]
- 25. Redmond S, Mayo Clinic NRT, Tilburt J, Cheville A. Non-pharmacological options in postoperative hospital-based and rehabilitation pain management (NOHARM): protocol for a stepped-wedge cluster-randomized pragmatic clinical trial. Pain Ther 2022 Sep;11(3):1037-1053. [doi: <u>10.1007/s40122-022-00393-x</u>] [Medline: <u>35657564</u>]
- 26. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care 2007 Dec;19(6):349-357. [doi: <u>10.1093/intqhc/mzm042</u>] [Medline: <u>17872937</u>]
- 27. Damschroder LJ, Reardon CM, Widerquist MAO, Lowery J. The updated consolidated framework for implementation research based on user feedback. Implement Sci 2022 Oct 29;17(1):75. [doi: <u>10.1186/s13012-022-01245-0</u>] [Medline: <u>36309746</u>]
- 28. Hamilton A. Rapid qualitative analysis: updates/developments VA HSR&D National Cyberseminar.: QUERI Implementation Research Group; 2020. URL: <u>https://www.hsrd.research.va.gov/for\_researchers/cyber\_seminars/archives/video\_archive.</u> <u>cfm?SessionID=3846</u> [accessed 2025-07-02]
- 29. Hamilton A. Qualitative methods in rapid turn-around health services research. In: VA HSR&D National Cyberseminar Series: Spotlight on Women's Health 2013. URL: <u>https://www.hsrd.research.va.gov/for\_researchers/cyber\_seminars/</u> archives/video\_archive.cfm?SessionID=780 [accessed 2025-07-02]
- Hamilton AB, Finley EP. Qualitative methods in implementation research: an introduction. Psychiatry Res 2019 Oct;280(112516):112516. [doi: 10.1016/j.psychres.2019.112516] [Medline: 31437661]
- 31. Nvivo. version version 14. 2024. URL: <u>www.lumivero.com</u> [accessed 2025-07-02]
- Powell BJ, Waltz TJ, Chinman MJ, et al. A refined compilation of implementation strategies: results from the Expert Recommendations for Implementing Change (ERIC) project. Implement Sci 2015 Feb 12;10:21. [doi: 10.1186/s13012-015-0209-1] [Medline: 25889199]
- 33. Nallani R, Fox CC, Sykes KJ, et al. Pain management and education for ambulatory surgery: a qualitative study of perioperative nurses. J Surg Res 2021 Apr;260:419-427. [doi: <u>10.1016/j.jss.2020.11.001</u>] [Medline: <u>33256986</u>]
- 34. Pain management core competencies for prelicensure clinical education: an interprofessional consensus. American Association of Colleges of Nursing. URL: <u>https://www.aacnnursing.org/Portals/0/PDFs/CCNE/Pain-Management.pdf</u>
- 35. Fishman SM, Young HM, Lucas Arwood E, et al. Core competencies for pain management: results of an interprofessional consensus summit. Pain Med 2013 Jul;14(7):971-981. [doi: <u>10.1111/pme.12107</u>] [Medline: <u>23577878</u>]
- Herr K, Marie BS, Gordon DB, et al. An interprofessional consensus of core competencies for prelicensure education in pain management: curriculum application for nursing. J Nurs Educ 2015 Jun;54(6):317-327. [doi: 10.3928/01484834-20150515-02] [Medline: 26057425]

- Gumus K, Musuroglu S, Karaman Ozlu Z, Tasci O. Determining the use of nonpharmacologic methods by surgical nurses for postoperative pain management and the influencing professional factors: a multicenter study. J Perianesth Nurs 2020 Feb;35(1):75-79. [doi: 10.1016/j.jopan.2019.04.011] [Medline: 31521495]
- 38. Ayaz NP, Sherman DW. Understanding attitudes, social norms, and behaviors of a cohort of post-operative nurses related to pain and pain management. Healthcare (Basel) 2022 May 4;10(5):844. [doi: 10.3390/healthcare10050844] [Medline: 35627981]
- 39. He HG, Jahja R, Lee TL, et al. Nurses' use of non-pharmacological methods in children's postoperative pain management: educational intervention study. J Adv Nurs 2010 Nov;66(11):2398-2409. [doi: 10.1111/j.1365-2648.2010.05402.x] [Medline: 20722797]
- 40. He HG, Pölkki T, Vehviläinen-Julkunen K, Pietilä AM. Chinese nurses' use of non-pharmacological methods in children's postoperative pain relief. J Adv Nurs 2005 Aug;51(4):335-342. [doi: <u>10.1111/j.1365-2648.2005.03505.x</u>] [Medline: <u>16086802</u>]
- Pölkki T, Laukkala H, Vehviläinen-Julkunen K, Pietilä AM. Factors influencing nurses' use of nonpharmacological pain alleviation methods in paediatric patients. Scand J Caring Sci 2003 Dec;17(4):373-383. [doi: <u>10.1046/j.0283-9318.2003.00239.x</u>] [Medline: <u>14629640</u>]
- Alrimali AM, Al-Hamad NM, Almazeani FH, Alharbi MD. Nonpharmacological pain management practices among nurses working in multiple centers in Saudi Arabia: A cross-sectional study. Journal of Integrative Nursing 2023;5(4):292-299. [doi: <u>10.4103/jin.jin\_94\_23</u>]
- 43. Rababa M, Al-Sabbah S, Hayajneh AA. Nurses' perceived barriers to and facilitators of pain assessment and management in critical care patients: a systematic review. J Pain Res 2021;14:3475-3491. [doi: <u>10.2147/JPR.S332423</u>] [Medline: <u>34764688</u>]
- Mędrzycka-Dąbrowska W, Dąbrowski S, Basiński A. Problems and barriers in ensuring effective acute and post-operative pain management--an international perspective. Adv Clin Exp Med 2015;24(5):905-910. [doi: <u>10.17219/acem/26394</u>] [Medline: <u>26768644</u>]
- 45. Elcigil A, Maltepe H, Eşrefgil G, Mutafoglu K. Nurses' perceived barriers to assessment and management of pain in a university hospital. J Pediatr Hematol Oncol 2011;33(Supplement 1):S33-S38. [doi: 10.1097/MPH.0b013e3182121bef]
- Bauer BA, Townsend KM, Cutshall SM, et al. Advanced practice providers' knowledge, attitudes, and utilization of complementary and integrative medicine at an academic medical center. Altern Ther Health Med 2020 Sep;26(5):8-16. [Medline: <u>32663179</u>]

#### Abbreviations

CDS: clinical decision support CFIR: Consolidated Framework for Implementation Research EHR: electronic health record ERIC: Expert Recommendations for Implementing Change NOHARM: Nonpharmacologic Options in postoperative Hospital-based and Rehabilitation pain Management NPPC: nonpharmacological pain care TENS: transcutaneous electrical nerve stimulation

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# **Original Paper**

# Limited Moderating Effect of Podcast Listening on Work Stress and Emotional Exhaustion Among Nurses During the COVID-19 Pandemic: Cross-Sectional Study

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# Abstract

**Background:** The COVID-19 pandemic placed unprecedented pressure on health care systems worldwide, significantly impacting frontline health care workers, especially nurses. These professionals faced considerable psychological stress from caring for patients with COVID-19 and the fear of spreading the virus to their families. Studies report that more than 60% (132/220) of nurses experience anxiety, depression, and emotional exhaustion, which adversely affect their mental health and the quality of care they provide.

**Objective:** This study aimed to investigate the relationship between work-related stress and emotional exhaustion among nurses and to assess whether listening to podcasts moderates this association.

**Methods:** A cross-sectional online survey was conducted between March 1, 2023, and March 31, 2023. A total of 271 clinical nurses, aged 20 years to 65 years, were recruited for the study. Participants were divided into 2 groups: experimental group consisting of regular podcast listeners (n=173) and control group comprising nonlisteners (n=98). Ethical approval for this study was obtained from the local ethics committee (IRB number YGHIRB20230421B). Validated scales were used to measure work stress, emotional dissonance, and emotional exhaustion. Data analysis included descriptive statistics, independent *t* tests, and structural equation modeling to examine the relationships between variables.

**Results:** No statistically significant differences were found between the experimental and control groups in terms of overall work stress (mean difference=-0.09, 95% CI -0.31 to 0.13; P=.42) or emotional exhaustion (mean difference=0.07, 95% CI -0.15 to 0.29; P=.53). Emotional dissonance emerged as a significant predictor of emotional exhaustion in both the experimental ( $\beta=0.476$ , P<.001) and control ( $\beta=0.321$ , P=.01) groups. Nurses reporting higher workloads had significantly higher emotional exhaustion levels (experimental group:  $\beta=0.302$ , P<.001; control group:  $\beta=0.327$ , P=.002). Podcast listening demonstrated only a slight, nonsignificant moderating effect.

**Conclusions:** Although podcasts alone may not significantly reduce work stress or emotional exhaustion among nurses, there was a potential, albeit limited, moderating effect of podcasts on emotional well-being. They could serve as a supplementary tool for emotional support. However, broader and more comprehensive interventions are required to address the underlying causes of stress and emotional exhaustion in this population. More in-depth exploration and recommendations are possible by analyzing the content and patterns of listening. Further research is needed to examine the long-term benefits of integrating podcasts with other digital tools for holistic stress management in health care settings.

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#### KEYWORDS

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work stress; emotional exhaustion; podcasts; nurses; COVID-19; mental health

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# Introduction

#### **Background and Significance**

Following the initial outbreak in December 2019, the COVID-19 pandemic rapidly spread across the globe, resulting in a severe public health crisis. The pandemic imposed immense pressure on health care systems worldwide, particularly affecting frontline health care workers who bear significant responsibilities and endure substantial psychological stress. These health care workers made great sacrifices and contributions to combat the pandemic, yet they faced challenges such as nursing staff shortages, which had a profound impact on the global health care sector. Nurses were not only tasked with caring for patients with COVID-19 but also worried about transmitting the virus to their families, further exacerbating their psychological stress and adversely affecting their mental health [1].

#### Work Stress and Emotional Exhaustion Among Nurses

Studies indicate that more than 60% (132/220) of nurses experience anxiety, depression, and emotional exhaustion due to prolonged patient care, impacting both their physical and mental well-being, as well as the quality of patient care they provide [2]. For instance, research by Lai et al [3] revealed that 126 of 250 nurses (50.4%) exhibit symptoms of depression, 112 of 251 nurses (44.6%) experience anxiety, 85 of 250 nurses (34%) experience insomnia, and as many as 179 of 250 nurses (71.5%) report distress. These data highlight the issue of emotional exhaustion among nurses in high-pressure environments.

# The Potential Role of Digital Interventions in Stress Management

The mental health challenges faced by nurses have drawn attention to the need for strategies to improve their psychological well-being. Previous research has predominantly focused on improving work environments and workplace ethics, while few explored the efficacy of digital media interventions for managing stress within health care settings. These interventions range from mobile apps to web-based programs targeting diverse populations including adolescents, health care workers, and patients with cancer [4-7]. With the advancement of information and network technologies, new media tools such as podcasts have gained attention. Podcasts, as an unofficial platform that crosses institutional and organizational boundaries, offer anonymity and flexibility, making them a potential resource for helping nurses manage stress and emotions.

#### The Rise of Podcasts and Their Use in Health Care

With the progression of information and network technologies, podcasts have emerged as a popular form of media in Taiwan. In our survey, 201 of 250 participants (80.3%) reported using the internet to access online news or lifestyle information. Podcasts, although introduced in the early 2000s, gained substantial popularity during the COVID-19 pandemic and became part of the stay-at-home economy [8]. Due to a feeling of companionship and flexibility, podcasts have become a popular companion media format. A report by Commonwealth Magazine [9] indicated that most podcast listeners use podcasts

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for relaxation and entertainment, while programs like "Med persona" cater to the personal needs of health care professionals and inspire their professional development.

#### **Research Gap and Study Rationale**

Podcasts are becoming increasingly important for supporting the emotional health and resilience of nurses, especially in the face of the challenges posed by the COVID-19 pandemic. These podcast programs provide essential resources for health care professionals, offering guidance and shared experiences to help nurses cope with the emotional labor and psychological stress often encountered in their work. However, despite their growing popularity, there is limited empirical research investigating the actual effectiveness of podcasts in reducing work-related stress and emotional exhaustion among nurses. This study aimed to fill this research gap by systematically examining whether podcast listening can serve as a useful tool for emotional support and stress relief in nursing practice.

#### **Objectives and Research Questions**

The primary objective of this study was to investigate the impact of work-related stress on emotional exhaustion among nurses and to determine whether listening to podcasts can mitigate this effect. The study aimed to provide empirical evidence regarding the effectiveness of podcasts as a tool for emotional management and stress relief among nursing staff.

To achieve this objective, we focused on 2 main research questions: (1) Can listening to podcasts help nurses manage their emotions and alleviate work -related stress? and (2) Can podcasts modulate the level of emotional exhaustion among nurses?

By addressing these questions, the study aimed to gain a deeper understanding of the potential benefits of incorporating podcasts into stress management and emotional support programs for nurses, ultimately enhancing their overall well-being and job performance.

# Methods

#### **Study Design and Participants**

The study used convenience sampling to ensure the accuracy and reliability of the study results. The participants were clinical care providers aged between 20 years and 65 years. The participants were divided into 2 groups: experimental group consisting of nurses who regularly listened to podcasts and control group comprising nurses who did not listen to podcasts. This grouping facilitated a comparative analysis of the potential impact of podcast listening on alleviating work-related stress and emotional exhaustion among nurses.

Exclusion criteria included any hearing impairments, ensuring that the selected sample accurately met the study's requirements.

#### **Data Collection Procedures**

During the recruitment process, participants in the experimental group were introduced to the study via a recorded message played by podcast hosts. This message explained the study's purpose, objectives, and instructions for completing the questionnaire. Participants in the control group received the

same information in written form on the introduction page of the online survey platform. Participants were assured that their data would be used solely for research purposes, their privacy would be protected, and their participation was voluntary. They were informed their rights would not be affected if they chose not to participate. Those who agreed to participate were asked to sign a consent form and were then provided with a link to the online survey.

Data collection was conducted through a noninvasive online questionnaire. Participants were informed that they could withdraw from the study at any time if they felt uncomfortable. The questionnaire was administered by experienced researchers, and all responses were securely stored in a cloud database. Participants' identities were anonymized using research codes to protect their privacy, in compliance with personal data protection laws and relevant regulations.

If participants felt any discomfort while completing the questionnaire, they were allowed to terminate their participation at any time.

#### **Statistical Analysis**

During the study period, from March 1, 2023, to March 31, 2023, a total of 271 valid questionnaires were collected. The experimental group consisted of 173 nurses who regularly listened to podcasts, and the control group consisted of 98 nurses who did not listen to podcasts. The analysis focused on demographic attributes such as age, marital status, number of children, educational background, nursing experience, department, position, level of advancement, emotional disposition, and podcast listening habits.

This descriptive analysis provides a comprehensive overview of the demographic and occupational characteristics of the study participants, laying the foundation for further analysis of the relationships between these variables and the outcomes of interest.

# **Ethical Considerations**

All procedures of this study adhered to ethical guidelines. Contact information for the primary researcher and detailed instructions for submitting responses were provided. Informed consent was obtained from all participants, and all data were anonymized. No incentives nor rewards were offered. Ethical approval for this study was granted by the Yuan's General Hospital Ethics Committee (Institutional Review Board approval number: YGHIRB20230421B).

# Results

# **Participant Characteristics**

A total of 271 nurses participated in the study. Most participants were aged between 21 years and 39 years (187/271, 69%) and held a university-level education (221/271, 81.5%). The majority were unmarried (144/271, 53.1%), had no children (159/271, 58.7%), and had between 2 years and 20 years of nursing experience (205/271, 75.7%). Most held clinical nursing positions (229/271, 85.4%) and were distributed across various hospital departments, including the emergency department (22/271, 8.1%) and internal medicine (31/271, 11.4%) and surgical (54/271, 19.9%) wards. In terms of emotional disposition, most participants reported having a positive outlook (212/271, 78.2%). Among podcast listeners, the majority had been listening for less than 3 months (80/173, 46.1%). Detailed demographic information is presented in Table 1.



Table 1. Demographic data of the study participants (n=271).

Variable	Results, n (%)
Age (years)	
21-29	90 (33.2)
30-39	97 (35.8)
40-49	65 (24)
50-59	18 (6.6)
60-69	1 (0.4)
Marital status	
Unmarried	144 (53.1)
Married	121 (44.6)
Divorce	6 (2.2)
Widowed	0 (0)
Separated	0 (0)
Education	
Specialist	20 (7.4)
2-year junior college program	16 (5.9)
University	221 (81.5)
Master	13 (4.8)
PhD	1 (0.4)
Nursing experience (years)	
0-1	22 (8.1)
2-10	123 (45.4)
11-20	82 (30.3)
21-30	34 (12.5)
31-40	9 (3.3)
41-50	1 (0.4)
Number of children	
0	159 (58.7)
1	41 (15.1)
2	62 (22.9)
3	9 (3.3)
>4	0 (0)
Service department	
Outpatient department	47 (17.3)
Emergency Department	22 (8.1)
Operating room	19 (7)
Intensive Care Unit	39 (14.4)
Medical Ward	31 (11.4)
Surgical Ward	54 (19.9)
Obstetrics and gynecology	18 (6.6)
Pediatrics	1 (0.4)
Other single	40 (14.8)

Emotional personality

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Va	iable	Results, n (%)
	Positive emotions	212 (78.2)
	Negative emotions	59 (21.8)
Nu	rsing duties	
	Nurse	229 (84.5)
	Nursing team leader	18 (6.6)
	Deputy director of nursing	6 (2.2)
	Head nurse	17 (6.3)
	Nursing supervision	1 (0.4)
	Nursing director	0 (0)
Ad	vanced level	
	New staff	2 (0.7)
	<1 year of clinical work experience	25 (9.2)
	>1 year of clinical work experience, completed the first-year clinical competency training for nursing staff, and passed the review successfully	41 (15.1)
	>2 years of clinical work experience, completed the second-year clinical competency training for nursing staff, and passed the review successfully	142 (52.4)
	>3 years of clinical work experience, completed the third-year clinical competency training for nursing staff, and passed the nursing association's case report review successfully	38 (14)
	>4 years of clinical work experience, completed the fourth-year clinical competency training for nursing staff, and passed the nursing association's administrative project review successfully	23 (8.5)
Po	dcast listening habits (n= 173)	
	1 month	46 (26.6)
	3 months	34 (19.5)
	6 months	18 (10.4)
	1 year	24 (13.9)
	1-3 years	32 (18.5)
	3-5 years	13 (7.5)
	5-10 years	5 (2.8)
	>10 years	1 (0.6)

Age ( $\chi^2_4$ =49.158, *P*=.09; Table 2) and marital status ( $\chi^2_2$ =2.223, *P*=.33) were not significantly different between the experimental and control groups. The number of children was significantly different between the 2 groups ( $\chi^2_2$ =12.215, *P*=.007). In the experimental group (ie, nurses who regularly listen to podcasts), a higher proportion of participants were childless (61/98, 62%), whereas in the control group, a greater number of nurses had children (75/173, 43.4%). This difference may impact how nurses cope with work stress and experience emotional exhaustion, as studies have shown that nurses with children face additional family caregiving responsibilities, which may exacerbate their psychological stress. Additionally, since the number of children was a significant factor, it should be

considered in the interpretation of the results to avoid potential confounding effects. There were no significant differences between the groups in educational level ( $\chi^2_3$ =5.742, *P*=.22), nursing experience ( $\chi^2_4$ =36.885, *P*=.38), department ( $\chi^2_5$ =14.571, *P*=.07), position ( $\chi^2_2$ =1.911, *P*=.75), advancement level ( $\chi^2_2$ =2.058, *P*=.84), and emotional disposition ( $\chi^2_1$ =0.512, *P*=.47). Independent *t* tests revealed no significant differences between the experimental and control groups regarding workload ( $t_{269}$ =-.879, *P*=.51) and emotional exhaustion ( $t_{269}$ =0.295, *P*=.30). These findings suggest that podcast listening did not significantly affect the levels of work stress or emotional exhaustion among the nurses in this study (Tables 2 and 3).



Table 2. Comparison of the distribution of individual variables between the 2 groups.

Variables	Experimental group (n=98), n (%)	Control group (n=173), n (%)	$\chi^2 (df)$	P value
Age (years)			49.158 (4)	.09
21-29	41 (41.9)	49 (28.3)		
30-39	36 (36.7)	61 (35.3)		
40-49	16 (16.3)	49 (28.3)		
50-59	5 (5.1)	13 (7.5)		
60-69	0 (0)	1 (0.6)		
Marital status			2.223 (2)	.33
Unmarried	57 (58.2)	87 (50.3)		
Married	40 (40.8)	81 (46.8)		
Divorced	1 (1)	5 (2.9)		
Widowed	0 (0)	0 (0)		
Separated	0 (0)	0 (0)		
Number of children			12.215 (3)	.007
0	61 (62.2)	98 (56.6)		
1	21 (21.4)	20 (11.6)		
2	12 (12.2)	50 (28.9)		
3	4 (4.1)	5 (2.9)		
>4	0 (0)	0 (0)		
Education			5.742 (4)	.22
specialist	8 (8.2)	12 (6.9)		
2-year junior college program	7 (7.1)	9 (5.2)		
University	82 (83.7)	139 (80.3)		
Master	1 (1)	12 (6.9)		
PhD	0 (0)	1 (0.6)		
Nursing experience (years)			36.885 (5)	.38
0-1	12 (12.2)	10 (5.8)		
2-10	45 (46)	78 (45.1)		
11-20	32 (32.7)	50 (29)		
21-30	7 (7.1)	27 (15.6)		
31-40	2 (2)	7 (4)		
41-50	0 (0)	1 (0.5)		
Service department			14.571 (7)	.07
Emergency department	18 (18.4)	29 (16.8)		
Operating room	2 (2)	20 (11.6)		
Intensive care unit	8 (8.2)	11 (6.4)		
Medical ward	13 (13.3)	26 (15)		
Surgical ward	13 (13.3)	18 (10.4)		
Obstetrics and gynecology	25 (25.5)	29 (16.8)		
Pediatrics	9 (9.2)	9 (5.2)		
Other single	0 (0)	1 (0.6)		
Nursing duties			1.911 (3)	.75

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Va	riables	Experimental group (n=98), n (%)	Control group (n=173), n (%)	$\chi^2 (df)$	P value
	Nurse	85 (86.7)	144 (83.2)		
	Nursing team leader	7 (7.1)	11 (6.4)		
	Deputy director of nursing	2 (2)	4 (2.3)		
	Head nurse	4 (4.1)	13 (7.5)		
	Nursing supervision	0 (0)	1 (0.6)		
	Nursing director	0 (0)	0 (0)		
Ad	vanced level			2.058 (5)	.84
	New staff	1 (1)	1 (1)		
	<1 year of clinical work experience	11 (11.2)	14 (8.1)		
	>1 year of clinical work experience, completed the first-year clinical com- petency training for nursing staff, and passed the review successfully	17 (17.3)	24 (13.9)		
	>2 years of clinical work experience, completed the second-year clinical competency training for nursing staff, and passed the review successfully	50 (51)	92 (53.2)		
	>3 years of clinical work experience, completed the third-year clinical competency training for nursing staff, and passed the nursing association's case report review successfully	12 (12.2)	26 (15)		
	>4 years of clinical work experience, completed the fourth-year clinical competency training for nursing staff, and passed the nursing association's administrative project review successfully	7 (7.1)	16 (9.2)		
En	notional personality			0.512 (1)	.47
	Positive emotions (optimistic character)	79 (80.6)	133 (76.9)		
	Negative emotions (pessimistic character)	19 (19.4)	40 (23.1)		

Table 3. Comparison of emotional exhaustion between	1 the experimental	group and conti	ol group.
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Tests	Experimental group(n=98), mean (SD)	Control group(n=173), mean (SD)	P value
Workload	5.21 (1.11)	5.09 (1.13)	.51
Patients' or relatives' requirements	4.96 (1.19)	4.47 (1.30)	.39
Patient suffering	4.98 (1.11)	4.95 (1.25)	.24
Team collaboration problems	4.31 (1.09)	4.30 (1.12)	.80
Emotional dissonance	4.65 (1.38)	4.61 (1.30)	.77
Emotional exhaustion	4.80 (1.16)	4.78 (1.07)	.30

#### **Descriptive Statistics of Key Variables**

In this study, the primary contributors to emotional exhaustion among nursing staff included heavy workloads, difficult patient interactions, and the distress of witnessing patient suffering. Specifically, "too many patients to care for" was scored the highest, at a mean of 5.41, in the workload category, indicating that the large number of patients significantly increased work stress, leading to emotional dissonance and eventual exhaustion. In the category of patient and family demands, "communicating with difficult or demanding patients" received a mean score of 5.13, highlighting the challenges nurses faced with handling difficult communication, which further exacerbates emotional exhaustion. Additionally, "witnessing patient pain and suffering" received a mean score of 5.30, reflecting the emotional toll on nurses who felt powerless to alleviate patient suffering, resulting in emotional buildup and exhaustion.

Regarding team cooperation, "lack of recognition for career development" received a mean score of 4.58, suggesting that the lack of acknowledgment for professional growth contributes to burnout and diminished enthusiasm for advancing in the nursing profession. In terms of emotional dissonance, "my emotions displayed for professional reasons are not consistent with my true feelings" received a mean score of 4.69, showing how the need to suppress personal emotions to meet professional standards leads to negative emotional buildup and exhaustion. Finally, "I feel exhausted at the end of the workday" received the highest mean score, at 5.30, in the emotional exhaustion category, underscoring the intense pressure and stress nurses experienced daily, leading to significant emotional exhaustion (Table 4).

Table 4. Questionnaire content related to each variable.

Variables	Questionnaire content	Results, mean (SD) <sup>a</sup>	Dimension score, mean <sup>b</sup>
Workload			5.02
w1	Insufficient time to accomplish tasks	4.59 (1.33)	
w2	Too many patients	5.41 (1.27)	
w3	Being assigned too many different tasks	5.25 (1.19)	
w4	Lack of vacation time	4.87 (1.33)	
w5	Having so much work that everything cannot be done well	4.98 (1.27)	
Patients' a	and relatives' requirements		4.81
pr1	Dealing with difficult/demanding patients	5.13 (1.29)	
pr2	Dealing with difficult/demanding relatives	5.05 (1.39)	
pr3	Patients and/or family hostility or violence	4.59 (1.41)	
pr4	Lack of cooperation with the patient	4.74 (1.37)	
pr5	Conflict between the patient and their family	4.56 (1.40)	
Patient su	ffering		5.02
ps1	Seeing the physical pain and suffering in patients	5.30 (1.24)	
ps2	Physical deterioration in patients	5.22 (1.31)	
ps3	No therapeutic hope	4.79 (1.33)	
ps4	Worrying about patients' loneliness	4.92 (1.24)	
ps5	Being confronted with denial of the disease	4.89 (1.33)	
Team colla	aboration problems		4.35
tcp1	Lack of recognition for work well done	4.53 (1.27)	
tcp2	Experiencing conflicts with co-workers	4.14 (1.38)	
tcp3	Unpleasant colleagues	4.18 (1.257)	
tcp4	Disagreeing with physicians' practices	4.44 (1.26)	
tcp5	Poor communication between coworker	4.21 (1.283)	
tcp6	No reward for career development and advancement	4.58 (1.384)	
Emotional	l dissonance		4.61
ed1	The emotions that I feel in my job do not correspond to those Iwould like to feel.	4.57 (1.358)	
ed2	My work situation brings me to experience emotions different than those I would like to feel.	4.61 (1.374)	
ed3	I experience a discrepancy between the emotions I consider to be rofessional and what I feel.	4.57 (1.35)	
ed4	The emotions I show in order to be professional are not consistent with my inner feelings.	4.69 (1.413)	
Emotional	exhaustion		4.75
ee1	I feel used up at the end of the workday.	5.3 (1.18)	
ee2	I feel fatigued when I get up in the morning and have to face another day on the job.	5.28 (1.201)	
ee3	I've become more callous toward people since I took this job.	4.63 (1.345)	
ee4	Working with people directly puts too much stress on me.	4.53 (1.31)	
ee5	I feel recipients blame me for some of their problems.	4.59 (1.332)	
ee6	I feel frustrated by my job.	4.35 (1.267)	
ee7	Working with people all day is really a strain for me.	4.59 (1.337)	

<sup>a</sup>Based on the Lister 7-point method (possible score ranging from 1 to 7).

<sup>b</sup>Mean of all item scores within a specific dimension (eg, stress, satisfaction, emotional state).

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#### **Structural Equation Modeling and Partial Least Squares Results**

This study used partial least squares to assess the reliability and validity of the collected questionnaire data. The analysis focused on internal consistency, convergent validity, and discriminant validity to ensure the accuracy of the data. Reliability was evaluated using Cronbach  $\alpha$  and composite reliability. Both indicators demonstrated high reliability for all constructs, with Cronbach  $\alpha$  values exceeding 0.86 and composite reliability values greater than 0.89, indicating strong internal consistency. Convergent validity was assessed using factor loadings and average variance extracted (AVE). Factor loadings primarily aim to explore whether the predefined factor model aligns with the collected observational data. This process examines whether the number of factors and the factor loadings of the observed variables meet expectations, thus validating the model's

consistency with the empirical data. All item factor loadings were greater than 0.7, showing a strong relationship between items and their respective constructs. The AVE values were greater than 0.5, confirming that the constructs captured sufficient variance from their items. Discriminant validity was evaluated by comparing the square root of the AVE values with the correlations between constructs. All constructs exhibited good discriminant validity, with the square root of AVE exceeding the correlations between constructs, indicating that these constructs are distinct from one another (Tables 5-7).

To enhance the statistical interpretability of the correlations between constructs, we calculated the P values for the correlation coefficients presented in Table 7 using Pearson correlation analysis. As shown in Table 7, given the sample size of 271, all interconstruct correlations reached statistical significance (P<.001).



Table 5. Questionnaire aspects for factor loading.

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Questionnaire aspects (analysis code)	Factor loading
Workload	
w1	0.860
w2	0.896
w3	0.874
w4	0.925
Patients' and relatives' requirements	
pr1	0.915
pr2	0.913
pr3	0.938
pr4	0.924
pr5	0.925
Patient suffering	
ps1	0.904
ps2	0.930
ps3	0.901
ps4	0.915
ps5	0.909
Team collaboration problems	
tcp1	0.917
tcp2	0.906
tcp3	0.759
tcp4	0.931
tcp5	0.836
tcp6	0.882
Emotional dissonance	
ed1	0.964
ed2	0.969
ed3	0.973
ed4	0.937
Emotional exhaustion	
eel	0.785
ee2	0.802
ee3	0.891
ee4	0.879
ee5	0.884
ee6	0.899
ee7	0.880



Table 6. Reliability and validity of the questionnaire.

Questionnaire constructs	Cronbach $\alpha$	CR <sup>a</sup>	AVE <sup>b</sup>
ed <sup>c</sup>	0.972	0.973	0.923
ee <sup>d</sup>	0.947	0.948	0.741
pr <sup>e</sup>	0.959	0.961	0.852
ps <sup>f</sup>	0.950	0.951	0.832
tcp <sup>g</sup>	0.934	0.936	0.761
$\mathbf{w}^{\mathbf{h}}$	0.920	0.932	0.791

<sup>a</sup>CR: composite reliability.

<sup>b</sup>AVE: average variance extracted.

<sup>c</sup>ed: emotional dissonance.

<sup>d</sup>ee: emotional exhaustion.

<sup>e</sup>tcp: team collaboration problems.

<sup>f</sup>ps: patient suffering.

<sup>g</sup>pr: patients' and relatives' requirements.

<sup>h</sup>w: workload.

Table 7.	Discriminant	validity of the q	uestionnaire,	based on	Pearson r	correlation	values	(n=271).

Questionnaire constructs		ed <sup>a</sup>	ee <sup>b</sup>	pr <sup>c</sup>	ps <sup>d</sup>	tcp <sup>e</sup>	w <sup>f</sup>
ed							
	r	0.961	0.797	0.648	0.615	0.738	0.664
	<i>P</i> value	g	<.001	<.001	<.001	<.001	<.001
ee							
	r	0.797	0.861	0.628	0.561	0.760	0.745
	<i>P</i> value	<.001	_	<.001	<.001	<.001	<.001
pr							
	r	0.648	0.628	0.923	0.604	0.670	0.686
	<i>P</i> value	<.001	<.001	_	<.001	<.001	<.001
ps							
	r	0.615	0.561	0.604	0.912	0.536	0.503
	<i>P</i> value	<.001	<.001	<.001	_	<.001	<.001
Tcp	)						
	r	0.738	0.760	0.670	0.536	0.872	0.617
	<i>P</i> value	<.001	<.001	<.001	<.001	_	<.001
w							
	r	0.664	0.745	0.686	0.503	0.617	0.889
	<i>P</i> value	<.001	<.001	<.001	<.001	<.001	_

<sup>a</sup>ed: emotional dissonance.

<sup>b</sup>ee: emotional exhaustion.

<sup>c</sup>tcp: team collaboration problems.

<sup>d</sup>ps: patient suffering.

<sup>e</sup>pr: patients' and relatives' requirements.

<sup>f</sup>w: workload.

<sup>g</sup>Not applicable.

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## Discussion

# The Impact of Emotional Dissonance on Emotional Exhaustion

The findings support the hypothesis that emotional dissonance leads to emotional exhaustion among nursing staff, which is consistent with previous research showing that emotional dissonance depletes emotional resources and contributes to burnout.

# The Impact of Work-Related Factors on Emotional Dissonance

Workload had a significant positive effect on emotional dissonance in the control group ( $t_{269}$ =2.257, P=.02) but not in the experimental group ( $t_{269}$ =1.467, P=.14). Patient and family demands did not significantly affect emotional dissonance in either group. Caring for patients who were suffering showed a marginal effect in the experimental group ( $t_{269}$ =1.948, P=.051) but was not significant in the control group. Teamwork issues significantly influenced emotional dissonance in both groups ( $t_{269}$ =5.925, P≤.001)

# The Impact of Work-Related Factors on Emotional Exhaustion

Workload significantly impacted emotional exhaustion in both groups (experimental group:  $t_{269}$ =4.283, *P*<.001; control group:  $t_{269}$ =3.082, *P*=.002). The effects of patient and family demands and caring for suffering patients were not significant. Teamwork issues were significantly associated with emotional exhaustion in both groups (experimental:  $t_{269}$ =2.239, *P*=.03; control:  $t_{269}$ =2.522, *P*=.01).

# Moderating Effects of Listening to Podcasts on Work-Related Factors

None of the hypothesized moderating effects of podcast listening were statistically significant. The effects of workload, patient and family demands, caring for patients who are suffering, teamwork issues, and emotional dissonance on emotional exhaustion were not significantly moderated by podcast use (all P values >.05).

The model explained a substantial portion of the variance in emotional dissonance (experimental:  $R^2=0.618$ ; control:  $R^2=0.629$ ) and emotional exhaustion (experimental:  $R^2=0.731$ ; control:  $R^2=0.711$ ), but podcast listening did not significantly moderate the relationships among the studied variables (Table 8).

#### Table 8. Path coefficients.

Hypotheses	Experime	Experimental group Hypothesis Control group supported?				Hypothesis supported?		
	Path co- efficient	t (df)	P value		Path co- efficient	t (df)	P value	
Emotional dissonance and emotional exhaus- tion	0.476	6.427 (269)	<.001	Yes	0.321	2.583 (269)	.01	Yes
Patients' and relatives' requirement and emo- tional dissonance	0.123	1.135 (269)	.26	No	0.113	0.660 (269)	.51	No
Patient suffering and emotional dissonance	0.173	1.948 (269)	.051	Yes	0.179	1.403 (269)	.16	No
Team collaboration problems and emotional dissonance	0.507	5.925 (269)	<.001	Yes	0.348	2.961 (269)	.003	Yes
Workload and emotional dissonance	0.125	1.467 (269)	.14	No	0.299	2.257 (269)	.02	Yes
Patients' and relatives/ requirements and emo- tional exhaustion	-0.004	0.044 (269)	.97	No	-0.021	0.167 (269)	.87	No
Patient suffering and emotional exhaustion	0.045	0.853 (269)	.39	No	0.047	0.490 (269)	.32	No
Team collaboration problems and emotional exhaustion	0.168	2.239 (269)	.03	Yes	0.293	2.522 (269)	.01	Yes
Workload and emotional exhaustion	0.302	4.283 (269)	<.001	Yes	0.327	3.082 (269)	.002	Yes

#### **Emotional Dissonance and Emotional Exhaustion**

This study found a significant positive correlation between emotional dissonance and emotional exhaustion among nursing staff. Specifically, as emotional dissonance increases, so does the risk of emotional exhaustion. This pattern was observed in both the experimental group (nurses who regularly listened to podcasts) and control group (nurses who did not listen to podcasts). However, the emotional dissonance levels were slightly lower in the experimental group, suggesting that listening to podcasts may have a mild mitigating effect. The data showed that emotional dissonance is a significant predictor of emotional exhaustion. These findings are consistent with previous research, confirming that emotional dissonance depletes emotional resources, ultimately leading to emotional exhaustion among nursing staff.

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# Workload, Emotional Dissonance, and Emotional Exhaustion

The results indicated significant positive correlations between workload and both emotional dissonance and emotional exhaustion. High workloads increased the risk of these outcomes, especially for nurses who did not listen to podcasts. In the experimental group, the path coefficient for the impact of workload on emotional dissonance was 0.125 ( $t_{269}$ =1.467, P=.14), which was not significant, while in the control group, it was 0.299 ( $t_{269}$ =2.257, P=.02), indicating a significant effect. Similarly, the path coefficients for the impact of workload on emotional exhaustion were 0.302 ( $t_{269}$ =4.283, P<.001) in the experimental group and 0.327 ( $t_{269}$ =3.082, P=.002) in the control group. These findings suggest that, although podcasts may help alleviate some stress, they are not sufficient to prevent emotional exhaustion under high workload conditions.

#### **Patient and Family Demands**

The impact of patient and family demands on emotional dissonance and emotional exhaustion was minimal. Neither the experimental nor control group exhibited significant effects from these demands. For emotional dissonance, the path coefficient was 0.123 ( $t_{269}$ =0.135, P=.26) in the experimental group and 0.113 ( $t_{269}$ =0.660, P=.51) in the control group. For emotional exhaustion, the coefficients were -0.004 ( $t_{269}$ =0.044, P=.97) in the experimental group and -0.021 ( $t_{269}$ =0.167, P=.87) in the control group. This suggests that the professional skills and emotional management strategies of nursing staff effectively mitigate the impact of patient and family demands.

#### **Caring for Patients Who Are Suffering**

In the experimental group, caring for patients who are suffering had an almost significant impact on emotional dissonance (path coefficient 0.173;  $t_{269}$ =1.948, P=.051), but it was not significant in the control group (path coefficient 0.179;  $t_{269}$ =1.403, P=.16). However, its impact on emotional exhaustion was not significant in either group. This suggests that, although caring for patients who are suffering may lead to emotional dissonance, it does not necessarily result in emotional exhaustion, possibly due to effective emotional management and professional support systems.

#### **Teamwork Issues**

Teamwork issues showed a significant positive correlation with both emotional dissonance and emotional exhaustion. In the experimental group, the path coefficient for emotional dissonance was 0.507 ( $t_{269}$ =5.925, P<.001), and for emotional exhaustion, it was 0.168 ( $t_{269}$ =2.239, P=.03). In the control group, the coefficients were 0.348 ( $t_{269}$ =2.961, P=.003) and 0.293 ( $t_{269}$ =2.522, P=.01), respectively. These results indicate that issues such as poor communication and conflict within teams significantly increase stress, leading to emotional dissonance and exhaustion.

#### Podcasts as a Moderating Factor

The study explored whether listening to podcasts could mitigate the effects of workload, patient demands, caring for patients

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who are suffering, and teamwork issues on emotional dissonance and exhaustion. However, the moderating effects of podcasts were generally not significant. For example, in the experimental group, the moderation of the impact of workload on emotional dissonance (P=.14) was not significant. Similarly, podcasts did not significantly reduce the impact of patient demands or teamwork issues on emotional exhaustion.

#### **Comparison With Previous Work**

This study builds on existing research that has explored the relationship between emotional dissonance, workload, and emotional exhaustion among health care professionals. Previous studies, such as those by Bakker and Heuven [10] and Diestel and Schmidt [11], established a significant link between emotional dissonance and emotional exhaustion, highlighting the harmful effects of emotional labor on health care workers. Our findings confirm these studies, showing that emotional dissonance is a key predictor of emotional exhaustion in nursing staff. However, our research adds a new dimension by examining the potential moderating role of podcast listening in this relationship. Although the impact of emotional dissonance on exhaustion remains substantial regardless of podcast use, the slight alleviation observed in the experimental group suggests that podcasts may offer some emotional relief, an aspect not explored in earlier studies.

In terms of workload, our findings align with the existing literature, emphasizing the stress induced by high workloads in health care professionals. Studies by Glasberg et al [12] and Garrosa et al [13] highlighted that heavy workloads bring immense stress, leading to emotional exhaustion. Our study confirms these findings but also introduces the novel consideration of podcasts as a potential buffer. However, the effects of podcasts were insufficient and did not counteract the overwhelming impact of high workloads, suggesting the need for more comprehensive interventions.

Furthermore, unlike previous studies that mainly focused on the direct effects of patient demands and teamwork issues on emotional health, our study investigated these factors in the context of podcast use. Although the impact of patient demands on emotional dissonance and exhaustion was minimal, teamwork issues were found to have a significant impact, consistent with prior research. However, the moderating role of podcasts in mitigating these effects was limited, offering a nuanced understanding of the boundaries of digital media interventions in high-stress work environments.

#### Factors Influencing the Study Results

The findings of this study indicate that the number of children the nurses had significantly differed between the 2 groups (P=.007), which may influence the interpretation of work stress and emotional exhaustion outcomes. Previous research has suggested that nurses with children may have heavier family responsibilities, leading to differences in their stress adaptation and emotional regulation compared with those without children. Particularly during the COVID-19 pandemic, nurses not only faced clinical stress but also the combined burden of childcare, household responsibilities, and health care duties, which could further contribute to increased emotional exhaustion.

However, we did not conduct a subgroup analysis to explore the impact of the number of children on the moderating effect of podcast listening. Therefore, future research should consider incorporating this variable into the model and using multivariate regression analysis or moderation effect analysis to control for potential confounding factors, ensuring the accuracy of study results.

#### **Strengths and Limitations**

#### Strengths

This study has several strengths, including innovative use of podcasts, comprehensive analyses, and the ability to apply the findings in a practical setting.

This study is among the first to explore the use of podcasts as a tool for emotional support and stress management among nursing staff. By incorporating emerging digital media tools, the research offers new insights into how health care professionals can leverage technology to improve their emotional well-being. Regarding the analysis, the study thoroughly examines multiple sources of stress, including emotional dissonance, workload, patient demands, and teamwork issues, providing a holistic view of the factors leading to emotional exhaustion in nursing. The findings also have direct implications for health care institutions and policymakers, suggesting practical measures such as integrating podcast programs into emotional support strategies for nursing staff. Nevertheless, the generalizability of these findings to a broader nursing population should be interpreted with caution and warrants further validation in diverse clinical settings.

#### Limitations

At the same time, the study had some limitations, including sample representativeness, its cross-sectional design, the use of self-reported data, variations in podcast content and listening patterns by the participants, a potential lack of generalizability due to the cultural and linguistic context, and differences in the number of children the nurses had between the groups.

The study's sample was limited to specific regions and health care institutions, which may affect the sample representativeness and restrict the generalizability of the findings. Different regions or types of health care institutions may have varying stressors and coping mechanisms. Additionally, the accessibility and adoption of digital interventions such as podcasts may differ across health care settings, further impacting the applicability of the results.

This cross-sectional study was conducted at a single point in time, making it challenging to capture the dynamic nature of stress and emotional exhaustion over time. Therefore, the long-term impact of podcast use on emotional well-being could not be assessed. Future longitudinal studies are needed to examine whether continued engagement with podcasts can lead to sustained emotional support and stress reduction among health care professionals.

The reliance on self-reported data introduces the possibility of subjective biases, such as social desirability or recall bias, which may affect the accuracy of the results. Participants may have provided responses based on perceived expectations rather than

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their actual experiences. Additionally, objective measures, such as physiological indicators of stress (eg, cortisol levels, heart rate variability), were not included, limiting the study's ability to validate findings through biometric data.

The study did not account for the variation in podcast content, format, duration, and listening frequency, all of which could influence the results. Different types of podcasts may have varying effects on emotional support and stress reduction. For instance, content focused on relaxation techniques or peer support may provide stronger psychological benefits than general entertainment podcasts. Furthermore, the study did not assess individual differences in podcast engagement, such as the extent to which participants actively absorbed content versus using it as background noise. Future research should consider categorizing podcast types and evaluating their differential effects on emotional well-being.

The study was conducted in Taiwan, and cultural factors may influence how caregivers perceive stress and use podcasts. In collectivist cultures like Taiwan, social and familial expectations may shape nurses' stress coping strategies differently than in individualistic cultures. Additionally, the availability of health-related podcasts in the local language may affect accessibility and engagement. The effectiveness of podcasts as an emotional support tool may vary depending on cultural attitudes toward digital health interventions and professional well-being. As a result, the findings may not be directly applicable to different cultural settings, and cross-cultural comparisons would be beneficial in future studies.

One of the limitations of this study was the significant difference in the number of children that nurses had between the groups, which may affect the internal validity of the research findings. Since nurses with children may experience higher levels of stress and emotional exhaustion, this factor should be considered when interpreting the results to account for its potential impact on the study findings. Future research may consider conducting subgroup analyses to explore the effects of varying family responsibilities on the moderating effect of podcast listening.

Additionally, the cross-sectional design limits the ability to infer causality. Future studies are recommended to adopt a longitudinal approach to further examine the long-term impact of podcast listening on emotional exhaustion.

#### **Future Research Directions**

Therefore, future research should consider longitudinal study designs, expanding the sample diversity, analyzing podcast content, conducting comparative studies across health care professions, integrating podcasts with other digital tools, and conducting cross-cultural comparisons.

Longitudinal designs with sufficient time duration could track the impact of podcast use on emotional well-being over time. Furthermore, future longitudinal studies could help better understand the long-term impact of the variables examined in our research. This approach would help determine the long-term benefits or drawbacks of integrating podcasts into emotional support programs for health care professionals.

To enhance the generalizability of the findings, future studies should include more diverse samples, covering different regions, health care environments, and cultural contexts. This would provide a broader understanding of how podcasts can be utilized across various settings.

Future research should also analyze the specific content and quality of the podcasts used by health care professionals. Understanding which types of content are most effective in reducing stress and emotional exhaustion could lead to more targeted and effective podcast programs.

Exploring the use of podcasts across different health care professionals (eg, doctors, pharmacists, physical therapists) could reveal how podcast interventions can be customized to address the unique stressors faced by each group.

Combining podcasts with other digital tools (eg, mobile health apps or online counseling platforms) could create a more comprehensive emotional support system for health care workers. Future research should explore the synergies of using multiple digital resources for stress management.

Comparative studies between different countries and cultures would help determine how cultural factors influence the acceptance and effectiveness of podcasts as a stress management tool. This could lead to more culturally sensitive interventions in global health care settings.

#### Conclusion

This study highlights the significant impact of work-related stress on emotional exhaustion among nursing staff and explores the potential of podcasts as a digital intervention to mitigate these effects. The findings indicate a strong association between higher work stress and increased emotional exhaustion, which poses critical challenges for both the well-being of nursing professionals and the quality of patient care. However, the findings of this study also suggests that regular engagement with podcasts, particularly those focused on emotional management and stress relief, may provide a beneficial coping mechanism, contributing to reduced emotional exhaustion among nurses.

The results provide evidence supporting the integration of podcasts as a supplementary psychological support tool within health care institutions. By incorporating digital mental health interventions such as podcasts, institutions can offer accessible and flexible psychological support, ultimately improving job satisfaction, emotional resilience, and overall well-being among nursing staff. Additionally, the study underscores the need for policy initiatives to actively promote and support digital interventions aimed at improving the mental health and professional development of health care workers.

Despite these insights, certain limitations must be acknowledged. The study identified a significant difference in the number of children between groups, which may influence stress coping mechanisms and the moderating effect of podcast listening. Future research should control for this variable to ensure an accurate evaluation of podcast interventions. Moreover, although podcasts may serve as a viable supplementary intervention, their moderating effect remains limited, indicating the need for further exploration into comprehensive psychological support strategies.

Future studies should investigate the long-term effects of podcast engagement, assess its efficacy across diverse health care settings and cultural contexts, and explore potential synergies with other digital or traditional psychological support programs. The integration of podcasts and similar digital tools represents a promising avenue for enhancing the psychological support systems available to nursing professionals, potentially improving health care outcomes and bolstering the resilience of the health care workforce.

#### **Conflicts of Interest**

None declared.

#### References

- Chang I, Cheng W, Kung W. A stress relief app intervention for newly employed nursing staff: quasi-experimental design. JMIR Mhealth Uhealth 2019 Dec 18;7(12):e15785 [FREE Full text] [doi: 10.2196/15785] [Medline: 31850848]
- Babapour A, Gahassab-Mozaffari N, Fathnezhad-Kazemi A. Nurses' job stress and its impact on quality of life and caring behaviors: a cross-sectional study. BMC Nurs 2022 Mar 31;21(1):75 [FREE Full text] [doi: 10.1186/s12912-022-00852-y] [Medline: 35361204]
- Lai J, Ma S, Wang Y, Cai Z, Hu J, Wei N, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. JAMA Netw Open 2020 Mar 02;3(3):e203976 [FREE Full text] [doi: 10.1001/jamanetworkopen.2020.3976] [Medline: 32202646]
- 4. Sîrbu V, David OA. Efficacy of app-based mobile health interventions for stress management: a systematic review and meta-analysis of self-reported, physiological, and neuroendocrine stress-related outcomes. Clin Psychol Rev 2024 Dec;114:102515. [doi: 10.1016/j.cpr.2024.102515] [Medline: 39522422]
- Boucher EM, Ward H, Miles CJ, Henry RD, Stoeckl SE. Effects of a digital mental health intervention on perceived stress and rumination in adolescents aged 13 to 17 years: randomized controlled trial. J Med Internet Res 2024 Mar 29;26:e54282 [FREE Full text] [doi: 10.2196/54282] [Medline: 38551617]
- Agarwal AK, Southwick L, Gonzales RE, Bellini LM, Asch DA, Shea JA, et al. Digital engagement strategy and health care worker mental health: a randomized clinical trial. JAMA Netw Open 2024 May 01;7(5):e2410994 [FREE Full text] [doi: 10.1001/jamanetworkopen.2024.10994] [Medline: 38787562]

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- Zhang Y, Flannery M, Zhang Z, Underhill-Blazey M, Bobry M, Leblanc N, et al. Digital health psychosocial intervention in adult patients with cancer and their families: systematic review and meta-analysis. JMIR Cancer 2024 Feb 05;10:e46116 [FREE Full text] [doi: 10.2196/46116] [Medline: 38315546]
- 8. Huang C, Chung J. Podcast programs more than doubled this year: survey. Taipei Times. 2020 Sep 06. URL: <u>https://www.taipeitimes.com/News/taiwan/archives/2020/09/06/2003742905</u> [accessed 2024-05-20]
- Kiernan MA, Mitchell BG, Russo PL. The power of podcasts: Exploring the endless possibilities of audio education and information in medicine, healthcare epidemiology, and antimicrobial stewardship. Antimicrob Steward Healthc Epidemiol 2023 Jun 05;3(1):e98 [FREE Full text] [doi: 10.1017/ash.2023.178] [Medline: 37325680]
- 10. Bakker AB, Heuven E. Emotional dissonance, burnout, and in-role performance among nurses and police officers. International Journal of Stress Management 2006 Nov;13(4):423-440. [doi: 10.1037/1072-5245.13.4.423]
- 11. Diestel S, Schmidt K. Costs of simultaneous coping with emotional dissonance and self-control demands at work: results from two German samples. J Appl Psychol 2011 May;96(3):643-653. [doi: 10.1037/a0022134] [Medline: 21142345]
- Glasberg AL, Eriksson S, Norberg A. Burnout and 'stress of conscience' among healthcare personnel. J Adv Nurs 2007 Feb;57(4):392-403. [doi: 10.1111/j.1365-2648.2007.04111.x] [Medline: 17291203]
- Garrosa E, Moreno-Jiménez B, Rodríguez-Muñoz A, Rodríguez-Carvajal R. Role stress and personal resources in nursing: a cross-sectional study of burnout and engagement. Int J Nurs Stud 2011 Apr;48(4):479-489. [doi: <u>10.1016/j.ijnurstu.2010.08.004</u>] [Medline: <u>20828694</u>]

#### Abbreviations

**AVE:** average variance extracted

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**Original Paper** 

# Clinical, Operational, and Economic Benefits of a Digitally Enabled Wound Care Program in Home Health: Quasi-Experimental, Pre-Post Comparative Study

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# Abstract

**Background:** The demand for home health care and nursing visits has steadily increased, requiring significant allocation of resources for wound care. Many home health agencies operate below capacity due to clinician shortages, meeting only 61% to 70% of demand and frequently declining wound care referrals. Implementing artificial intelligence–powered digital wound care solutions (DWCSs) offers an opportunity to enhance wound care programs by improving scalability and effectiveness through better monitoring and risk identification.

**Objective:** This study assessed clinical and operational outcomes across 14 home health branches that adopted a DWCS, comparing pre- and postadoption data and outcomes with 27 control branches without the technology.

**Methods:** This pre-post comparative study analyzed clinical outcomes, including average days to wound healing, and operational outcomes, such as skilled nursing (SN) visits per episode (VPE) and in-home visit durations, during two 7-month intervals (from November to May in 2020-2021 and 2021-2022). Data were extracted from 14,278 patients who received wound care across adoption and control branches. Projected cost savings were also calculated based on reductions in SN visits.

**Results:** The adoption branches showed a 4.3% reduction in SN VPE and a 2.5% reduction in visit duration, saving approximately 309 staff days. In contrast, control branches experienced a 4.5% increase in SN VPE and a 2.2% rise in visit duration, adding 42 days. Healing times improved significantly in the adoption branches, with a reduction of 4.3 days on average per wound compared to 1.6 days in control branches (P<.001); pressure injuries, venous ulcers, and surgical wounds showed the most substantial improvements.

**Conclusions:** Integrating digital wound management technology enhances clinical outcomes, operational efficiencies, and cost savings in home health settings. A reduction of 0.3 SN VPE could generate annual savings of up to US \$958,201 across the organization. The adoption branches avoided 1187 additional visits during the study period. If control branches had implemented the DWCS and achieved similar outcomes, they would have saved 18,546 healing days. These findings emphasize the importance of incorporating DWCSs into wound care programs to address increasing demands, clinician shortages, and rising health care costs while maintaining positive clinical outcomes.

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#### **KEYWORDS**

home health care; artificial intelligence; AI; digital wound care; wound assessment; operational efficiency; clinical outcomes; healing time; cost saving; skilled nursing visits

## Introduction

The demand for home health care and nursing visits has surged due to the persistent rise in the prevalence of comorbidities and the aging population [1,2]. In the United States, 2% of the population have complex chronic wounds, further driving the growing demand for home health care services [3]. Approximately, a third of patients who use home health have at least one wound [4,5], leading to the allocation of a substantial portion of the budget and resources in a home health agency (HHA) for nursing visits being dedicated to wound assessment and care [5]. Nursing visits in HHAs consume a significant proportion of health care delivery costs, primarily due to the time spent by nurses in assessing and managing wounds [6]. Studies have indicated that wound management uses, on average, about 50% to 70% of the nurses' resources [7-11], with over 60% of their time dedicated to changing dressings [12], resulting in an average of extra 3 visits per week [7].

According to the 2019 report from the Centers for Medicare & Medicare Services (CMS), 1.6% of the US population received wound care at a Medicare-certified HHA, totaling 5,266,931 individuals with wounds [13]. This suggests that approximately 15,800,793 patient contacts for dressing changes occur per week, requiring around 7,900,396 clinician hours per week to be spent on wound care visits in HHAs [13]. Research supports the notion that effective wound care team [14]. However, the absence of a standardized approach to evaluating wounds and the limited communication platforms for supporting collaboration between clinicians may lead to unnecessary or prolonged visits and extended healing times [15].

Research studies have reported that wounds, especially pressure injuries, pose the highest risk factor for hospitalization, increasing the length of stay by an average of 4.31 days [16,17]. Thus, with 1 in 3 patients who use home health dealing with wounds, a focus on providing higher-quality, more efficient care for patients with wounds has the potential to lead to faster healing and reduced complications for patients, as well as a substantial cost savings and improved reimbursement for HHAs and the health care system.

The increasing number of visits, visit duration, healing time for wounds, and hospital stays have placed a significant burden on the already financially stained health care system, compounded by a shortage of specialized nurses [18]. The majority of HHAs operate below capacity due to clinician shortage, only meeting 61% to 70% of the demand for wound care, leading many to reject wound care referrals [19,20]. This crisis is partly due to inadequate allocation of resources, funding constraints at the organizational level, and the increasing number of nurses leaving the practice or retiring [18]. Thus, addressing the substantial resource demand for managing chronic wounds poses a significant challenge for these agencies [5].

In light of these challenges, it remains crucial to control costs while optimizing outcomes within the health care system. Recognizing the high complexity and resource costs of providing wound care in home health, the CMS allocated the highest base reimbursement for the wound clinical grouping under its Patient Driven Groupings Model value–based payment regime, which was rolled out nationwide in 2020 [13]. Additionally, to address the sustainable health care costs associated with unintended hospital use (such as acute care hospitalizations and emergency department visits), CMS introduced its Expanded Home Health Value-Based Purchasing Model in 2023. This program adjusts an HHA's annual Medicare reimbursement based on the achievement of various quality measures, with the most heavily weighted measure being "unintended hospital use."

Using a digital wound care solution (DWCS) for patients with wounds has been linked to faster healing times [21] and more efficient wound care documentation [22]. DWCSs integrate artificial intelligence (AI) to monitor wound progress and identify potential risks [23], and they are interoperable with organizational systems, allowing efficient and secure data exchange. The seamless data exchange through AI technologies [24] is crucial for establishing a cohesive wound care program that can adopt and scale up digital documentation and objective AI assessment data. Recognizing these benefits, many health care settings have transitioned to incorporating digital technologies to enhance clinician efficiency, capacity, and confidence, ultimately allowing them to deliver a higher quality of care to more who require wound care [21,22,25].

In 2021, CenterWell Home Health (CenterWell), an HHA with 355 branches across 40 states in the United States, launched a comprehensive wound care program to deliver high-quality care. The program involved providing advanced education and training for clinicians in wound management and using the DWCS Swift Skin and Wound (Swift Medical Inc) for quality wound care evaluations. The training program, known as Prevention Intervention, Management, and Education (PRIME), was designed to build the knowledge, skills, and abilities of clinicians in wound care, establishing a network of skilled wound care champions in the field. The DWCS is an evidence-aligned, AI-based technology that captures precise wound images and accurate measurements and provides predictive analytics supporting the wound escalation processes to provide ongoing performance support.

There is a lack of research evaluating the impact of integrating technology into wound care delivery within a home health setting. To our knowledge, this study represents the first attempt to outline the clinical and operational advantages of a wound care program incorporating digital technology in a home health environment. The study's objective was to evaluate the enhancements in clinical outcomes (such as the average time required to heal a wound) and operational outcomes (including the volume of skilled nursing [SN] visits per episode [VPE] and the duration of in-home SN visits) at 14 CenterWell branches



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(initially scoped for this implementation and study). We examined the same 7-month period (from November to May) before (2020) and after (2021) the implementation of the DWCS as part of the comprehensive wound care model in home health. Additionally, the study compared the changes in these clinical and operational benefits with a similar control group of PRIME-certified home health branches that had not yet adopted the digital solution.

# Methods

#### **Study Design and Data Sources**

This benefits-evaluation study used a pre-post comparative design, using wound care data captured in the Homecare Homebase (HCHB) health information system. HCHB is an electronic medical record (EMR) software developed in 1999. This software is hosted on the cloud and is designed to facilitate home health care frontline workers' abilities to monitor their clinical outcomes and operational activities to enhance the quality of patient care.

Through the HCHB platform, a home health organization can extract a wide range of clinical and administrative data. These include admission and referral data; patient assessment details such as start date of wound care, 60-day episode start and end dates, wound types and stages; as well as the date and time of visits within the 60-day episode. Additionally, it can retrieve information about the discipline and service code of clinicians conducting the visits, discharge dates, hospitalization details, patients' demographics, comorbidities, and payer types. The study's focus was to extract structured data that pertain to the comprehensive management of patients with wounds. This involved filtering the data within the study periods to include records of patients with wounds in the Integumentary Command Center (ICC).

#### **Ethical Considerations**

In this study, for the postadoption data, the DWCS used industry-standard protocols; for example, using Health Level 7 to wirelessly transfer encrypted wound care information (wound images and documentation recorded by clinicians at the participating branches using the solution) bidirectionally with HCHB in real time to ensure that outcome data could be monitored and to eliminate double documentation. Wound care data were then accessed from the EMR for tracking and analysis. All communications to the servers follow the Advanced Encryption Standards and comply with the Health Insurance Portability and Accountability Act.

Institutional review board approval was provided by CenterWell HealthCare Center for this quality improvement (QI) descriptive evaluation study. This QI study, which adheres to Tri Council Policy Statement QI policy, was granted an exemption of ethics review (ID:2023-0100) from Pearl IRB, LLC, an independent institutional review board.

#### **Data Abstraction Process and Sample**

The anonymous wound care assessment records were collected from the ICC, an entity focused on the comprehensive management of patients with wounds, at 14 CenterWell branches

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where the DWCS was implemented as part of the comprehensive wound care model. Additionally, records were obtained from 27 control branches at CenterWell that had not yet adopted the DWCS into practice. The 27 control branches were carefully selected to match the criteria of the adoption branches in terms of size; geographical locations; capacity; volume of referrals; and the clinicians' levels of clinical wound care education, training, skills, and expertise. This rigorous selection process aimed to ensure an unbiased comparison when assessing the impact of the DWCS technology on clinical and operational outcomes.

This study compared the change in clinical outcomes by analyzing the median days to heal a wound in the pre- and postadoption periods within the study timeframe for the 14 adoption sites and the 27 control sites. Additionally, operational outcomes were compared, including the number of SN VPE, the associated projected cost-savings, and the duration of in-home SN visits in the same periods for the adoption and control branches.

The study and analysis included wound assessments of all patients with any type of wound that met the following criteria:

- 1. There were wound records (primary and secondary diagnoses) of any type recorded on admission from both adoption and control branches at CenterWell that were referred to and managed at these sites during the 7-month study period (from November 1, 2020, to May 31, 2021, and from November 1, 2021, to May 31, 2022).
- 2. For the postadoption period, wounds had to be assessed and managed using the Swift Medical Inc solution at the participating 14 adoption branches in the postadoption period.
- 3. The records pertained to adult patients aged 18 years or older.

Any wounds outside of the study period were excluded from the analysis. Patients at adoption branches who did not receive wound care using the technology during the study period were not included in the analysis in the postadoption period. This exclusion applied to patients with closed surgical wounds, external fixators, bruising, cellulitis, and extensive diffuse dermatological conditions.

From the 14 adoption branches, we collected and included data from 5239 sixty-day wound episodes involving 3738 unique patients in 2020-2021 (preadoption period) and 3958 sixty-day wound episodes involving 2757 unique patients in 2021-2022 (postadoption period). Similarly, for the 27 control branches, the analysis incorporated data from 5592 sixty-day episodes involving 3859 unique patients in 2020-2021 (preadoption period) and 5429 sixty-day episodes involving 3924 unique patients in 2021-2022 (postadoption period).

The organization's wound care research team (KJ, DG, and KC) independently extracted all required wound patient data for the adoption and control branches based on the wound start data and medical record number from the HCHB EMR during the first week of August 2022. Using the same instrument, filters, steps, and procedures, the eligible wound data were accessed and then deidentified for sharing with the evaluation team (HTM

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and DM) for analysis. Each patient was assigned a study and episode ID number, with no linkage between the medical record number and study ID developed to ensure patient anonymity.

The deidentified data, including essential wound assessment–related variables such as patients' characteristics, episode ID, referral date, branch code, type of wound, classification and anatomical location of wound, wound care start date and effective date of care, start and end dates of episode, wound status, primary diagnosis, visit start date and time, visit end time, duration of visit, service code and description, discipline code, and payor type, were shared in a Microsoft Excel spreadsheet with the evaluation team through a secure platform.

#### **Statistical Analysis**

We analyzed wound data in both the adoption and control groups during the pre- and postadoption periods. This analysis encompassed both numeric variables, such as patients' age, and categorical variables, including patients' sex, wound type, payor type, episode status, and comorbidities. In addition, the study calculated several data indictors:

- Home visit utilization, assessed based on the average number of SN visits per 60-day episode: This metric was determined by dividing the number of SN visits (numerator) by the total number of episodes cared for (denominator) at the participating branches during the study period.
- Home visit efficiency, assessed based on average time to complete an SN visit per 60-day episode: It involved calculating the mean time to complete an SN visit, measured in minutes. This calculation was based on the time lapse between the start and end time of each in-home visit per 60-day episode. This analysis considered visits conducted by skilled nurses (registered nurse [RN] and licensed practical nurse [LPN]). These visits included the following specific service description codes: RN Oasis Admission, SN high Tech Visit-Lasting 1.5 Hours, SN Infusion Subsequent Visit, SN PRN Visit as Needed, SN Rapid Subsequent Visit, and SN Subsequent Visit. As no out-of-home documentation occurs for routine and SN visits, the calculated time encompassed all patient care and documentation activities within a visit. Overall, the findings were summarized using frequencies, means, and SDs.

Average days to heal a wound: The analysis of average days to heal a wound included any type of wound with an inactive date and considered as "healed," as determined by CenterWell. The study collected the first and last date (inactive date) of the wound and calculated the average days (mean) to heal based on the number of days between the start date and the inactive date of healed wounds. Patients with open wounds who were discharged were not included if the wound was not known to be healed. This analysis segmented the data by wound type (ie, pressure injury, venous ulcer, etc). A Student sample two-tailed t test was used to examine the difference in the average number of days to heal a wound across adoption and control branches between the pre- and postadoption periods. The significance of the statistical test was accepted atP<.05.

Data analysis was conducted using SPSS software (version 28; IBM Corp).

The analyses showed that the days to heal for both the adoption and control groups were normally distributed, as assessed by Shapiro-Wilk normality test (P>.05). Additionally, there was homogeneity of variances, as assessed by the Levene test for equality of variances for both the adoption and control groups (P=.17 and P=.32, respectively).

# Results

### **Overall Characteristics**

The data were collected from 14,278 patients with wounds from both the adoption and control branches, all of whom were recorded in the ICC platform and fulfilled the inclusion criteria. Of these patients, 26.2% (n=3738) were from the adoption branches in the preadoption period and 19.3% (n=2757) were from the adoption branches in the postadoption period. The age of the patients ranged from 23 to 108 years, with approximately half (n=7351, 51.5%) of the participants being female. The included wounds encompassed various types, with surgical wounds and pressure injuries being the most common (Table 1). Overall, there were no statistically significant differences (P>.05) between the adoption and control groups in the different time periods, indicating a comparable distribution of wound types across the groups.



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Characteristics	Adoption branches		Control branchers		
	Preadoption period (November 2020 to May 2021)	Postadoption period (November 2021 to May 2022)	Preadoption period (November 2020 to May 2021)	Postadoption period (November 2021 to May 2022)	
Unique patient admission, n	3738	2757	3859	3924	
Age (years), mean (SD)	73.1 (13.4)	72.3 (13.7)	73.6 (13.2)	74.6 (11.6)	
Sex, n (%) <sup>a</sup>					
Male	1854 (49.6)	1331 (48.3)	1863 (48.3)	1879 (47.9)	
Female	1884 (50.4)	1426 (51.7)	1996 (51.7)	2045 (52.1)	
Wounds episodes managed at participating branches, n	5239	3958	5592	5429	
Wound type, n (%) <sup>b</sup>					
Arterial ulcer	41 (0.8)	23 (0.6)	30 (0.5)	31(0.6)	
Burn	24 (0.5)	11 (0.3)	37 (0.7)	36 (0.7)	
Diabetic ulcer	254 (4.8)	120 (3.0)	326 (5.8)	285 (5.2)	
Pressure injury	1445 (27.6)	1081 (27.4)	1535 (27.4)	1483 (27.3)	
Skin tear	278 (5.3)	230 (5.8)	416 (7.4)	379 (7)	
Surgical wound	1739 (33.2)	1374 (34.7)	1406 (25.3)	1435 (26.4)	
Traumatic wound	357 (6.8)	306 (7.7)	505 (9)	489 (9)	
Venous ulcer	358 (6.8)	444 (11.2)	457 (8.2)	506 (9.3)	
Others <sup>c</sup>	743 (14.2)	369 (9.3)	880 (15.7)	785 (14.5)	
Episodes associated with comorbidities, n (%) <sup>b</sup>	2664 (50.8)	2182 (55.1%)	3143 (56.2)	3202 (59)	
Episodes not associated with comorbidities, n $(\%)^{b}$	2575 (49.2)	1776 (44.9)	2449 (43.8)	2224 (41)	
Current episodes, n (%) <sup>b</sup>	396 (7.6)	270 (6.8)	178 (3.2)	225 (4.1)	
Discharged episodes, n (%) <sup>b</sup>	2341 (44.7)	1780 (45.1)	2725 (48.7)	2615 (48.2)	
Recertified episodes, n $(\%)^{b}$	2502 (47.8)	1908 (48.3)	2689 (48.1)	2589 (47.7)	

<sup>a</sup>Percentages use the number of unique patient admissions as the denominator.

<sup>b</sup>Percentages use the number of wound episodes as the denominator.

<sup>c</sup>Other types of wounds: abrasion, laceration, blisters, seroma, carcinoma, and hematoma.

#### **Reduction in Utilization of SN Home Care Visits**

The data show that the adoption branches experienced a decrease in the average number of SN visits per 60-day episode during the postadoption period as compared to the preadoption period. This led to a decline of 4.3% in the average number of SN VPE from the preadoption period to the postadoption period. On the other hand, the control branches saw a 4.5% increase in the average SN VPE. Consequently, the adoption branches showed an 8.7% improvement in visit utilization compared to the control branches over the same period, as illustrated in Table 2.

Table 2. Comparison of average skilled nursing visits per episode between the adoption and control branches in the pre- and postadoption periods.

Branches	Preadoption period (November 2020 to May 2021)		Postadoption period (November 2021 to May 2022)		
	Visits, n	Skilled nursing visits per episode, n	Visits, n	Skilled nursing visits per episode, n	
Adoption	36,433	7	26,825	6.7	
Control	36,969	6.6	37,678	6.9	

#### **Improved SN Wound Care Visit Efficiency**

During the preadoption period, the adoption branches spent an average of 43.2 (SD 40.27) minutes per episode, amounting to

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XSL•FO RenderX 1,573,171 minutes for completing visits. However, in the postadoption period, the average time per episode reduced to 42.1 (SD 37.52) minutes, resulting in a total time spent of 1,128,658 minutes by the adoption branches. This decrease led

to a 2.5% reduction in the average time required to complete a visit. In total, the adoption group saved 309 days (equivalent to 444,513 minutes) of staff time spent on SN home visits. On the other hand, the control branches experienced a 2.2% increase in the average time to complete the SN visit, from an average

of 40.9 minutes (SD 34.20) to 41.8 minutes (SD 36.37). Overall, the adoption branches saw a 4.4% improvement compared to the control group from the preadoption period to the postadoption period, as depicted in Table 3.

Table 3. Comparison of average time to complete a skilled nursing visit between the adoption and control branches in the pre- and postadoption periods.

Branches	Preadoption period (November 2020 to May 2021)		Postadoption period (November 2021 to May 2022)		
	Visits, n	Average time to complete a skilled nursing visit (min)	Visits, n	Average time to complete a skilled nursing visit (min)	
Adoption	36,433	43.2	26,825	42.1	
Control	36,969	40.9	37,678	41.8	

#### Improved Average Days to Heal a Wound

A significant decrease in the average healing time of wounds was observed at the adoption branches compared to the control branches (P<.001). On average, the adoption branches saw an average reduction of 4.3 days per wound (from 19.7 days to 15.4 days), which was greater than the control group's average reduction of 1.6 days (from 25.9 days to 24.3 days). This corresponds to a 2.7-day improvement compared to the control group, and an overall 15.7% improvement in healing time for the adoption branches (Table 4). Additionally, significant

differences were noted in the average days saved between the pre- and postadoption periods for the adoption branches, particularly the reduction in days to heal for pressure injuries, venous ulcers, and surgical wounds (P=.01, P<.001, and P<.001, respectively). In contrast, the average healing time for traumatic wounds, surgical wounds, and diabetic ulcers were increased from the preadoption period to the postadoption period for the control branches. No significant differences were found for any saved days for different types of wounds between the control group between the pre- and postadoption periods (all P>.05; Table 4).

Table 4. Average days to heal a wound between the adoption and control branches in the pre- and postadoption periods.

Type of wound	Adoption branches				Control branches					
	Preadoption p (November 20 2021)	adoption periodPostadoption periodvember 2020 to May(November 2021 to1)2022)		period )21 to May	<i>P</i> value	Preadoption period (November 2020 to May 2021)		Postadoption period (November 2021 to May 2022)		P value
	Days to heal, mean (SD)	Episodes, n	Days to heal, mean (SD)	Episodes, n		Days to heal, mean (SD)	Episodes, n	Days to heal, mean (SD)	Episodes, n	
All wounds	19.7 (13.9)	2185	15.4 (15.0)	1856	<.001 <sup>a</sup>	25.9 (20.4)	2770	24.3 (19.7)	2200	.98
Diabetic ulcer	17.9 (12.6)	106	16.8 (15.4)	55	.68	34.0 (21.1)	326	34.2 (18.3)	261	.98
Pressure injury	18.9 (13.0)	679	15.3 (14.3)	540	.01	30.4 (21.2)	735	29.9 (18.6)	695	.88
Skin tear	16.8 (11.6)	72	14.3 (11.7)	80	.14	14.4 (15.2)	116	14.2 (14.6)	110	.92
Surgical wound	20.8 (15.2)	608	15.4 (15.9)	508	<.001	18.3 (18.0)	514	21.3 (16.7)	345	.01
Traumatic wound	20.8 (13.5)	136	17.9 (15.6)	183	.06	22.9 (19.9)	305	24.0 (19.8)	125	.19
Venous ulcer	18.9 (13.3)	268	13.4 (15.4)	313	<.001	31.9 (21.1)	357	29.8 (20.5)	255	.85
Others	21.2 (15.7)	316	17.6 (15.5)	177	.06	28.1 (20.9)	280	30.5 (19.1)	274	.32

<sup>a</sup>*P*<.05.

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## Discussion

#### **Principal Findings**

To our knowledge, this descriptive, pre-post evaluation study is the first to investigate the impact of adopting digital wound management technology in a home health setting as part of a comprehensive wound care program. Overall, our study recorded a general improvement in clinical and operational benefits among the adoption branches in the postadoption period compared to the preadoption period, surpassing the control branches over the same time frame. For instance, skilled nurses in the adoption branches saved 444,513 minutes, equivalent to 309 days, spent conducting in-home wound care visits after implementing the technology in practice, while the control group added 42 days to the time spent conducting the visits. This finding is crucial for addressing the consequences of the growing shortage of trained nurses in the health care system [26] and the increasing demand to cope with the continuous rise in wound prevalence and the aging population [27].

On average, nurses provide patients with three dressing changes per week [28-30], and according to O'Keeffe [12], this takes up to 66% of the available nursing time. Also, literature has shown that up to 35% of this time is spent on documentation [26,31-34], and 21% is spent on care coordination [26,31]. In

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a previous study, Lindholm et al [35] stated that among a population of 694 patients with wounds, changing wound dressings alone consumed time comparable to full-time employment of about 57 nurses.

The time spent changing a dressing in a typical wound care visit is not only about the physical act of changing the dressing but also always involves other activities such as wound assessment, measurement, and decision-making on the need to change a dressing and the choice of dressing. This comprehensive approach can make the process time-consuming for nurses, as highlighted in studies by Hadcock [36] and Fletcher and Wasek [37], and could be challenging at times [37]. Moreover, the advent of electronic health records was intended to streamline wound care coordination and documentation at home health organizations [38], but studies by Burton et al [39], Sockolow et al [40], and Yang et al [38] have shown that electronic health records may only partially support these processes and can add to the nurses' workload.

The time-saving benefits documented in our study aligns with a previous study that found implementing the Swift Medical Inc solution in an outpatient clinic could potentially save up to 51.7 days of clinicians' time per year compared to traditional wound assessment methods [22]. The observed time saved during home visits may be attributed to the provision of a technology to nurses that helps facilitate effective wound management. The technology allowed for accurate clinical wound information and precise wound images to be captured, enabled online documentation during visits, allowed the electronic exchange of clinical information, and facilitated remote monitoring with experts. This accessibility to best practice wound assessment ultimately led to improved care and cost outcomes.

Further, after implementing the technology, the adoption branches also experienced a 4.3% reduction in the average number of SN visits needed to care for a wound per episode. This reduction in home SN VPE could generate significant cost savings in the home health care setting. Assuming the average hourly rates of LPNs and RNs conducting the SN visits in home health care range from US \$26.85 to US \$42.85, according to the US Bureau of Labor Statistics [41], CenterWell could potentially save US \$600,413 to US \$958,201 annually across the organization for every 0.3 reductions in SN VPE, based on a total of 60,898 episodes cared for at the organization in a year. Furthermore, compared to the control group, if the adoption branches had not implemented the Swift Medical Inc solution, they would have conducted an additional 1187 visits during the study period.

Evidence suggests that incorporating technology into wound care management can lead to substantial cost savings by reducing nurses' transportation costs and the utilization of wound care materials with each additional visit [42]. Additionally, Lindholm and Searle [5] demonstrated in a cost-effectiveness study that saving 260 hours of nurses' time per year could result in up to an 80% reduction in management costs. This, in turn, could lead to a reduction in care delivery costs and an increase in practice capacity, allowing for better resource management and reduced workload on clinicians,

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which may mitigate costs associated with staff burnout, attrition, and recruitment [43]. The time saved could be redirected to managing other patients or engaging in valuable activities [5]. A survey study indicated that clinicians expressed a strong interest in using any saved time to educate current patients on dressing change techniques, thus creating an opportunity for additional time savings that could be allocated to care coordination [37].

It is important to note that despite conducting fewer visits per wound episode and saving time during each visit at the adoption branches, the quality of care provided at these branches remained consistently high. In fact, there was a significant improvement in the average days to heal a wound between the pre- and postadoption periods at the adoption branches. Several research studies have shown that chronic wounds often have extended healing times, which can lead to increased consultation time, treatment supply consumption, dressing changes, and assessment sessions [44-48]. Moreover, prolonged healing times can increase the risk of complications and hospitalization, ultimately adding to the total cost of wound care [44-48]. As a result, time to heal could be the principal driver in reducing total wound care costs [45-48]. Our findings revealed a 15.7% reduction in the average days to heal a wound for the branches that adopted the technology from the preadoption period to the postadoption period (P < .001), resulting in a savings of 4.3 days for the adoption branches and only 1.6 days for the control branches. It is projected that if the control branches had adopted the solution and experienced the same improvement as the adoption branches, they would have saved 18,546 days in healing patients with wounds over the same period.

The management of wound care involves a variety of practices including assessment, treatment delivery, utilization of advanced products, services, and supportive tools to improve skills and optimize wound care and management [49-51]. The inclusion of AI technology in wound care can significantly enhance clinicians' ability to manage patient care through precision, efficiency, and interoperability. A study by Chairat et al [24] demonstrated that AI integration can streamline documentation and ensure smooth data exchange across health care systems. Research also has demonstrated that AI algorithms, when applied to wound images captured by smart devices, can achieve over 90% accuracy in identifying wound types and dimensions, streamlining the documentation process and ensuring seamless data exchange across health care systems [24]. Therefore, integrating technology as an essential component of the program is crucial for enhancing wound care, as evidenced by various studies [44,49-52].

Our research indicates that implementing wound care management technology enhances patient outcomes and contributes to cost containment and savings. This aligns with the estimated US \$15.7 trillion expansion of the global economy by 2030 attributed to the implementation of AI-based technologies, including assisted intelligence, automation, and autonomous intelligence [53]. Additionally, staying current with wound care knowledge and advancements and integrating technology can significantly improve proficiency in wound care and assist evidence-informed clinicians in delivering effective

treatment recommendations, irrespective of wound complexity or clinician expertise.

Chronic wounds are often tied to comorbid conditions, increasing the complexity of wound management and placing more burdens on clinicians and patients [46]. Meanwhile, CMS expects HHAs to take on more responsibility in caring for these patients with clinically complex conditions and bridge the referral gap in this population [13].

Hence, it is essential to modernize health care and implement wound management technology to bolster evidence-based practices and enhance clinical management [50], regardless of the wound complexity or the practitioners' experience [50,54-56]. This can be accomplished through the practical implementation of deep learning for automated tracing of wound dimensions, accurate measurements [22], automated wound tissue segmentation [57], and predictive modelling [23], thus enabling real-time decision-making that ensures timely patient-centered care.

As evidenced by our study, the branches that adopted the digital solution demonstrated improvements in managing more complex wounds with comorbid conditions, showing a 1.5% increase compared to the control branches. Additionally, these branches reported a 5% improvement in the rate of healed wounds from the preadoption period to the postadoption period, contrasting with the observed 9% decrease in the overall rate of healed wounds at the control branches. These findings illustrate a modest improvement in the effectiveness of using advanced wound management solutions that have a potentially larger impact if adopted across additional branches within the enterprise. Therefore, integrating AI-powered wound care model enables better wound care delivery and management.

#### Limitations and Strengths

A major strength of this study is the inclusion of patients who require wound care managed at 41 different branches at one of the largest HHAs in the United States. We also included a control group of 27 PRIME-certified branches, allowing us to compare operational and clinical changes and marginal benefits against them for the same periods. However, while the branches (adoption and control groups) were comparable with regard to demographics, clinical variables, and wound care education and training, generalizing the results warrants caution. Other institutions may not be similar in size, patient demographics, and operational and clinical workflow, so the results should be interpreted within this context.

We used the as-treated analysis approach to gain valuable insight into the impact of implementing the Swift Medical Inc solution in practice. To ensure the accuracy of our findings, we excluded patients who had not undergone assessment using the Swift Medical Inc solution at the adoption sites during the study period. This approach provided a focused understanding of the true impact of the technology on the assessed outcomes. It is important to note that this study was conducted within a specific time frame of 7 months (from November to May) in both 2020-2021 and 2021-2022. The COVID-19 pandemic significantly disrupted priorities and various aspects of the wound care continuum in 2020, as highlighted by Sen [58]. The increased infection rates of the respiratory pathogen among populations with comorbidities prompted heightened attention to high-risk patients [58] in the preadoption period, and this may have had an unforeseen impact on our findings, either positive or negative.

In addition, due to a lack of data, the study did not assess the sociodemographic variables of patients with wounds, diagnostic methods, nurses' travel costs, cost of used wound supplies, patient costs, or quality of life. Including these variables in exploring the technology's cost-effectiveness would provide valuable insight into the potential savings associated with technology in wound care. A future comprehensive cost-effectiveness study that includes all these variables would be beneficial in informing policy makers and payers about the tangible economic impact of adopting technology for home health to reduce care costs and improve patient outcomes.

Nevertheless, this study presented preliminary data on the impact of adopting a comprehensive wound care management model with the inclusion of technology. Our findings illustrated that HHAs could realize cost savings and clinical and operational improvements by integrating this technology into the wound care program. Therefore, the results may hold significant value for health care providers, administrators, policy makers, and insurance companies.

#### Conclusion

Incorporating wound management technology into the wound care paradigm can improve operational efficiencies in home health settings by reducing the time required to complete in-home visits and decreasing the volume of SN VPE. These benefits can lead to significant cost savings. In addition, this approach also supports more effective clinical care, leading to faster wound healing, which facilitates the managing of more wound episodes annually, ultimately increasing revenue.

There is a clear need to establish a standardized comprehensive approach that incorporates digital tools as part of the wound care program. Doing so can help address challenges related to wound care assessment, increasing demands, limited human health resources, and increased burnout within the health care setting.

Furthermore, by following Centerwell's example of enhancing clinicians' wound care knowledge and skills with the aid of wound care management technology, other home health care organizations can achieve similar results. This includes reducing the average healing time of wounds by 27% and saving clinicians approximately 530 days annually that would have been spent on conducting more in-home wound care visits.



#### **Conflicts of Interest**

HTM, AC, and RDJF are all current employees of Swift Medical Inc. DM is a former employee of Swift Medical Inc. All other authors have no conflicts to declare.

#### References

- 1. Lyder CH. Pressure ulcer prevention and management. Annu Rev Nurs Res 2002;20:35-61. [doi: <u>10.1891/0739-6686.20.1.35</u>] [Medline: <u>12092517</u>]
- Dowsett C, Bielby A, Searle R. Reconciling increasing wound care demands with available resources. J Wound Care 2014 Nov 02;23(11):552, 554, 556-552558 passim. [doi: 10.12968/jowc.2014.23.11.552] [Medline: 25375403]
- 3. Sen CK, Gordillo GM, Roy S, Kirsner R, Lambert L, Hunt TK, et al. Human skin wounds: a major and snowballing threat to public health and the economy. Wound Repair Regen 2009;17(6):763-771 [FREE Full text] [doi: 10.1111/j.1524-475X.2009.00543.x] [Medline: 19903300]
- 4. Ellenbecker CH, Samia L, Cushman MJ, Alster K. Chaper 13 patient safety quality in home health care. In: Hughes RG, editor. Patient Safety and Quality: An Evidence-Based Handbook for Nurses. Rockville, MD: Agency for Healthcare Research and Quality (US); Apr 2008.
- Lindholm C, Searle R. Wound management for the 21st century: combining effectiveness and efficiency. Int Wound J 2016 Jul 27;13 Suppl 2(Suppl 2):5-15 [FREE Full text] [doi: 10.1111/iwj.12623] [Medline: 27460943]
- 6. Ayello E, Lyder CH. A new era of pressure ulcer accountability in acute care. Adv Skin Wound Care 2008 Mar;21(3):134-140; quiz 140-142. [doi: 10.1097/01.ASW.0000305421.81220.e6] [Medline: 18388668]
- Posnett J, Gottrup F, Lundgren H, Saal G. The resource impact of wounds on health-care providers in Europe. J Wound Care 2009 Apr;18(4):154-161. [doi: <u>10.12968/jowc.2009.18.4.41607</u>] [Medline: <u>19349935</u>]
- 8. Srinivasaiah N, Dugdall H, Barrett S, Drew P. A point prevalence survey of wounds in north-east England. J Wound Care 2007 Nov;16(10):413-416, 418. [doi: 10.12968/jowc.2007.16.10.27910] [Medline: 18065016]
- 9. Drew P, Posnett J, Rusling L, Wound Care Audit Team. The cost of wound care for a local population in England. Int Wound J 2007 Jun;4(2):149-155 [FREE Full text] [doi: 10.1111/j.1742-481X.2007.00337.x] [Medline: 17651229]
- Defez C, Fabbro-Peray P, Cazaban M, Boudemaghe T, Sotto A, Daurès JP. Additional direct medical costs of nosocomial infections: an estimation from a cohort of patients in a French university hospital. J Hosp Infect 2008 Feb;68(2):130-136. [doi: <u>10.1016/j.jhin.2007.11.005</u>] [Medline: <u>18201796</u>]
- 11. Moore Z, Loney A, Probst S, Ryan H, Milne C, Meaume S. 3.5 Billion hours of nurse time released by 2030: potential efficiency gains from shared care and longwear advanced foam dressings. Wounds Int 2022;13(2):32-38 [FREE Full text]
- 12. O'Keeffe M. Evaluation of a community-based wound care programme in an urban area [Poster]. 2006 Presented at: 16th EWMA Conference; May 18-20, 2006; Prague, Czech Republic.
- 13. Home health quality reporting program. Centers for Medicare & Medicaid Services. 2022. URL: <u>https://www.cms.gov/</u> medicare/quality-initiatives-patient-assessment-instruments/homehealthqualityinits [accessed 2024-12-03]
- 14. Voegeli D, Posnett J, Franks P, Harding K, Edmonds M, Moffatt C, et al. Skin Breakdown: The Silent Epidemic. Hull, England: Smith & Nephew Foundation; 2007.
- Stone P, Glied S, McNair P, Matthes N, Cohen B, Landers TF, et al. CMS changes in reimbursement for HAIs: setting a research agenda. Med Care 2010 May;48(5):433-439 [FREE Full text] [doi: 10.1097/MLR.0b013e3181d5fb3f] [Medline: 20351584]
- Graves N, Birrell F, Whitby M. Effect of pressure ulcers on length of hospital stay. Infect Control Hosp Epidemiol 2005 Mar;26(3):293-297. [doi: <u>10.1086/502542</u>] [Medline: <u>15796283</u>]
- 17. Allman RM, Goode PS, Burst N, Bartolucci AA, Thomas DR. Pressure ulcers, hospital complications, and disease severity: impact on hospital costs and length of stay. Adv Wound Care 1999;12(1):22-30. [Medline: 10326353]
- Buchan J, Aiken L. Solving nursing shortages: a common priority. J Clin Nurs 2008 Dec;17(24):3262-3268 [FREE Full text] [doi: 10.1111/j.1365-2702.2008.02636.x] [Medline: 19146584]
- Famakinwa J. Why home health providers are producing high referral rejection rates. Home Health Care News. 2022 Feb 16. URL: <u>https://homehealthcarenews.com/2022/02/why-home-health-providers-are-producing-high-referral-rejection-rates/</u><u>#:~:text=That's%20largely%20due%20to%20the,from%20CarePort%2C%20a%20WellSky%20company</u> [accessed 2025-03-28]
- 20. The Royal College of Nursing. Frontline first: nursing on red alert. StudyLib. 2013 Apr. URL: <u>https://studylib.net/doc/14375496/frontline-first-nursing-on-red-alert-april-2013#google\_vignette</u> [accessed 2025-03-28]
- 21. Mohammed HT, Mannion D, Cassata A, Fraser RDJ. Trends in pressure injury prevalence rates and average days to healing associated with adoption of a comprehensive wound care program and technology in skilled nursing facilities in the United States. Wounds 2024 Jan;36(1):23-33 [FREE Full text] [doi: 10.25270/wnds/23089] [Medline: 38417821]
- Mohammed HT, Bartlett RL, Babb D, Fraser RDJ, Mannion D. A time motion study of manual versus artificial intelligence methods for wound assessment. PLoS One 2022 Jul 28;17(7):e0271742 [FREE Full text] [doi: 10.1371/journal.pone.0271742] [Medline: 35901189]

RenderX

- Gupta R, Goldstone L, Eisen S, Ramachandram D, Cassata A, Fraser RDJ, et al. Towards an AI-based objective prognostic model for quantifying wound healing. IEEE J Biomed Health Inform 2024 Feb;28(2):666-677. [doi: 10.1109/JBHI.2023.3251901] [Medline: <u>37028088</u>]
- 24. Chairat S, Chaichulee S, Dissaneewate T, Wangkulangkul P, Kongpanichakul L. AI-assisted assessment of wound tissue with automatic color and measurement calibration on images taken with a smartphone. Healthcare (Basel) 2023 Jan 16;11(2):273 [FREE Full text] [doi: 10.3390/healthcare11020273] [Medline: 36673641]
- 25. Song EH, Milne C, Hamm T, Mize J, Harris K, Kuplicki S, et al. A novel point-of-care solution to streamline local wound formulary development and promote cost-effective wound care. Adv Skin Wound Care 2020 Feb;33(2):91-97. [doi: 10.1097/01.ASW.0000617852.54001.46] [Medline: 31972581]
- 26. Lim ML, Ang SY. A time–motion observation study to measure and analyse clinical nursing workload in an acute care hospital in Singapore. Proceedings of Singapore Healthcare 2019 Mar 22;28(2):124-128. [doi: 10.1177/2010105819834569]
- Falcone M, de Angelis B, Pea F, Scalise A, Stefani S, Tasinato R, et al. Challenges in the management of chronic wound infections. J Glob Antimicrob Resist 2021 Sep;26:140-147 [FREE Full text] [doi: 10.1016/j.jgar.2021.05.010] [Medline: 34144200]
- 28. Drury V, Francis K, Chapman Y. Where have all the young ones gone: implications for the nursing workforce. Online J Issues Nurs 2008 Dec 05;14(1). [doi: 10.3912/ojin.vol14no1ppt03]
- 29. Kotwani M. Caring for an aging society: how to ensure Singapore has enough nurses. Channel News Asia. 2017. URL: https://www.channelnewsasia.com/news/singapore/
- caring-for-an-ageing-society-how-to-ensure-singapore-has-enough-8921492 [accessed 2018-12-12]
   30. Chan LE. Healthcare experts concerned over lack of manpower in long-term care sector. Channel News Asia. 2016. URL: <a href="http://www.channelnewsasia.com/news/singapore/">http://www.channelnewsasia.com/news/singapore/</a>
   be the sector of th
- <u>healthcare-experts-concerned-over-lack-of-manpower-in-long-term%E2%80%938160534</u> [accessed 2017-12-10]
  31. Hendrich A, Chow MP, Skierczynski BA, Lu Z. A 36-hospital time and motion study: how do medical-surgical nurses
- spend their time? Perm J 2008 Sep;12(3):25-34 [<u>FREE Full text</u>] [doi: <u>10.7812/tpp/08-021</u>] [Medline: <u>21331207</u>]
- Farquharson B, Bell C, Johnston D, Jones M, Schofield P, Allan J, et al. Frequency of nursing tasks in medical and surgical wards. J Nurs Manag 2013 Sep 08;21(6):860-866. [doi: <u>10.1111/jonm.12110</u>] [Medline: <u>23924377</u>]
- Westbrook JI, Li L, Georgiou A, Paoloni R, Cullen J. Impact of an electronic medication management system on hospital doctors' and nurses' work: a controlled pre-post, time and motion study. J Am Med Inform Assoc 2013 Nov 01;20(6):1150-1158 [FREE Full text] [doi: 10.1136/amiajnl-2012-001414] [Medline: 23715803]
- Lavander P, Meriläinen M, Turkki L. Working time use and division of labour among nurses and health-care workers in hospitals a systematic review. J Nurs Manag 2016 Nov 01;24(8):1027-1040. [doi: <u>10.1111/jonm.12423</u>] [Medline: <u>27581093</u>]
- 35. Lindholm C, Bergsten A, Berglund E. Chronic wounds and nursing care. J Wound Care 1999 Jan;8(1):5-10. [doi: 10.12968/jowc.1999.8.1.25828] [Medline: 10214192]
- 36. Hadcock JL. The development of a standardized approach to wound care in ICU. Br J Nurs 2000 May 25;9(10):614-616, 618, 620 passim. [doi: 10.12968/bjon.2000.9.10.6272] [Medline: 11235271]
- 37. Fletcher J, Wasek S. Clinician perspectives on time and resources related to dressing changes. Wounds Int 2016;7(4):28-32 [FREE Full text]
- Yang Y, Bass E, Bowles K, Sockolow PS. Impact of home care admission nurses' goals on electronic health record documentation strategies at the point of care. Comput Inform Nurs 2019 Jan;37(1):39-46 [FREE Full text] [doi: 10.1097/CIN.00000000000468] [Medline: 30074919]
- 39. Burton LC, Anderson GF, Kues IW. Using electronic health records to help coordinate care. Milbank Q 2004;82(3):457-81, table of contents [FREE Full text] [doi: 10.1111/j.0887-378X.2004.00318.x] [Medline: 15330973]
- 40. Sockolow P, Bass EJ, Eberle CL, Bowles KH. Homecare nurses' decision-making during admission care planning. Stud Health Technol Inform 2016;225:28-32. [doi: 10.3233/978-1-61499-658-3-28] [Medline: 27332156]
- 41. May 2023 national occupational employment and wages estimates. US Bureau of Labor Statistics. URL: <u>https://www.bls.gov/oes/current/oes\_nat.htm</u> [accessed 2025-01-17]
- 42. Gray LC, Armfield NR, Smith AC. Telemedicine for wound care: current practice and future potential. Wound Pract Res 2010;18(4):158-163 [FREE Full text]
- 43. Joy H, Bielby A, Searle R. A collaborative project to enhance efficiency through dressing change practice. J Wound Care 2015 Jul 02;24(7):312, 314-312, 317. [doi: <u>10.12968/jowc.2015.24.7.312</u>] [Medline: <u>26198553</u>]
- 44. Norman RE, Gibb M, Dyer A, Prentice J, Yelland S, Cheng Q, et al. Improved wound management at lower cost: a sensible goal for Australia. Int Wound J 2016 Jun 03;13(3):303-316 [FREE Full text] [doi: 10.1111/iwj.12538] [Medline: 26634882]
- 45. Kerstein MD, Gemmen E, van Rijswijk L, Lyder CH, Phillips T, Xakellis G, et al. Cost and cost effectiveness of venous and pressure ulcer protocols of care. Disease Management and Health Outcomes 2001;9(11):651-636. [doi: 10.2165/00115677-200109110-00005]
- 46. Posnett J, Franks PJ. The burden of chronic wounds in the UK. Nurs Times 2008 Jan;104(3):44-45. [Medline: 18293879]

RenderX

- Dowsett C, Davis L, Henderson V, Searle R. The economic benefits of negative pressure wound therapy in community-based wound care in the NHS. Int Wound J 2012 Oct;9(5):544-552 [FREE Full text] [doi: <u>10.1111/j.1742-481X.2011.00913.x</u>] [Medline: <u>22321132</u>]
- 48. Stephen-Haynes J, Bielby A, Searle R. Putting patients first: reducing the humaneconomic costs of wounds. Wounds UK 2011 Aug 31;7(3):47-55 [FREE Full text]
- 49. McCluskey P, McCarthy G. Nurses' knowledge competence in wound management. Wounds UK 2012 May 31;8(2):37-47 [FREE Full text]
- Madden M, Stark J. Understanding the development of advanced wound care in the UK: interdisciplinary perspectives on care, cure and innovation. J Tissue Viability 2019 May;28(2):107-114 [FREE Full text] [doi: 10.1016/j.jtv.2019.03.003] [Medline: 30935740]
- Newton H. Cost-effective wound management: a survey of 1717 nurses. Br J Nurs 2017 Jun 22;26(12 Suppl):S44-S49. [doi: <u>10.12968/bjon.2017.26.12.S44</u>] [Medline: <u>28640734</u>]
- 52. Graves N, Zheng H. Modelling the direct health care costs of chronic wounds in Australia. Wound Pract Res 2014 Mar;22(1):20-24, 26-20-24, 33 [FREE Full text]
- 53. Sizing the prize: PwC Global Artificial Intelligence Study: exploiting the AI revolution. PwC. 2017. URL: <u>https://www.pwc.com/gx/en/issues/artificial-intelligence/publications/artificial-intelligence-study.html</u> [accessed 2025-01-17]
- Moore ZEH, Aynge GE, Carr CG, Horton AJ, Jones HA, Murphy NS, et al. A clinical support app for routine wound management: reducing practice variation, improving clinician confidence and increasing formulary compliance. Int Wound J 2022 Aug 06;19(5):1263-1275 [FREE Full text] [doi: 10.1111/iwj.13868] [Medline: 35793908]
- 55. Thompson N, Gordey L, Bowles H, Parslow N, Houghton P. Reliability and validity of the revised photographic wound assessment tool on digital images taken of various types of chronic wounds. Adv Skin Wound Care 2013 Aug;26(8):360-373. [doi: 10.1097/01.ASW.0000431329.50869.6f] [Medline: 23860221]
- 56. Halstead LS, Dang T, Elrod M, Convit RJ, Rosen MJ, Woods S. Teleassessment compared with live assessment of pressure ulcers in a wound clinic: a pilot study. Adv Skin Wound Care 2003;16(2):91-96. [doi: <u>10.1097/00129334-200303000-00010</u>] [Medline: <u>12690232</u>]
- 57. Ramachandram D, Ramirez-GarciaLuna JL, Fraser RDJ, Martínez-Jiménez MA, Arriaga-Caballero JE, Allport J. Fully automated wound tissue segmentation using deep learning on mobile devices: cohort study. JMIR Mhealth Uhealth 2022 Apr 22;10(4):e36977 [FREE Full text] [doi: 10.2196/36977] [Medline: 35451982]
- Sen CK. Human wound and its burden: updated 2020 compendium of estimates. Adv Wound Care (New Rochelle) 2021 May 01;10(5):281-292 [FREE Full text] [doi: 10.1089/wound.2021.0026] [Medline: 33733885]

#### Abbreviations

AI: artificial intelligence CenterWell: CenterWell Home Health CMS: Centers for Medicare & Medicare Services DWCS: digital wound care solution EMR: electronic medical record HCHB: Homecare Homebase HHA: home health agency ICC: Integumentary Command Center LPN: licensed practical nurse PRIME: Prevention Intervention, Management, and Education QI: quality improvement RN: registered nurse SN: skilled nursing VPE: visits per episode

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# Effectiveness of m-Learning in Enhancing Knowledge Retention for Nurses' Lifelong Learning: Quasi-Experimental Study

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# Abstract

**Background:** The current information and communication technologies, digital literacy, and ease of access to communication and information devices by nurses provide them with new ways and intention to access information for technical-scientific updating, ensuring the quality and safety of health care. Mobile learning (m-learning) offers a flexible and accessible alternative for continuing professional education, overcoming barriers such as time constraints and financial burden.

**Objective:** This study aimed to evaluate the effectiveness of m-learning in nurses' knowledge retention of chronic obstructive pulmonary disease self-management, using a Massive Open Online Course with integrated virtual clinical simulation.

**Methods:** A quasi-experimental pre- and posttest study was conducted, with no control group, among 168 nurses from a Portuguese hospital. The intervention included an asynchronous online course with 13 modules. Knowledge retention was assessed by comparing the mean scores before and after the course.

**Results:** The results indicated a significant increase in knowledge retention. The participants' average score increased from 59.97% in the initial assessment to 84.05% in the final assessment (P<.001). Nurses with a master's degree exhibited a higher level of basic knowledge than those with a bachelor's degree. The course completion rate was 93.45%, reflecting significant engagement attributed to gamification and clinically relevant content.

**Conclusions:** This study confirms the effectiveness of m-learning in improving knowledge retention in nursing. This strategy is a valuable approach to lifelong learning, promoting quality and safety in delivering health care. m-learning is useful in nurses' lifelong learning, offering flexibility and more effective support for clinical practice. Integrating virtual simulation and gamification boosted motivation and reduced drop-out rates, highlighting the potential of m-learning in lifelong learning in health care.

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#### KEYWORDS

m-learning; nursing; continuing education; knowledge retention; COPD; MOOC; clinical virtual simulation; chronic obstructive pulmonary disease; Massive Open Online Courses; mobile learning

# Introduction

#### Background

Available information and communication technologies (ICT), digital literacy, and easy access to communication and information devices provide nurses with new opportunities for technical and scientific updating. These advancements are directly linked to the safety and quality of care [1]. However, nowadays, there are still barriers to accessing lifelong learning [2], such as the need to balance family and professional life and the associated financial burden [3,4]. On the other hand, the decrease in human resources and their turnover and the increase in workload in health institutions are obstacles to nurses' continuing [5,6].

The use of ICT-based platforms by health care institutions as a strategy for providing lifelong learning to nurses enables large-scale access with no geographical and time limits [7-9].

The World Health Organization defines a digital health intervention as the specific use of digital technology to achieve health-related objectives. An example of these interventions is managing training and educational content and making it available to health professionals in digital format [10]. Digital education includes computer-based offline and online education, open and massive online courses, serious games and gamification, augmented reality environments, virtual reality, virtual simulations of clinical cases, psychomotor skills training, and mobile learning (m-learning), among others [11].

e-learning, electronic learning or web-based learning often complement traditional teaching models, encompassing



knowledge through digital technologies. These educational approaches promote access to training for health professionals [10,12].

The technological development has leveraged changes in education and fostered the use of mobile technologies in the acquisition of knowledge and its mobilization for clinical practice [13]. Current distance education contexts demand the use of mobile devices in addition to traditional computers [14].

We have been witnessing the progressive introduction and incorporation of e-learning as a pedagogical strategy coupled with the growing access to portable distance communication devices, such as smartphones and mobile internet networks. Within this new reality, m-learning has emerged as a new opportunity to promote nurses' access to digital education as a critical resource for lifelong learning. m-learning is the management and provision of education and training content in electronic format for health care professionals [10]. It allows users to access educational content via mobile devices, regardless of time and location [15]. Evidence shows that m-learning is at least as effective as traditional learning [11].

Massive Open Online Courses (MOOCs), made available by higher education institutions [16], certified and integrated into the in-service training programs of health institutions, are emerging as important contributors to incorporating m-learning in the continuing training of health professionals. Moreover, MOOCs can contribute to developing nurses' skills, specifically in training for self-management of noncommunicable chronic diseases such as chronic obstructive pulmonary disease (COPD).

#### **Massive Open Online Courses**

MOOCs are based on the definition of various concepts such as e-learning, mass communication, knowledge sharing, and openness [17]. MOOCs comprise quality content and aim at a large target audience, overcoming many of the in-class barriers [9]. With over 20 years of existence, these courses stand out for their creative methodology for conveying information and implementing innovative pedagogy and tools [18]. The MOOCs' primary goal in the health field is to improve the health status of the general population while promoting the safety and quality of the care provided [8].

In recent years, the number of MOOCs has grown exponentially, in line with the increase in the number of people with access to the internet [19,20]. In 2021, around 220 million people enrolled in online courses, representing twice the number of students enrolled in 2020 [21].

This reality explains the upward trend in using MOOCs, as they are easy to access and tend to be free [22]. The size of the global MOOC market was US \$9.45 billion in 2023, estimated to reach US \$39.72 billion by 2032 [23].

MOOCs comprise several characteristics, such as openness, which means the possibility of enrolling and withdrawing from the course; autonomy, referring to the pace of learning and goal attainment; diversity, which allows adaption to different time zones; and interactivity, where the effects of learning picture the sharing between participants [8].

MOOCs have been perceived as an innovative method enabling useful and effective online learning compared to face-to-face training [8]. Its success relies on the number of trainees that can be enrolled swiftly; its ability to respond to individual learning styles by using multiple tools for interaction between participants; its flexibility [2] and the guarantee of quality learning associated with cost savings in professional training.

In nursing education, the use of MOOCs has fostered the creation of broader learning opportunities for individuals and health institutions [24].

A MOOC must be designed considering the needs of the participants [25] and increase motivation and engagement. Continuous training that aims to respond to nurses' needs and is perceived as positive for the quality and safety of the care provided is more attractive and likely to better capture nurses' intention to attend and complete the course [26].

MOOCs used to develop professional competencies show higher enrollment and completion rates compared to more generic content [27,28].

The number of drop-outs in trainees from MOOCs before completion has been under analysis. In a study with 9 million students, only 5% to 18% of participants completed the course [29]. Another study reported a MOOC completion rate of less than 10% [30]. More recently, MOOC drop-out rates have ranged from 10% [31] to 85% [32].

The advantages and personal and professional gains for individuals who attend MOOCs are irrefutable, considering the impact on learning and overall knowledge pertaining to the development of skills, attitudes, confidence, and commitment [33].

Incorporating gamification features into MOOCs and using virtual patients for clinical decision training could help increase the involvement and motivation of participants to complete MOOCs [6,17,34]. MOOCs should integrate virtual patient simulators, recreating gamified environments, which are predictors of realism, fun, and motivation for participants, and reduce the drop-out rate [4,35], thus increasing MOOC completion rates [36,37].

However, little is known about the effectiveness of using m-learning for nurses' lifelong learning. Therefore, this study sought to assess the effectiveness of an m-learning strategy on nurses' knowledge retention.

## Methods

#### **Study setting**

A quasi-experimental pre- and posttest study was conducted without a control group, using a nonprobabilistic convenience sampling technique. All nurses from the Internal Medicine Department of a central hospital in northern Portugal who voluntarily agreed to participate in the study were considered eligible. Thus, all 193 nurses from the Internal Medicine departments were eligible to participate.

The primary outcome of the study was the nurses' level of knowledge, analyzed using a continuous variable expressed as



a percent (0 - 100). The calculation of the average level of knowledge before and after attending the MOOC resulted from computing the relative weight of each module included in the intervention. Knowledge retention was calculated by testing the differences between the average percent obtained before and after the intervention.

#### Intervention

The development of the MOOC was supported by the theme of self-management of COPD, considering the need expressed by the professionals within the study context and according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD). The GOLD initiative reveals that COPD is now one of the 3 leading causes of death in the world, and 90% of these deaths occur in low- and middle-income countries. Many people suffer from this disease for years and die prematurely because of it or disease-associated complications. Globally, the burden of COPD is expected to increase in the coming decades due to continued exposure to COPD risk factors and an aging population [38].

This study used the Adult Learning Theory of Malcolm Knowles (1913 - 1997), since for effective learning, adults—nurses in this case—have to perceive the usefulness of the knowledge provided and how to mobilize it for their daily practice [39].

This study included a training program available in MOOC format, called self-management of COPD (Ecare-COPD). This program has been subject to continuous validation, with special highlight for its adequacy and scientific and pedagogical relevance [6]. This MOOC was made available on NAU, an e-learning platform, created and administered by the Scientific Computing Unit (FCCN) of the Foundation for Science and Technology (FCT). This model supports training and enables the design of training programs in Portugal using the MOOC format.

This MOOC was organized into 13 modules, 12 of which are formative and include lessons on a topic. Each lesson includes a theoretical overview of the topic, one or more supporting videos (lasting about 5.06 min) and bibliographical references.

In addition, in module 13, which was not assessed, each participant was able to practice clinical decision-making through four clinical scenarios using the Body Interact virtual patient simulator [35,40-43]. In this module, each participant had the opportunity to mobilize the previously acquired knowledge using the game methodology.

#### **Data Collection**

Sociodemographic variables and variables characterizing the professional category of the participants were used to characterize the sample.

The level of knowledge was assessed using a set of items, including 29 multiple-choice questions and 24 true or false statements, on the clinical area of COPD. The assessment items were determined by the experts who developed the contents of the training program and validated by a group of experts in the field of the training program.

It should be noted that the evaluation questions were pretested with 10 nurses. At this stage, only editing corrections were

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deemed necessary and no question was amended. Knowledge assessment was performed through an initial knowledge assessment of the participants after registering on the NAU platform. All participants were able to attend the training program despite the initial assessment. Each participant was asked to complete a knowledge assessment at the end of each module.

#### **Data Analysis and Processing**

The statistical analysis was performed using SPSS Amos (version 29.0; IBM Corp) and SPSS (version 29.0; IBM Corp) software. Descriptive statistics and inferential analysis were used to analyze the different variables under study. The Student *t* test was used to test for differences between means. The results are reported according to APA standards, with Cohen *d* effect magnitude (0.2 low; 0.5 mean and 0.8 high) and *P* values set at <.05.

#### **Ethical Considerations**

Ethical approval was granted by the Ethics Committee of CHUPorto/ICBAS (reference number 2021.010). All participants received an informed consent form and the anonymity and confidentiality of the data collected was guaranteed. We have also ensured that participants have the option to participate and will not suffer any damage or loss in case they do not complete the training program.

# Results

This study included 168 nurses from the medicine department of a hospital in northern Portugal, representing 87% (n=193) of the total nursing staff in the department. The remaining 13% (n=25) of potential participants were absent due to temporary work incapacity, extended health-related leave, and parental leave.

Of the participants, 69.6% (n=117) were female, 11.3% (n=19) were male, and 19% (n=32) preferred not to answer. The mean age of nurses was 32.96 (SD 9.37; 24-59) years; average professional experience as a nurse of 10.12 (SD 7.50; 0-37) years, and an average experience of 6.43 (SD 6.22; 0-26) years in the Medicine Department of this hospital in the north of Portugal. Further, male nurses were older ( $t_{131}$ =-2.674; P=.004; Cohen d=0.67; men=37.94 and women=32.70), had longer professional experience ( $t_{132}$ =-3.401; P<.001; Cohen d=0.86; men=15.17 vs women=9.26), and had longer experience in the medical department ( $t_{131}$ =-2.615; P<.005; Cohen d=0.66; men=10.17 vs women=6.11). In this study, 74.4% (n=125) of the nurses held a bachelor's degree in nursing, 11.9% (n=20) held a master's degree, and 13.7% (n=23) opted not to disclose this information. Regarding professional categories, 66.1% (n=111) were general nurses, 19.6% (n=33) were specialist nurses, 1.2% (n=2) were nurse managers, and 13.1% (n=22) did not provide any information.

Regarding attendance at the training program, data analysis revealed that out of 168 participants, 157 successfully achieved an evaluation score exceeding 50%, thereby qualifying for a certificate of participation and completion. Among these, 99.36% (n=156) were issued certificates, while 0.63% (n=1)

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had still not received their certificates at the time of data extraction. In addition, 6.54% (n=11) of enrolled participants did not complete the training program despite completing their registration.

The participants completed an initial knowledge assessment, achieving an average score of 59.97% (SD 19.37; 0-97). The

final knowledge retention assessment was calculated by determining the relative weight of each module. Participants scored on average 84.05% (SD 24.29%; 0-100) in the final assessment.

Descriptive statistics for the evaluation of the 12 modules included in the training program are described in Table 1.

Table . Descriptive data for the assessment of the 12 modules of the formative program.

Modules assessed	Participants (N=168), mean (SD; range)
Module 1	92.01 (17.81; 33-100)
Module 2	80.70 (27.49; 0-100)
Module 3	98.11 (8.58; 33-100)
Module 4	88.28 (14.33; 40-100)
Module 5	92.48 (14.04; 40-100)
Module 6	83.33 (24.97; 0-100)
Module 7	88.85 (16.60; 25-100)
Module 8	58.97 (49.35; 0-100)
Module 9	67.95 (46.82; 0-100)
Module 10	83.44 (37.29; 0-100)
Module 11	91.28 (16.09; 20-100)
Module 12	87.90 (32.72; 0-100)

Statistically significant differences in knowledge retention were found between the mean initial assessment score of 59.97 (SD 19.37) and the final assessment score of 84.05 (SD 24.29;  $t_{167}$ =16.697; *P*<.001), with a large effect size (Cohen *d*=1.28).

An analysis of the relationships between sociodemographic and professional characteristics revealed a statistically significant difference in knowledge retention between the mean initial assessment scores of 69.15 (SD 12.77) among nurses with a master's degree, while those with a bachelor's degree had a mean score of 62.52 (SD 13.62;  $t_{143}$ =-2.037, *P*=.02, Cohen *d*=0.49). These findings demonstrate that nurses with a master's degree have a higher baseline knowledge on this subject compared to those nurses with a bachelor's degree.

These study results confirm that the implemented pedagogical strategy significantly enhances knowledge retention among nurses within this specific context.

## Discussion

#### **Principal Findings**

This study included a sample of 168 nurses from the medicine department of a hospital in northern Portugal who achieved an average score of 59.97% on the initial knowledge assessment. Throughout the training program, participants underwent final knowledge assessments at the end of each module, resulting in an overall average score of 84.05%. These findings demonstrate that the pedagogical strategy using ICT delivered through a MOOC and incorporating virtual clinical simulation significantly enhanced knowledge retention among nurses (P<.001, Cohen d=1.28).

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Numerous studies on educational programs support these findings, highlighting their effectiveness in improving knowledge outcomes [44-47].

The positive impact of interventions involving simulation on knowledge acquisition is also well documented, although primarily in studies with nursing students. These findings underscore the value of active learning strategies [48], which play a critical role in motivating trainees to acquire knowledge [49,50]. This evidence reinforces the rationale for integrating virtual clinical simulation and virtual patients into the MOOC's content.

This study also revealed that nurses holding a master's degree exhibited a higher level of knowledge in the initial assessment of this area compared to those with a bachelor's degree. These findings suggest that the second study cycle facilitates the consolidation of cognitive and instrumental skills and equips nurses with the ability to manage complex situations, such as empowering patients to self-manage chronic conditions such as COPD. Consequently, a master's degree is expected to enable nurses to deliver specialized and targeted interventions that address the actual needs of the population, implement evidence-based complex interventions, and promote the quality and safety of care.

The training program was conducted in a MOOC format and incorporated multimedia resources (eg, videos) and brief summaries of the latest evidence on COPD. These features enhance the perceived usefulness of a MOOC [51], fostering greater engagement and commitment to the learning process [52] while increasing participants' intention to enroll in similar courses in the future [53].

These factors may help to explain the low drop-out rate observed in this training program (6.55%), which is notably lower than those reported in previous studies [6,29-32,54].

As previously mentioned, the alignment of the MOOC with the participants' professional roles [27,28], specifically its focus on developing competencies to empower individuals with COPD to improve self-management of the disease, likely contributed to higher enrollment and completion rates.

In addition, the flexibility provided to participants to complete the training program [55] may have further supported the high completion rate by accommodating the professionals' needs to balance personal, family, and work responsibilities.

The use of simulation is increasingly significant in pre- and postgraduate programs [56]. High-fidelity simulation enables recreating a situation or event in which a virtual patient represents or responds to physiological parameters, providing high realism and dynamism for those involved [57]. This helps to optimize engagement in the learning process. High-fidelity simulation, which can include simulation with virtual patients, improves learning satisfaction, confidence, and self-efficacy among nursing students [58-60].

Virtual patient simulation has been used effectively to improve learning, specifically knowledge, self-confidence, practical skills, student satisfaction, and critical thinking [35,61]. It contributes to transforming learning environments into more interactive and creative scenarios, facilitating participants' learning and achieving goals [62]. The integration of simulation with virtual patients, along with the gamification component of the training program, played a pivotal role in promoting adherence and achieving higher completion rates. Using simulation with virtual patients is an effective strategy for fostering active learning and stimulating intrinsic motivation to learn. This approach enabled the recreation of clinical decision-making environments and scenarios that participants were familiar with, allowing them to identify opportunities to

enhance their decision-making skills when addressing daily challenges, in line with the findings from previous studies [4].

#### Limitations

This study had some limitations. The first limitation concerns the study's methodology, mainly because of the absence of a control group. This prevented attributing knowledge gains to the developed intervention. Further randomized controlled studies are suggested to confirm the results.

Also, since the sample was restricted to one medicine department in a single hospital institution, it hindered the generalizability of the results. Future research should include samples from different healthcare contexts.

In addition, the study was limited only to one intervention related to COPD self-management; thus, further investigation including other areas and dimensions of nursing practice is needed to examine the impact of implementing a pedagogical strategy in the continuous training of nurses.

In addition, future studies should focus on the longitudinal monitoring of the sample, particularly to assess knowledge retention on the subject under study.

#### Conclusions

The adopted training program improved knowledge retention. Therefore, it is an alternative for optimizing nurses' lifelong learning according to the program features, which have highly contributed to the completion rate (93.45%).

The obtained results provide relevant information to health institutions and their managers concerning the characteristics of a pedagogical strategy for the continuous training of nurses. These results align with the professionals' needs and attest to the quality and safety of care.

Similarly, the results of this study should enable higher education institutions responsible for designing MOOCs to reflect on their content and reformulate or improve them.

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#### **Conflicts of Interest**

None declared.

#### References

- 1. Ornellas T, Monteiro M. Lifelong learning entre profissionais de enfermagem: desafios contemporâneos. Rev Enf Ref 2023;VI Série(2):1-7. [doi: 10.12707/RVI22055]
- Aung KT, Abdul Razak R, Mohamad Nazry NN. Development of a risk communication in Massive Open Online Course (MOOC) module for nurses: a process description. Educ Med J 2024;16(Supp.1):67-78 [FREE Full text] [doi: 10.21315/eimj2024.16.s1.8]
- 3. Talan T. The effect of mobile learning on learning performance: a meta-analysis study. EDUC SCI-THEOR PRACT 2020;20(1):79-103. [doi: 10.12738/jestp.2020.1.006]
- 4. Padilha JM, Rosa JF, Cunha DJ. Gamification in healthcare education: demystifying a trend. In: Bernardes O, Amorim V, Moreira A, editors. Handbook of Research on the Influence and Effectiveness of Gamification in Education IGI Global 2022:46-62. [doi: 10.4018/978-1-6684-4287-6.ch003]

- 5. Stevens CJ, Horrigan J, Heale R, Koren I. Northeastern Ontario nurses' perceptions of e-learning: an interpretive description. Nurse Educ Today 2020 Sep;92:104509. [doi: <u>10.1016/j.nedt.2020.104509</u>] [Medline: <u>32599472</u>]
- Padilha JM, Machado PP, Ribeiro AL, Ribeiro R, Vieira F, Costa P. Easiness, usefulness and intention to use a MOOC in nursing. Nurse Educ Today 2021 Feb;97:104705. [doi: <u>10.1016/j.nedt.2020.104705</u>] [Medline: <u>33341525</u>]
- Zhao Y, Wang A, Sun Y. Technological environment, virtual experience, and MOOC continuance: a stimulus–organism–response perspective. Comput Educ 2020 Jan;144(C):103721. [doi: <u>10.1016/j.compedu.2019.103721</u>]
- 8. Longhini J, Rossettini G, Palese A. Massive open online courses for nurses' and healthcare professionals' continuous education: a scoping review. Int Nurs Rev 2021 Mar;68(1):108-121. [doi: 10.1111/inr.12649] [Medline: 33855697]
- 9. Bettiol S, Psereckis R, MacIntyre K. A perspective of massive open online courses (MOOCs) and public health. Front Public Health 2022;10:1058383. [doi: 10.3389/fpubh.2022.1058383] [Medline: 36589952]
- 10. WHO guideline recommendations on digital interventions for health system strengthening. World Health Organization. 2019. URL: <u>https://www.ncbi.nlm.nih.gov/books/NBK541902</u> [accessed 2025-06-20]
- 11. Car J, Carlstedt-Duke J, Tudor Car L, et al. Digital education in health professions: the need for overarching evidence synthesis. J Med Internet Res 2019 Feb 14;21(2):e12913. [doi: 10.2196/12913] [Medline: 30762583]
- 12. Digital skills and competences and successful digital education and training: fit for the digital era. European Council. 2023. URL: <a href="https://www.consilium.europa.eu/en/press/press-releases/2023/11/23/digital\_elucation\_end\_training\_fit\_for\_the\_digital\_era/forested\_2025\_02\_071">https://www.consilium.europa.eu/en/press/press-releases/2023/11/23/digital\_elucation\_end\_training\_fit\_for\_the\_digital\_era/forested\_2025\_02\_071</a>
- <u>digital-skills-and-competences-and-successful-digital-education-and-training-fit-for-the-digital-era/</u> [accessed 2025-02-07]
   Masat Harbali S, Koc Z. Change in nursing education: mobile-based learning approaches. J Educ Res Nurs 2022;18(1):123-127 [FREE Full text] [doi: 10.5152/jern.2022.29053]
- 14. Şenyuva E. Reflections on nursing education of technological developments. Florence Nightingale Hemsire Derg 2019 Feb;27(1):79-90. [doi: 10.26650/FNJN322556] [Medline: 34267964]
- 15. Picciano AG. Theories and frameworks for online education: seeking an integrated model. In: A Guide to Administering Distance Learning: Brill; 2021:79-103. [doi: 10.1163/9789004471382\_005]
- 16. Alharbi AH. Investigating the acceptance and use of massive open online courses (MOOCs) for health informatics education. BMC Med Educ 2023 Sep 8;23(1):656. [doi: 10.1186/s12909-023-04648-9] [Medline: 37684588]
- 17. Aparicio M, Oliveira T, Bacao F, Painho M. Gamification: a key determinant of massive open online course (MOOC) success. Inf Manag 2019 Jan;56(1):39-54. [doi: 10.1016/j.im.2018.06.003]
- Rambe P, Moeti M. Disrupting and democratising higher education provision or entrenching academic elitism: towards a model of MOOCs adoption at African universities. Education Tech Research Dev 2017 Jun;65(3):631-651. [doi: 10.1007/s11423-016-9500-3]
- 19. Zhu M, Sari AR, Lee MM. A comprehensive systematic review of MOOC research: research techniques, topics, and trends from 2009 to 2019. Education Tech Research Dev 2020 Aug;68(4):1685-1710. [doi: 10.1007/s11423-020-09798-x]
- 20. Liu C, Zou D, Chen X, Xie H, Chan WH. A bibliometric review on latent topics and trends of the empirical MOOC literature (2008–2019). Asia Pacific Educ Rev 2021 Sep;22(3):515-534. [doi: <u>10.1007/s12564-021-09692-y</u>]
- 21. Shah D. Class central's best online courses of the year (2022 edition). The Report. 2021. URL: <u>https://www.classcentral.com/</u> report/best-free-online-courses-2022 [accessed 2025-06-20]
- 22. Almeida BL, Christovam BP, Correia DM. El uso de blog como estrategia de formación continua en enfermería: una revisión integradora de la literatura. Enferm Glob 2017;17(1):500-528. [doi: <u>10.6018/eglobal.17.1.277841</u>]
- 23. MOOCs market share, trend, growth, forecast research, 2032. Business Research Insights. 2024. URL: <u>https://www.businessresearchinsights.com/market-reports/massive-open-online-course-mooc-market-122947</u> [accessed 2025-06-21]
- 24. Dağcı M. Massive open online courses in nursing: a retrospective descriptive study. Sağlık Bilimleri ve Klinik Araştırmaları Dergisi 2024;3(3):194-203. [doi: 10.5281/zenodo.14576715]
- 25. Zubala A, Lyszkiewicz K, Lee E, Underwood LL, Renfrew MJ, Gray NM. Large-scale online education programmes and their potential to effect change in behaviour and practice of health and social care professionals: a rapid systematic review. Interact Learn Environ 2018;27(5-6):797-812. [doi: 10.1080/10494820.2018.1465438]
- 26. Cunha DJ, Machado PP, Padilha JM. Aceitação pelos Enfermeiros da utilização de um Massive Open Online Course em contexto de formação contínua. Rev Port Enf Reab 2024;7(1):e395. [doi: <u>10.33194/rper.2024.395</u>]
- 27. Weinhardt JM, Sitzmann T. Revolutionizing training and education? Three questions regarding massive open online courses (MOOCs). Hum Resour Manag Rev 2019 Jun;29(2):218-225. [doi: <u>10.1016/j.hrmr.2018.06.004</u>]
- Kizilcec RF, Kambhampaty A. Identifying course characteristics associated with sociodemographic variation in enrollments across 159 online courses from 20 institutions. PLoS ONE 2020;15(10):e0239766. [doi: <u>10.1371/journal.pone.0239766</u>] [Medline: <u>33052947</u>]
- 29. Korn M, Levitz J. Online courses look for a business model. The Wall Street Journal. URL: <u>https://www.wsj.com/articles/</u> SB10001424127887324339204578173421673664106 [accessed 2025-06-20]
- 30. Breslow L, Pritchard DE, DeBoer J, Stump GS, Ho AD, Seaton DT. Studying learning in the worldwide classroom research into edx's first MOOC. Res Pract Assess 2013;8:13-25 [FREE Full text]
- Magaña-Valladares L, Rosas-Magallanes C, Montoya-Rodríguez A, Calvillo-Jacobo G, Alpuche-Arande CM, García-Saisó S. A MOOC as an immediate strategy to train health personnel in the cholera outbreak in Mexico. BMC Med Educ 2018 May 16;18(1):111. [doi: 10.1186/s12909-018-1215-1] [Medline: 29769059]

RenderX

- 32. Wang W, Guo L, He L, Wu YJ. Effects of social-interactive engagement on the dropout ratio in online learning: insights from MOOC. Behav Inform Technol 2019 Jun 3;38(6):621-636. [doi: 10.1080/0144929X.2018.1549595]
- Blum ER, Stenfors T, Palmgren PJ. Benefits of massive open online course participation: deductive thematic analysis. J Med Internet Res 2020 Jul 8;22(7):e17318. [doi: <u>10.2196/17318</u>] [Medline: <u>32672680</u>]
- 34. Gentry S, L'Estrade Ehrstrom B, Gauthier A, et al. Serious gaming and gamification interventions for health professional education. Cochrane Database Syst Rev 2018(6). [doi: <u>10.1002/14651858.CD012209.pub2</u>]
- Padilha JM, Costa P, Sousa P, Ferreira A. Clinical virtual simulation: predictors of user acceptance in nursing education. BMC Med Educ 2024 Mar 16;24(1):299. [doi: <u>10.1186/s12909-024-05154-2</u>] [Medline: <u>38493087</u>]
- 36. Buckley P, Doyle E. Gamification and student motivation. Interact Learn Environ 2016 Aug 17;24(6):1162-1175. [doi: 10.1080/10494820.2014.964263]
- 37. Khalil M, Wong J, de Koning B, Ebner M, Paas F. Gamification in MOOCs: a review of the state of the art. Presented at: 2018 IEEE Global Engineering Education Conference (EDUCON); Apr 17-20, 2018; Tenerife, Spain p. 1629-1638. [doi: 10.1109/EDUCON.2018.8363430]
- 38. Agustí A, Celli BR, Criner GJ, et al. Global initiative for chronic obstructive lung disease 2023 Report: GOLD executive summary. Eur Respir J 2023 Apr;61(4):2300239. [doi: 10.1183/13993003.00239-2023] [Medline: 36858443]
- 39. Valêska Araújo Costa Lima C, Yildirim K. ANDRAGOGIA: INSTRUMENTO DE EDUCAÇÃO E ORIENTAÇÃO AOS ADULTOS. COGNITIONIS 2022;5(2). [doi: 10.38087/2595.8801.166]
- 40. Padilha JM, Sousa PA, Pereira FM. Análise do uso de suportes tecnológicos e conteúdos informacionais pelos pacientes com doença pulmonar obstrutiva crónica. Acta Paul Enferm 2012;25(SPE1):60-66. [doi: 10.1590/S0103-21002012000800010]
- 41. Padilha JM, Machado PP, Ribeiro AL, Ramos JL. Clinical virtual simulation in nursing education. Clin Simul Nurs 2018 Feb;15:13-18. [doi: 10.1016/j.ecns.2017.09.005]
- 42. Padilha JM, Machado PP, Ribeiro A, Ramos J, Costa P. Clinical virtual simulation in nursing education: randomized controlled trial. J Med Internet Res 2019 Mar 18;21(3):e11529. [doi: 10.2196/11529] [Medline: 30882355]
- 43. Padilha JM, Ribeiro A, Rosa J, Marques D, Machado PP. Clinical virtual simulation as lifelong learning strategy—nurse's verdict. Clin Simul Nurs 2020 Oct;47:1-5. [doi: 10.1016/j.ecns.2020.06.012]
- 44. Keleekai NL, Schuster CA, Murray CL, et al. Improving nurses' peripheral intravenous catheter insertion knowledge, confidence, and skills using a simulation-based blended learning program: a randomized trial. Simul Healthc 2016 Dec;11(6):376-384. [doi: 10.1097/SIH.000000000000186] [Medline: 27504890]
- 45. Rutherford-Hemming T, Kelsey NC, Grenig DL, Feliciano M, Simko L, Henrich CM. Multisite single-blinded randomized control study of transfer and retention of knowledge and skill between nurses using simulation and online self-study module. Simul Healthc 2016 Aug;11(4):264-270. [doi: 10.1097/SIH.000000000000168] [Medline: 27388860]
- 46. Eglseer D. Development and evaluation of a Massive Open Online Course (MOOC) for healthcare professionals on malnutrition in older adults. Nurse Educ Today 2023 Apr;123:105741. [doi: <u>10.1016/j.nedt.2023.105741</u>] [Medline: <u>36746061</u>]
- Khalil AI, Hantira NY, Alnajjar HA. The effect of simulation training on enhancing nursing students' perceptions to incorporate patients' families into treatment plans: a randomized experimental study. Cureus 2023 Aug;15(8):e44152. [doi: 10.7759/cureus.44152] [Medline: <u>37638259</u>]
- 48. Chan HY, Chang HC, Huang TW. Virtual reality teaching in chemotherapy administration: randomised controlled trial. J Clin Nurs 2021 Jul;30(13-14):1874-1883. [doi: <u>10.1111/jocn.15701</u>] [Medline: <u>33555626</u>]
- 49. Torralba KD, Doo L. Active learning strategies to improve progression from knowledge to action. Rheum Dis Clin North Am 2020 Feb;46(1):1-19. [doi: 10.1016/j.rdc.2019.09.001] [Medline: 31757278]
- Jiang JL, Fu SY, Ma YC, Wang JH, Koo M. Comparative impact of active participation and observation in simulation-based emergency care education on knowledge, learning effectiveness, and satisfaction among undergraduate nursing students. Teach Learn Nurs 2024 Jul;19(3):e566-e573. [doi: 10.1016/j.teln.2024.04.003]
- 51. Chan MM, Barchino R, Medina-Merodio JA, de la Roca M, Sagastume F. MOOCs, an innovative alternative to teach first aid and emergency treatment: a practical study. Nurse Educ Today 2019 Aug;79:92-97. [doi: <u>10.1016/j.nedt.2019.05.008</u>] [Medline: <u>31112846</u>]
- Lim WC, Haslam RL, Ashton LM, Fenton S, Collins CE. Motivations of learners enrolled on a Massive Open Online Course – 'The Science of Weight Loss: Dispelling diet myths'. Health Educ J 2024 Mar;83(2):150-160. [doi: 10.1177/00178969231225060]
- Molinillo S, Aguilar-Illescas R, Anaya-Sánchez R, Vallespín-Arán M. Exploring the impacts of interactions, social presence and emotional engagement on active collaborative learning in a social web-based environment. Comput Educ 2018 Aug;123:41-52. [doi: <u>10.1016/j.compedu.2018.04.012</u>]
- 54. Aydin CH. MOOCs as change agents. The 2018 OpenupEd Trend Report on MOOCs. 2018. URL: <u>https://www.openuped.eu/</u> <u>images/Publications/The\_2018\_OpenupEd\_trend\_report\_on\_MOOCs.pdf</u> [accessed 2025-06-20]
- 55. Jia M, Gong D, Luo J, Zhao J, Zheng J, Li K. Who can benefit more from massive open online courses? A prospective cohort study. Nurse Educ Today 2019 May;76:96-102. [doi: <u>10.1016/j.nedt.2019.02.004</u>] [Medline: <u>30776535</u>]
- 56. Shorey S, Ng ED. The use of virtual reality simulation among nursing students and registered nurses: a systematic review. Nurse Educ Today 2021 Mar;98:104662. [doi: <u>10.1016/j.nedt.2020.104662</u>] [Medline: <u>33203545</u>]

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- 57. Hanshaw SL, Dickerson SS. High fidelity simulation evaluation studies in nursing education: a review of the literature. Nurse Educ Pract 2020 Jul;46:102818. [doi: <u>10.1016/j.nepr.2020.102818</u>] [Medline: <u>32623148</u>]
- 58. Üzen Cura Ş, Kocatepe V, Yıldırım D, Küçükakgün H, Atay S, Ünver V. Examining knowledge, skill, stress, satisfaction, and self-confidence levels of nursing students in three different simulation modalities. Asian Nurs Res (Korean Soc Nurs Sci) 2020 Aug;14(3):158-164. [doi: 10.1016/j.anr.2020.07.001] [Medline: 32653666]
- 59. Karataş Ç, Tüzer H. The effect of simulation-based training on the self-confidence and self-satisfaction of nursing students dealing with patients under isolation. Bezmialem Science 2020 Jul 1;8(3):227-232. [doi: <u>10.14235/bas.galenos.2019.3416</u>]
- 60. Alsaraireh A, Madhavanprabhakaran G, Raghavan D, Arulappan J, Khalaf A. Effect of a high-fidelity simulation-based teaching-learning experience (SBTLE) on maternal health nursing students' knowledge of postpartum hemorrhage, confidence, and satisfaction. Teach Learn Nurs 2024 Jan;19(1):e176-e181. [doi: 10.1016/j.teln.2023.10.009]
- 61. Foronda CL, Fernandez-Burgos M, Nadeau C, Kelley CN, Henry MN. Virtual simulation in nursing education: a systematic review spanning 1996 to 2018. Simul Healthc 2020 Feb;15(1):46-54. [doi: <u>10.1097/SIH.000000000000411</u>] [Medline: <u>32028447</u>]
- Bernacki ML, Greene JA, Crompton H. Mobile technology, learning, and achievement: advances in understanding and measuring the role of mobile technology in education. Contemp Educ Psychol 2020 Jan;60:101827. [doi: 10.1016/j.cedpsych.2019.101827]

#### Abbreviations

COPD: chronic obstructive pulmonary disease GOLD: Global Initiative for Chronic Obstructive Lung Disease ICT: information and communication technologies m-learning: mobile learning MOOC: Massive Open Online Course WHO: World Health Organization

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# The Effectiveness of a Question-Embedded Movie Clips Learning Program in Nursing Students: A Quasi-Experimental Pretest-Posttest Study

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# Abstract

**Background:** Technological innovations make significant impacts on nursing education. New teaching strategies are constantly emerging, offering students a dynamic and interactive educational experience. The Question-Embedded Movie Clips Learning program used in this study was developed based on the drill and practice learning principle, aiming to facilitate nursing students' skills and build their confidence before entering real clinical settings.

**Objective:** This study aims to investigate the comparative effect between the newly developed Question-Embedded Movie Clips Learning program and the current practice of mind mapping exercises on students' learning outcomes and study satisfaction.

**Methods:** This study adopted a quasi-experimental design using a pretest-posttest approach with nonequivalent groups. The study sample consisted of 132 third-year nursing students who enrolled in one of two class sections of the psychiatric nursing course at a university in Thailand. By flipping a coin, the first study section (n=62) was assigned to the intervention, and the second section (n=70) was assigned to the control group. During the 2-hour class sessions, students received identical learning structure and sequence, except for group exercises of either the Question-Embedded Movie Clips Learning program or the mind mapping. The data were collected through the pretest-posttest questionnaire, the perceived satisfaction with the learning experience scale, and the open-ended reflective questions.

**Results:** A statistically significant increase was observed in the learning outcome scores of both the intervention group ( $t_{61}$ =-30.48, 95% CI –10.59 to –9.28; *P*<.001) and the control group ( $t_{69}$ =-27.04, 95% CI –8.19 to –7.07; *P*<.001); all *t* statistics reported are based on 2-tailed tests. There was, however, a statistically significant difference in the outcome scores between the 2 groups. Even after controlling for pretest scores, students in the experimental group had a significantly higher adjusted mean score than those in the control group ( $F_{1,129}$ =67.67, *P*<.001).

**Conclusions:** The study has provided empirical evidence that using the Question-Embedded Movie Clips Learning program along with traditional instruction in teaching therapeutic relationships and communication significantly improves learning outcomes.

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#### **KEYWORDS**

web-based; embedded questions; video clips; therapeutic communication; nurse-patient relationship; nursing students

## Introduction

#### Background

An important skill set for nurses is interpersonal skills and communication. Mental health, in particular, is a branch of nursing that applies the therapeutic use of self and relationships as a means of bringing about positive health changes in patients. Despite being crucial for nursing care, many nursing students find learning interpersonal skills to be a challenge and struggle to establish therapeutic relationships with patients. As not all attributes of these complicated skills can be taught in lecture classrooms, nursing students express having difficulty learning

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them through conventional instruction and show preferences for more innovative, interactive, and practice-based strategies [1,2]. Nursing educators, therefore, need to shift from familiar teacher-centered teaching toward student-centered learning to provide an impactful educational experience.

Among studies aiming to identify the best teaching methods for clinical skill acquisition, there seems to be a consensus emerging about the importance of active learning and student engagement. Cumulative evidence strongly supports the benefit of incorporating instruction that is self-directed, reflective, immediate, stimulating, and experientially immersive to produce a constructive impact on students' learning outcomes [3].

Pedagogical strategies that carry labels such as student-directed education, process-oriented instruction, or experiential and authentic learning are increasingly being explored by nurse educators. As a result, innovative teaching, including simulation-based learning, flipped classrooms, artificial intelligence-based training, and web-based learning platforms with augmented or virtual reality are gradually being embraced as methods to prepare nursing students to meet professional demands [4,5].

Learning therapeutic communication effectively involves tailoring instruction to different learning styles and using a variety of teaching methods. By acknowledging and supporting learning preferences, student engagement and desirable learning outcomes can be ensured. Recent review studies highlighted the preference of kinesthetic and multimodal to be the most dominant learning style among undergraduate nursing students [6-8]. Several studies have also explored the issue of learning styles among Thai nursing students. A descriptive study examined the learning styles of 177 Thai nursing students using the Felder and Solomon index and found that most students (89.8%) were sensing learners who prefer to learn from observation, action, and problem-solving in gradual stages [9]. The result corresponded with studies reporting the majority of Thai nursing students' preference for multimodal learning of visual, auditory, read or write, and kinesthetic learning [10-12] with participative learning style being most prevalent [13]. Accordingly, this study incorporates movie-based case studies, embedded practice questions, and group work for learning strategies. Movie clips were used as real-world examples to promote critical thinking and reinforce practical skills through problem-solving. Additionally, group work and in-class presentations can promote active involvement, peer discussions, and knowledge sharing.

In Thailand, 7 studies on the use of innovative teaching strategies were found particularly relevant to teaching nursing students therapeutic communication. Two studies using standardized patient simulation reported positive effects on students' learning outcomes and satisfaction with mental health and psychiatric nursing courses [3, 14]. Another 3 studies used computer-assisted instruction to create online lessons and found that students had higher scores on learning achievement, perceived efficacy, and communication skills compared to students in the control group, who received conventional lectures [15-17]. Two of the studies explored using integrated digital technologies to provide an immersive learning experience for teaching therapeutic relationships and management of psychiatric patients in specific situations. The first study used augmented reality applications on smartphones and reported a high level of student satisfaction after the study [18]. The other study that used a virtual reality learning program found that students had higher scores on attitudes and confidence in managing patient aggression [19].

The current format for teaching interpersonal skills and therapeutic communication is text-based lectures combined with mind mapping group exercises. From the 2020-2022 academic year, mind mapping has been used as the standard teaching method for this topic. While exam results are satisfying for all learning requirements, the majority of nursing students who

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have completed the course feel that they have insufficient knowledge to effectively engage in therapeutic relationships with the patients. These difficulties in transferring theoretical knowledge into clinical practice are viewed as major obstacles in nursing education [20]. As lectures can make learning relatively superficial and transient, active learning strategies are needed. Though innovative strategies are being adopted by Thai nurse educators, the methods are restricted to tutorial and simulation use; other training strategies such as drill and practice and problem-solving instructions have not yet been studied for their effectiveness. To overcome the limitation of traditional text-based teaching, the Question-Embedded Movie Clips Learning (QEMCL) program used in this study was designed based on drill and practice, as well as instructional game principles. The aim of the study is to examine the effectiveness of the QEMCL program on nursing students' satisfaction and learning outcomes on the therapeutic use of self and communication skills.

#### **Theoretical Framework**

This study used the Classroom Action Research framework based on the Plan-Do-Check-Act cycle to make continuous teaching improvements. The cycle begins with the "PLAN" stage, which deals with preparing class lessons. The "DO" stage involves teaching the lesson, engaging in learning activities, and assigning work. The "CHECK" is to assess learning outcomes and make recommendations for improvements, and the "ACT" stage is the use of the improved teaching strategies in the classroom. Presenting the findings, or outcomes, of this learning project correlates with the "CHECK" stage, which aims to check whether what had been planned in the first stage has been achieved. The recommendations of this study are related to the "ACT" stage, which aims to improve the learning outcome of the lesson [21].

Literature reviews on studies examining the effectiveness of educational interventions for medical and nursing students' therapeutic communication skills have been widely conducted [22-25]. These reviews, however, primarily focused on summarizing educational programs, while only a few studies included a description of a theoretical framework. A more recent systematic review found that employing Jonassen's constructivist learning environments (CLEs) [26] can effectively promote the therapeutic communication education of nursing students and, therefore, was recommended for nurse educators [27]. The CLE instructional design postulates that students learn best by solving practical problems to integrate new knowledge into what they already know. Adopting this approach, this study was planned in accordance with CLE elements by providing problem-based case scenarios with the use of videoclips as cognitive tools and lecture clips as related information resources. A modeling instructional method was used, with the movie character acting as a role model illustrating the use of therapeutic communication techniques. With the constructivist approach, the teaching method of this study was designed to encourage critical thinking, problem-solving, and collaborative learning among nursing students.

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# Methods

#### **Ethical Considerations**

This study was approved by the ethics committee of Khon Kaen University (no. HE 662147). The participants consisted of nursing students from the Faculty of Nursing at Khon Kaen University. Students were offered the opportunity to join the study voluntarily, with the assurance that their participation would not affect their academic standing or grades. Informed consent was obtained from all study participants. Participants were assigned code numbers for all data entry purposes. The participant-to-code number list was then destroyed after all study data had been collected. No compensation was provided to participants for participating in this study.

#### Sample and Setting

Using the effect size of computer-based education on nursing knowledge from an earlier study [28], the power analysis yielded at least 59 participants, with an effect size of 0.43, a significance level of 0.05, and a power of 0.9. The inclusion criteria were (1) being enrolled in the psychiatric nursing course, (2) having access to a device (smartphone, tablet, or computer) that can perform online tasks, and (3) agreeing to participate in the study. The exclusion criteria were retaking the psychiatric nursing course. There were 132 third-year nursing students enrolled in one of two sections of the psychiatric nursing course at Khon Kaen University for the 2023 academic year who met the inclusion and exclusion criteria. For practical reasons and to ensure a comprehensive analysis, all 132 students were recruited to participate in the study on a voluntary basis.

#### **Recruitment and Data Collection**

The recruitment process started 2 weeks prior to the class date. By flipping a coin, students in the first study section (n=62) were assigned to the intervention, and those in the second section (n=70) were assigned to the control group. In the process of informed consent, students were informed about their potential placement in either an intervention or an active comparison group. Adobe Acrobat Sign was used to obtain online digital signatures of students' informed consent. By using codes, students' identities were not directly disclosed to ensure privacy and confidentiality. All students gave their permission to be part of the study and signed their consent to participate. To ensure structural consistency, both groups received a 30-minute self-study online lecture, took the pretest within 24 hours prior to the class session, and participated in a 2-hour class session. The class time for both groups was on the regular learning schedule that runs along the academic semester, so there was no interference with students' other learning that potentially affected their focus and willingness to engage. During the class sessions, students received identical learning materials and sequences, except for group exercises of either the QEMCL program or mind mapping. Class sessions for both sections were held on the same day, scheduled during consecutive time periods (8 - 10 AM for the first study section and 10 - 12 PM for the second study section), and led by the same instructor. Students in both groups took the posttest and filled out the satisfaction scale and open-ended reflective questions within 24 hours after class (see Figure 1). All tests were scheduled at the same time using the university's online examination administering system.



Figure 1. The flowchart of the research procedure. KKU: Khon Kaen University; QEMCL: Question-Embedded Movie Clips Learning program.



#### Instruments

There were 3 instruments used for data collection. The first was the QEMCL program, which is an interactive web-based learning program using question-embedded short movie clips that illustrate therapeutic relationships and communication techniques. This program is composed of short clips from 3 movies, each highly acclaimed for educational use: Good Will Hunting [29], Ordinary People [30], and The Prince of Tides [31]. Researchers selected 7 - 8 sequential clips from each movie, corresponding to the typical number of psychotherapy sessions. Each clip had 7 - 8 questions embedded in it, making a total of 53 - 62 questions per movie. The questions were organized to foster students' reflective activities, encourage them to identify with characters, and stimulate their clinical judgment. Interactive functions provided in the program to enhance active practice and skill development include immediate feedback with short contextual explanations, real-time scoring, and summative tests with certificates of accomplishment. The content validity of study questions was evaluated by 3 experts in the field, yielding an index of item-objective congruence (IOC) of 0.85. The program had an index of process and output efficiency (E1/E2) of 85/82.6. Details of the QEMCL program development and the evaluation of its efficiency have been reported elsewhere [32].

Only *Good Will Hunting* was selected for this study as the intervention group class exercise due to its coherent run-time and the 2-hour class period limitation. There were 7 selected scenes—Scene 1: First meeting; Scene 2: It's your turn to move; Scene 3: Super philosophy; Scene 4: Regrets; Scene 5: What

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XSL•F() RenderX do you want to do?; Scene 6: It's not your fault; and Scene 7: Do what your heart tells you. These scenes were chosen as they capture the essence of how phases of the therapeutic relationship can be constructed through therapy sessions [33]. Scene 1 portrayed the initial phase of the relationship with the important concept of mistrust along with the power of therapeutic authenticity and genuine connection. Scene 2 represented the identification phase where the therapist shows unconditional positive regard, respect, and empathy that creates a safe environment for therapeutic engagement. Scenes 3 through 5 depicted the working phase in which the therapist employs a delicate balance of self-disclosure, compassion, and directness to challenge the client's defense mechanisms. Scenes 6 and 7 portrayed how the therapist was working toward the termination phase, where masterful uses of active listening, nonjudgmental acceptance, and inducing emotional catharsis are illustrated to help the client explore his experiences, gain insights, overcome his emotional wounds, and find his purpose in life.

As *Good Will Hunting* is an American film, language barriers can be a concern. Additionally, the portrayal of American culture, including its values and beliefs, may be unfamiliar to students from different backgrounds. To overcome these challenges, the Thai subtitles were provided so that students could follow the story efficiently and be able to focus on the characters' behaviors and intentions. Although cultural differences undoubtedly shape language styles, the interpretation of meaning should not be reduced to stereotypical thinking, but instead to develop awareness, respect, sensitivity, and curiosity to understand value orientations. To facilitate culturally
responsive learning, students were asked, as part of group exercises, to identify the scenes they thought showed some aspect of American culture, analyze the different styles of communication, and propose alternative approaches from another cultural perspective. Using these teaching activities, the film can be a valuable resource in helping students recognize culturally influenced behavior and apply the communication strategies depicted in the movie to their own nursing practice.

The second instrument was a 30-item multiple-choice structured pretest-posttest questionnaire developed by the researchers. This questionnaire consists of 3 subscales measuring students' learning outcomes of memorization, understanding, and applied knowledge. The possible score range was 0 to 30 points. The reliability of the questionnaire was confirmed using the test-retest method with an intraclass correlation coefficient of 0.84. The third instrument was a 10-item scale designed by the researchers to assess students' perceived satisfaction with the learning experience. Each item featured a 5-point Likert scale ranging from strongly satisfied to strongly dissatisfied with a possible score from 0 to 50. This measure consists of 3 subscales of the learner's usability, learning content, and the system and function. The pilot test of this scale yielded a Cronbach  $\alpha$ coefficient for internal consistency of 0.83. Finally, 2 open-ended reflective questions were used to evaluate students' intention to recommend learning exercises to others as well as their perceived benefits and limitations of the exercises.

#### **Statistical Analysis**

Data were analyzed with descriptive statistics, chi-square test, *t* test, and analysis of covariance (ANCOVA) using Stata 16.1. To check for ANCOVA assumptions, the homogeneity of regression slopes was examined. A nonsignificant interaction between pretest scores and groups (P=.21, 95% CI –0.52 to 0.11) was found, suggesting that the slopes of regression lines for the control and intervention groups were the same. For the homogeneity of variances, Levene test results indicated that the variances were equal across the 2 groups ( $F_{1,130}$ =0.7, P=.4). Additionally, the normality of residuals was confirmed by the q-q plot, the kernel density histogram, and the Shapiro-Wilk test ( $w_{132}$ =0.98, P=.12).

# Results

Before analyzing the outcome differences, descriptive statistics of each variable were performed. Table 1 presents the results of the homogeneity test for students' general characteristics. The average ages of students in the intervention and control groups were 21.61 (SD 0.75) and 21.53 (SD 0.58), respectively. There were higher percentages of women than men in both the intervention group (60/62, 97%) and the control group (63/70, 90%). No significant difference, however, was observed in either mean age ( $t_{130}$ =-0.72, two-tailed, 95% CI -0.32 to 0.15;

P=.47) or proportion of gender ( $\chi^2_1$ =2.4, P=.12).

 Table . Demographics of the participants in the intervention and control groups.

Variable	Control group (n=70)	Intervention group (n=62)	Statistic test
Age (years), n (%)			$t_{130}$ =-0.72 <sup>a</sup> , 95% CI -0.32 to 0.15; P=.47
21	36 (51)	31 (50)	
22	31 (44)	27 (44)	
23	3 (4)	1 (2)	
24	0 (0)	3 (5)	
Mean (SD)	21.61	21.53	
Gender, n (%)			$\chi^2_1$ =2.4, <i>P</i> =.12
Male	7 (10)	2 (3)	
Female	63 (90)	60 (97)	

<sup>a</sup>Independent 2-tailed *t* test.

As shown in Table 2, the learning outcome scores and students' satisfaction of both groups were compared. The average pretest scores of the intervention group (n=62) and the control group (n=70) were not statistically different ( $t_{130}$ =0.3, 95% CI –0.51 to 0.67; *P*=.77). The *t* statistics reported elsewhere are based on 2-tailed tests. Compared to the control group, the intervention group had a larger increase between pretest and posttest, with significantly different posttest scores ( $t_{130}$ =-8.23, 95% CI –2.75 to –1.68; *P*<.001). The overall satisfaction scores of both the

intervention and control groups were high, with each item ranging from 4 to 4.8. There was, however, a significant difference in student satisfaction scores between the 2 groups ( $t_{130}$ =-2.93, 95% CI -3.24 to -0.63; *P*<.001). The students in the intervention and control groups were most satisfied with the learner's usability (mean 4.52, SD 0.5; mean 4.31, SD 0.51), system and function (mean 4.24, SD 0.51; mean 4.05, SD 0.55), and learning content (mean 4.11, SD 0.44; mean 3.92, SD 0.43), respectively.

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Table .	Comparison	of the	learning	outcome	and	student	satisfaction.
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Variable	Control group (n=62), mean (SD)	Intervention group (n=70), mean (SD)	Independent $t$ test <sup>a</sup>
Learning outcome			
Pretest	15.43 (1.83)	15.34 (1.60)	<i>t</i> <sub>130</sub> =0.3, 95% CI –0.51 to 0.67; <i>P</i> =.77
Posttest	23.06 (1.41)	25.27 (1.68)	<i>t</i> <sub>130</sub> =-8.23, 95% CI -2.75 to -1.68; <i>P</i> <.001
Paired $t$ test <sup>a</sup>	<i>t</i> <sub>69</sub> =–27.04, 95% CI –8.19 to –7.07; <i>P</i> <.001	<i>t</i> <sub>61</sub> =–30.48, 95% CI –10.59 to –9.28; <i>P</i> <.001	
Student satisfaction	40.76 (3.67)	42.69 (3.93)	<i>t</i> <sub>130</sub> =-2.93, 95% CI -3.24 to -0.63; <i>P</i> <.001

#### <sup>a</sup>Two-tailed.

To avoid any potential difference in the respondents' levels of knowledge at the beginning of the study, tests of ANCOVA were conducted to examine the comparative effects of the QEMCL and mind mapping strategies on student posttest scores, with students' pretest scores as the covariate. The results indicate that there was a significant difference in learning outcomes between the 2 groups, with  $F_{1,129}$ =67.67, P<.001. As shown in Table 3, after controlling for pretest scores, the posttest scores were related to the group variable. Students in the QEMCL group had a significantly higher adjusted mean score (mean

25.27, SD 0.19) than those in the mind mapping group (mean 23.06, SD 0.18). Moreover, the partial eta square ( $\eta^2$ ) values provided information about the effects of the pretest and the groups on the posttest scores. The effect size of the group on the posttest was 0.3441, meaning the group variable explained 34.2% (160/465) of the posttest learning outcome after removing the variation explained by the pretest. On the other hand, the effect size of the pretest was 0.0165, which means approximately 1.7% (5.11/310.11) of the posttest variance was explained by the pretest.

Table . Results of ANCOVA<sup>a</sup> test for mean scores of learning outcomes.

Variable	Partial sums of squares	Degrees of freedom	Mean square	F test	Significance	Partial eta-square
Model	166.72	2	83.34	35.26	.000	0.3534
Groups	160.00	1	160.00	67.67	.000	0.3441
Pretest score	5.11	1	5.11	2.16	.144	0.0165
Residual	305.00	129	2.36	b	—	_
Total	471.72	131	3.60	_	_	_

<sup>a</sup>ANCOVA: analysis of covariance.

<sup>b</sup>Not applicable.

As for the question about the students' intention to recommend learning exercises to other students, 62 (100%) students of the intervention group (n=62) indicated that they would recommend the QEMCL program to others, while 59 (84%) of those in the control group (n=70) did so for the mind mapping activity. In the intervention group (n=62), 54 (87%) students stated that the QEMCL program was highly beneficial to their learning, and 8 (13%) stated that it was somewhat beneficial. In the control group (n=70), only 46 (66%) and 23 (33%) students, respectively, gave the mind mapping exercise the same ratings. No students stated that either learning activity was of small benefit or no benefit at all to their learning. Table 4 presents key quotations excerpted from the open-ended responses regarding the perceived benefits and limitations of the learning exercises. The benefits included (1) improving learning efficiency, (2) thought provoking, (3) enhancing understanding, and (4) inspiring self-directed learning. The limitation was an inadequate application feature. Students' reflections on learning experiences also revealed significant implications that teachers should design interactive learning programs. Specifically, students defined the benefits of the program associated with its capacity to foster deep learning and enhance memory content, reduce anxiety, and increase motivation, as well as the simplicity of use. Reported program limitations were associated with the small number of movies and with technical problems.

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Table . Students' reflections on learning experience.

QEMCL <sup>a</sup>	Mind mapping

b

#### Perceived benefits

Improving learning efficiency

- "Repetitive learning through the exercise helps me to see the same thing from different angles and start to recognize a pattern, and that, for me, brings out clarity." [ID#0128]
- "The clips provided context of when, why, and how to use particular communication techniques." [ID#0156]

#### Thought provoking

- "You don't know what to say to your patients, until you hear it from the experts. It can, at least, get you start before you can find your own (words)." [ID#0154]
- "The movie gets me prepared of all the possible challenging situations I might face during the encounter with patients. Especially the violent behaviors at the beginning. Yeah, I think that's what I get the most from the movie, how to get past all the mistrust before being able to work on real problems." [ID#0134]

Enhancing understanding or disputing the misunderstanding

- "I don't think I can ever understand (the concept of) "abreaction" from reading. Even after seeing it from the movie, it's still hard to describe in words." [ID#0151]
- "The movies give me a realistic picture of therapeutic relationship." [ID#0107]
- "Depression or aggressiveness, they all sound the same to me from the lecture, until I saw the clips and had to answer the question, then, I could tell them apart." [ID#0115]
- "I used to think that I have to always say smart things, give recommendations for patients to solve their problems, you know, being a superior one for them to depend on. But Dr. McGuire did the opposite, he had so many chances to tell Will what is the right thing to do, but he didn't. Instead, he asked and waited for the answer from Will, even when Professor Lambeau asked him to tell Will what to do. That makes me realized that I was wrong, and I need to figure out what is actually the purpose of therapeutic communication."

#### Promoting culturally responsive learning

- "I think grabbing patient's neck is not an acceptable manner for the therapist to do, but that might happen to anybody when you lost the temper, even for therapist, whether he's an American or Thai." [ID#0107]
- "I feel that the way Will talk to Dr. McGuire is not what I normally see in Thai patients. It's almost like talking back to someone you should pay more respect to." [ID#0142]

#### Inspiring self-directed learning

• "Immediate feedback and scoring make me learn faster, it's like you • have a personal tutor." [ID#0124]

#### Perceived limitations

Limited application features

The complexity of the infrastructure

• "Some of the provided explanations are too short. It'll be better to elaborate to some extent. Or even better, add the function that we (students) can ask for more explanation if needed." [ID#0157]

<sup>a</sup>QEMCL: Question-Embedded Movie Clips Learning. <sup>b</sup>Not applicable.

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- "It turns the boring and hard to understand textbook lessons into beautiful artworks that is a lot easier to pay attention to." [ID#0205]
- "Comparing your work with those of other groups helps to correct the misunderstandings and highlight importance issues." [ID#0252]

- "By trying to identify key concepts, sorting them into categories, and linking them together to get a comprehensive picture, the class content has been simplified so that it is easy to understand and memorize." [ID#0221]
- "Pictorial illustrations make abstract concepts perceptible and manageable." [ID#0256]
- "Mind maps help connect concepts and makes the dispersed detailed become one conforming theme." [ID#0260]

"You can keep the (mind map) work for review before exam." [ID#0229]

# Discussion

#### **Principal Findings**

The results of this study showed increased posttest scores for both the QEMCL (intervention) and mind mapping exercise (control) groups. The implementation of both learning methods is, therefore, supported for improving students' learning outcomes on therapeutic use of self and communication. However, there was a significant difference between the posttest scores of the 2 groups after controlling for the effect of pretest scores. The difference was in favor of the experiment group, indicating a higher learning achievement by the OEMCL group (P<.001). The effect size of 0.3441, as measured by partial eta square, was quite large, with 34.4% (160/465) of the difference in variance explained by overall learning. This magnitude of effect is consistent with previous meta-analysis studies, which have shown positive computer-based education effects on knowledge ranging from 0.24 to 0.43 [28,34]. The results suggest that QEMCL can be used as a teaching tool to improve upon traditional teaching strategies.

Both groups showed significant differences between pretest and posttest scores, suggesting that the 2 approaches are both powerful instructional tools for nurse educators. This finding is in line with previous studies that support the benefit of using mind mapping and film-based learning strategies. The focus on classification and memorization makes the mind mapping exercise particularly beneficial to students' ability to process and absorb new knowledge [35]. As students create mind maps, they learn to retrieve keywords, conceptualize learning content, and organize their thinking to generate comprehensive illustrations [36,37]. Moreover, students' enjoyment of generating artistic drawings facilitates their emotional engagement and memory retention [38,39]. Similarly, the movie clips in the QEMCL program enable students to envision themselves engaging in therapeutic relationships with patients. The exercise provides visual tools that help students learn by watching the clips, and then analyzing and exchanging their thoughts with others. This art-based learning method has been described as a Visual Thinking Strategy (VTS). By stimulating visual areas of the brain, the VTS allows students to describe, analyze, and interpret information through observing and discussing mind map images and movie scenarios [40].

Though the learning outcome effects were significant within both the intervention and control groups, the difference in learning outcomes between the 2 groups was also significant, suggesting the superiority of the QEMCL over mind mapping. This finding can be explained as follows: a picture may be worth a thousand words, but it cannot tell the whole story. Stories make the nurse-patient relationship and the context of using therapeutic techniques become apparent. Movie plots depict how clinical situations change and unfold over time. The mind mapping exercise may be able to stimulate visual thinking, but the QEMCL goes further by using storytelling to reinforce critical thinking. This narrative pedagogy helps students to think through and interpret situations they encounter from multiple perspectives and to understand clinical reasoning as a complex process [41,42]. With *Good Will Hunting*, the therapeutic relationship between Will Hunting and Dr Sean Maguire became vividly presented to students [ID#0107, 0115, and 0151]. The students learn how the therapist gets through the initial phase of the relationship with challenging situations from the patient's mistrust [ID#0134]. Movie clips illustrate the effective use of techniques that open up opportunities for students to imitate and become accustomed to therapeutic communication [ID#0154 and 0156]. In addition, the clips provided thought-provoking ideas for students to reconsider prior misunderstandings and work on gaining new knowledge [ID#0134]. Finally, the clips directly expose students to diverse communication styles, teaching them to respect diversity and adapt their ways to suit culturally specific gestures [ID#0107 and 0142].

Previous studies support that dynamic visual media, such as videoclips, improve the processing and understanding of information by engaging both hemispheres of the brain. As the left side processes the dialogue, plot, rhythm, and lyrics, and the right side processes the visual images, sound effects, and harmonic relationships, videoclips capture students' attention and stimulate thinking more quickly and more effectively than direct statements, setting out concepts, or straight course material [43]. Furthermore, compared to the noninteractive mind mapping exercise, interactive features of QEMCL such as stopping and replaying videoclips, getting feedback, and tracking personal progress allow students to personally distribute their attention and cognitive resources across the videos. The selected scenarios with embedded questions encourage students to think critically, correct their misunderstandings, and develop their own communication strategies. This participatory instructional strategy creates a constructive learning environment in which students are active participants who engage in problem-based and transformative learning. Students can advance at their own pace and in harmony with their unique cognitive skills and needs [44]. The QEMCL is, then, promising to facilitate procedural learning of discrimination, concept application, and rule-using, which are subskills of Bloom's psychomotor domain [45].

Considering themes emerging from students' reflection, those in the mind mapping group used keywords such as identifying key concepts, sorting those concepts into groups, placing them in classified orders, and linking them together to get a comprehensive picture. Those in the QEMCL group, on the other hand, used terms such as identifying proper concepts in a given scenario, differentiating among similar concepts, distinguishing principles applied in particular situations, clarifying the rationale for the choice of action, and discriminating between possible responses in various situations. Bloom's taxonomy categorizes 6 levels of cognitive complexity: knowledge, comprehension, application, analysis, synthesis, and evaluation [45]. Students' reflections indicated that the mind mapping exercise helped them memorize class content as organized structures and details, suggesting cognitive learning outcomes mostly at the knowledge level. Students in the other group stated that the QEMCL provides vivid examples of how to interpret patient behaviors and select different responses for the best probable outcome based on details unique to specific situations. Such reflection indicates that their learning outcomes were at the comprehension and application levels. This explanation is consistent with their higher posttest scores on

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the subscale of understanding (mean 8.53, SD 0.9; mean 7.41, SD 0.88) and applied knowledge (mean 8.77, SD 0.97; mean 7.47, SD 0.97), while the control group scores higher on the memorization subscale (mean 8.17, SD 1.05; mean 7.97, SD 0.9).

#### Limitations

First, the knowledge test questions were identical for pre- and posttest, which could allow for familiarity with the questions. To minimize the testing effect, alternative measures with equivalent difficulty of the outcome variable should be used for repeated assessment. Second, even though the pretest score was statistically controlled as a covariate variable, other potential confounding variables such as prior academic performance in relevant courses should also be considered to ensure the validity of the results. Third, students in the second section who have the class from 10 AM to 12 PM may experience fatigue, reduced concentration, or cognitive overload, as they already had another class compared to those in the first section who had the class from 8 to 10 AM. Finally, the findings of this study have limited generalizability because the sample included nursing students from only one university. Therefore, further studies using nationwide systematic sampling are highly recommended.

#### Conclusions

As instructional approaches are designed for varying purposes, identifying the best teaching strategies to promote nursing

students' engagement in academic and clinical settings has always been a challenge for nursing educators. While conventional text-based or lecture-based classroom environments facilitate students' learning by listening, the mind mapping and the QEMCL exercises provide visual thinking tools that help students organize class content. The mind mapping exercise can help students organize their thoughts in a way that is easy to refer back to and build upon, while the QEMCL puts students in contact with realistic hypothetical situations and allows them to learn through observation, accumulating practical experience they will be able to integrate into real situations. Nursing education should not only promote students' theoretical thinking but also improve their implicit knowledge and clinical skills. Incorporating computer-based drills and practice lessons with traditional class structures appears to be an effective pedagogical methodology, especially for lessons with limited class time. With the readiness of the university's online support system and the simplicity of the application, the current learning program was implemented as planned with all students following study instructions. Given the easy identification of and access to appropriate material in this age of online learning, the use of the QEMCL program should be encouraged. Based on the current findings, we can conclude that QEMCL is both an enjoyable and effective teaching tool, yielding significantly higher learning gains than mind mapping exercises.

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#### **Authors' Contributions**

CC led the development of the study by drafting the protocol and the initial data collection tools. Both CC and JS contributed to the data collection and the statistical analysis. CC was responsible for drafting the manuscript while JS provided critical feedback about the study design, data collection, analysis, and reporting. Both authors have contributed to the preparation and review of the paper and agreed on the final version.

#### **Conflicts of Interest**

None declared.

Checklist 1 CONSORT-eHEALTH checklist (V 1.6.1). [PDF File, 1259 KB - nursing\_v8i1e71111\_app1.pdf]

#### References

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- Ghasemi MR, Moonaghi HK, Heydari A. Strategies for sustaining and enhancing nursing students' engagement in academic and clinical settings: a narrative review. Korean J Med Educ 2020 Jun;32(2):103-117. [doi: <u>10.3946/kjme.2020.159</u>] [Medline: <u>32486620</u>]
- Phillips BC, Johnson J, Khalid N, Zapparrata N, Albright G. Benefits of an online interactive educational program over traditional textbooks. Nurse Educ 2023;48(5):270-275. [doi: <u>10.1097/NNE.00000000001398</u>] [Medline: <u>36881473</u>]
- 3. Stanley MJ, Hall K. A paradigm shift for the nursing education model: a scoping review. J Nurs Educ 2024 Mar;63(3):141-147. [doi: 10.3928/01484834-20240108-08] [Medline: 38442398]

- Fernández-Alcántara M, Escribano S, Juliá-Sanchis R, et al. Virtual simulation tools for communication skills training in health care professionals: literature review. JMIR Med Educ 2025 May 6;11(1):e63082. [doi: <u>10.2196/63082</u>] [Medline: <u>40327882</u>]
- Stamer T, Steinhäuser J, Flägel K. Artificial intelligence supporting the training of communication skills in the education of health care professions: scoping review. J Med Internet Res 2023 Jun 19;25(1):e43311. [doi: <u>10.2196/43311</u>] [Medline: <u>37335593</u>]
- 6. Frantz J. Learning styles among nursing students, the implications for higher education institutions: a systematic review. SAJHE 2014;28(6). [doi: 10.20853/28-6-427]
- 7. Shumba TW, Iipinge SN. Learning style preferences of undergraduate nursing students: a systematic review. AJNM 2019;21(1). [doi: 10.25159/2520-5293/5758]
- 8. Almarwani AM, Elshatarat R. Understanding learning styles in undergraduate nursing programs of the Kingdom of Saudi Arabia: an integrative literature review. Open Nurs J 2022;16:e2209260. [doi: 10.2174/18744346-v16-e2209260]
- Wongtienlai K, Yaemsuda T, Kampak K, Mornthawee S. Learning styles and learning self-efficacy of nursing students at the Royal Thai Navy College of Nursing, Naval Medical Department. Procedia - Social and Behavioral Sciences 2015 Jul;197:1018-1022. [doi: 10.1016/j.sbspro.2015.07.297]
- 10. Thaewopia S, Tongnarong P, Wichai S. Learning style of nursing students at Boromarajonani College of Nursing Khon Kaen. J Nurs Health Care 2017;35(2):227-235 [FREE Full text] [FREE Full text]
- Tuicharoen J, Elter PT, Munsraket R, Sonthipumas I, Muenthaisong S. VARK learning styles of bachelor degree nursing students at Boromarajonani College of Nursing, Nakhon Ratchasima Province, Thailand. J Health Sci Thail 2020;29(6):1073-1085 [FREE Full text]
- 12. Wattanakul B, Karuncharernpanit S, Ngamkham S. The relationship between learning preferences and learning styles in undergraduate nursing students. TRC Nurs J 2021;14(2):283-297 [FREE Full text]
- 13. Hengudomsub P, Chaimongkol N, Toonsiri C. Learning styles and perceived academic self-efficacy among nursing students. Thai Pharm Sci J 2023;18(2):125-131 [FREE Full text]
- 14. Robkob W, Inchaithep S, Thinwang W. Development of learning outcomes based on learning and evaluation redesigned using standardized patient in simulation-based learning (SBL) in mental health and psychiatric nursing courses. J Health Sci Scholar 2022;9(1):228-252 [FREE Full text]
- Khumkom S. Effect of using smart educational media creator (SEMC) on learning achievement of nursing practicum of mental health and psychiatric and critical thinking among nursing students. J Nurs Educ 2015;8(4):126-139 [FREE Full text]
- 16. Christraksa W, Chetchaovalit T. The effect of computer assisted instruction entitled therapeutic relationship and communication for psychiatric patients on perceived efficacy among nursing students, Faculty of Nursing, Prince of Songkla University. J Res Nurs Midwif Health Sci 2019;39(1):53-65 [FREE Full text]
- 17. Kidhathong S, Tonkuriman A. Effectiveness of using multimedia as co-teaching on nursing students' knowledge and skills regarding the therapeutic relationships and communication. J Nurs Minist Public Health 2022;32(1):14-26 [FREE Full text]
- 18. Chaleoykitti S, Chiewsothorn S, Nuyleis Y. The development of an innovative learning method with augmented reality applications on smartphone. J Nurs Res Innov Health 2019;25(1):5-15 [FREE Full text]
- 19. Nuilers Y, Chiewsothorn S, Injui R. The effects of virtual reality learning program on attitudes and confidence in managing patient aggression of the Royal Thai Army nursing students. J Royal Thai Army Nurses 2022;23(1):140-149 [FREE Full text]
- 20. Hashemiparast M, Negarandeh R, Theofanidis D. Exploring the barriers of utilizing theoretical knowledge in clinical settings: a qualitative study. Int J Nurs Sci 2019 Oct 10;6(4):399-405. [doi: 10.1016/j.ijnss.2019.09.008] [Medline: 31728392]
- 21. Deming WE. Out of the Crisis: MIT Press; 2000.
- 22. Chua JYX, Ang E, Lau STL, Shorey S. Effectiveness of simulation-based interventions at improving empathy among healthcare students: a systematic review and meta-analysis. Nurse Educ Today 2021 Sep;104:105000. [doi: 10.1016/j.nedt.2021.105000] [Medline: 34146845]
- 23. Gutiérrez-Puertas L, Márquez-Hernández VV, Gutiérrez-Puertas V, Granados-Gámez G, Aguilera-Manrique G. Educational interventions for nursing students to develop communication skills with patients: a systematic review. Int J Environ Res Public Health 2020 Mar 26;17(7):2241. [doi: 10.3390/ijerph17072241] [Medline: 32225038]
- 24. Handeland JA, Prinz A, Ekra EMR, Fossum M. The role of manikins in nursing students' learning: a systematic review and thematic metasynthesis. Nurse Educ Today 2021 Mar;98:104661. [doi: 10.1016/j.nedt.2020.104661] [Medline: 33298327]
- 25. Kyaw BM, Posadzki P, Paddock S, Car J, Campbell J, Tudor Car L. Effectiveness of digital education on communication skills among medical students: systematic review and meta-analysis by the digital health education collaboration. J Med Internet Res 2019 Aug 27;21(8):e12967. [doi: 10.2196/12967] [Medline: 31456579]
- 26. Jonassen DH. Designing constructivist learning environments. In: Reigeluth CM, editor. Instructional-Design Theories and Models: A New Paradigm of Instructional Theory: Lawrence Erlbaum Associates; 1999, Vol. 2:215-241.
- 27. Hong S, Lee JY. Evaluation of therapeutic communication education for nursing students based on constructivist learning environments: a systematic review. Nurse Educ Today 2022 Dec;119:105607. [doi: 10.1016/j.nedt.2022.105607] [Medline: 36306635]

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- 28. Roh KH, Park HA. A meta-analysis on the effectiveness of computer-based education in nursing. Healthc Inform Res 2010 Sep;16(3):149-157. [doi: 10.4258/hir.2010.16.3.149] [Medline: 21818434]
- 29. Colorado Mountain College. Good Will Hunting [DVD].: Miramax Home Entertainment; 2000. URL: <u>https://cmc.marmot.org/</u> <u>Record/.b38116868</u> [accessed 2025-07-03]
- 30. Colorado Mountain College. Ordinary People [DVD].: Paramount Pictures; 1980. URL: <u>https://cmc.marmot.org/Hoopla/</u> <u>MWT12003682?searchId=788871853&recordIndex=3&page=1</u> [accessed 2025-07-07]
- 31. Colorado Mountain College. The prince of tides [DVD].: Columbia TriStar Home Entertainment; 2001. URL: <u>https://cmc.</u> marmot.org/Record/.b27713921?searchId=761100816&recordIndex=18&page=1 [accessed 2025-07-06]
- 32. Choenarom C, Juntapim S, Samputtanon J. The development of a question-embedded movie clips learning program for therapeutic use of self and communication in nursing students. Nurs Sci J Thail 2025;43(1):68-86 [FREE Full text]
- 33. Peplau HE. Peplau's theory of interpersonal relations. Nurs Sci Q 1997;10(4):162-167. [doi: 10.1177/089431849701000407] [Medline: 9416116]
- Feng JY, Chang YT, Chang HY, Erdley WS, Lin CH, Chang YJ. Systematic review of effectiveness of situated e-learning on medical and nursing education. Worldviews Evid Based Nurs 2013 Aug;10(3):174-183. [doi: <u>10.1111/wvn.12005</u>] [Medline: <u>23510119</u>]
- 35. Mammen JR. Computer-assisted concept mapping: visual aids for knowledge construction. J Nurs Educ 2016 Jul 1;55(7):403-406. [doi: 10.3928/01484834-20160615-09] [Medline: 27351610]
- 36. Abou Elazayiem Bayumi H, Aly Abd el Fatah Aly E, Ali Salem Maharem T, Mohammed Ahmed Mohammed E. Effectiveness of mind mapping strategy on nurses' knowledge and practice regarding infection control measures in operating room. Egyptian Journal of Health Care 2022 Mar 1;13(1):1981-1994. [doi: <u>10.21608/ejhc.2022.261311</u>]
- 37. Shrivastava SR, Shrivastava PS. From chaos to clarity: use of mind maps as a tool to ensure better learning among medical students. Indian J Community Med 2024;49(1):233-236. [doi: <u>10.4103/ijcm.ijcm\_312\_23</u>] [Medline: <u>38425952</u>]
- 38. Sajadi AS, Majd PM, Maroufi SS, Abolghasemi J. Mind mapping in recalling and retrieving core contents in anesthesia technology students. J Educ Health Promot 2023;12:397. [doi: <u>10.4103/jehp.jehp\_1423\_22</u>] [Medline: <u>38333160</u>]
- 39. Spencer JR, Anderson KM, Ellis KK. Radiant thinking and the use of the mind map in nurse practitioner education. J Nurs Educ 2013 May;52(5):291-293. [doi: 10.3928/01484834-20130328-03] [Medline: 23550549]
- Mata FR, Fernández-Donaire L, Canet-Velez O, Torralbas-Ortega J, Sastre-Rus M, Roca J. Nursing student learning of biosciences through movies and concept maps: a mixed study. Nurse Educ Today 2022 Oct;117:105480. [doi: 10.1016/j.nedt.2022.105480] [Medline: <u>35905596</u>]
- 41. McAllister M. Exploring transformative learning and the courage to teach a values based curriculum. Nurse Educ Pract 2015 Nov;15(6):480-484. [doi: 10.1016/j.nepr.2015.01.007] [Medline: 25662481]
- 42. Zhu Y, Bai Y, Wang A, Liu Y, Gao Q, Zeng Z. Effects of a death education based on narrative pedagogy in a palliative care course among Chinese nursing students. Front Public Health 2023;11:1194460. [doi: 10.3389/fpubh.2023.1194460]
- 43. Jääskeläinen IP, Sams M, Glerean E, Ahveninen J. Movies and narratives as naturalistic stimuli in neuroimaging. Neuroimage 2021 Jan 1;224:117445. [doi: 10.1016/j.neuroimage.2020.117445] [Medline: 33059053]
- 44. Malicki A, Vergara FH, Van de Castle B, et al. Gamification in nursing education: an integrative literature review. J Contin Educ Nurs 2020 Nov 1;51(11):509-515. [doi: 10.3928/00220124-20201014-07] [Medline: 33104811]
- 45. Bloom BS, Englehart MD, Furst EJ, Hill WH, Krathwohl DR. Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook 1 Cognitive Domain: Longmans; 1956.

#### Abbreviations

ANCOVA: analysis of covariance CLEs: constructivist learning environments IOC: item-objective congruence QEMCL: Question-Embedded Movie Clips Learning VTS: Visual Thinking Strategy

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# Supporting Web-Based Teaching and Learning of Virtual Care Skills and Competencies: Development of an Evidence-Informed Framework

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# Abstract

**Background:** Professionals across caring disciplines have played a significant role in the development of virtual care, which uses remote technologies to offer support and services from a distance. As virtual care becomes increasingly essential, instructors must ensure that students are equipped with both interpersonal abilities and digital competencies, merging traditional hands-on methods with web-based learning. Despite its growing importance, there is a lack of comprehensive frameworks to guide the design and delivery of web-based learning experiences that foster the development of virtual caring skills and competencies among students in caring professions.

**Objective:** This study aims to develop an evidence-informed framework to support web-based teaching and learning of virtual caring skills and competencies.

**Methods:** We present a synthesis of our research resulting in an evidence-informed framework. We integrated findings from an evidence synthesis, surveys, and semistructured interviews with students and educators, and consultations with key stakeholders.

**Results:** Principles of this framework include (1) connection and interaction; (2) compassion, empathy, and care; (3) vulnerability; (4) a client-centered focus; (5) inclusivity and accessibility; and (6) flexibility. The framework's four main domains are (1) virtual caring skills; (2) teaching and learning methods; (3) barriers to teaching, learning, and providing virtual care; and (4) facilitators of teaching, learning, and providing virtual care.

**Conclusions:** This framework was developed by and for students and educators to aid in planning, promoting, and enhancing virtual caring skills development. It can be used to better equip students to provide virtual care, thereby positively impacting client care and outcomes. This framework can support educators, students, decision makers, and practice partners to build learning experiences aimed at preparing students to provide virtual care effectively.

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#### **KEYWORDS**

virtual care; telehealth; telemedicine; education; distance; clinical competence; empathy; patient-centered care; educational technology; curriculum; health education

# Introduction

#### Background

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Professionals across caring disciplines, including educators, doctors, nurses, social workers, and allied health professionals, have played a crucial role in the global response to COVID-19 pandemic. The rapid shift toward virtual care, where care is provided remotely through information technologies, has placed an unparalleled burden on these caring professionals [1,2]. With

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virtual care practices now essential for health care delivery, it is imperative to educate current students in caring professions and expose them to the requisite interpersonal and technological competencies for effective virtual care. However, there are no comprehensive frameworks to support the development and implementation of web-based learning opportunities that help students in caring professions develop the required virtual caring skills and competencies.

#### **Caring Professional Education**

Caring professions, such as education, medicine, nursing, social work, and other allied health professions, are dedicated to supporting the health, well-being, development, education, and social needs of individuals and communities. These professions prioritize humanitarian objectives over material needs. Traditionally, education in caring professions relied on conventional methods such as face-to-face lectures, experiential in-class learning, and seminar formats. These educational approaches were often complemented by work-integrated learning placements, where students engaged with seasoned educators and practicing health professionals to acquire essential hands-on skills, dispositions, and competencies (eg, K-12 classrooms, hospital settings, and counseling centers) [3,4]. The landscape of education has evolved in caring professions due to advancements in technology and the emergence of virtual care. The integration of technology into education has opened new avenues for learning and skill development through web-based platforms, simulations, and virtual reality, for example, which supplement traditional teaching methods. The shifts to web-based and blended learning models have placed growing emphasis on fostering competencies related to virtual care, including effective communication through digital platforms, ethical considerations in telehealth, and leveraging technology to enhance client experiences and outcomes. While web-based education and some aspects of virtual care existed prior to the COVID-19 pandemic, the pandemic required everyone, irrespective of profession, location, or preference, to find new and inclusive ways of integrating web-based education and virtual care.

#### **Impact of COVID-19 Pandemic**

The COVID-19 pandemic necessitated an abrupt shift and expansion to virtual teaching, learning, and caring, prompting caring professional degree programs to adopt alternative strategies for providing students with necessary training experiences and learning opportunities [1,5,6]. This sudden transition placed unprecedented demands on higher education institutions to effectively instruct core competencies crucial to care provision and on caring professionals to ensure the meaningful implementation of virtual care in practice [1,4]. Despite long-standing literature emphasizing the need to support educators in meeting students' requirements [7,8], this need has become even more critical in the context of the COVID-19 pandemic [9].

This global crisis brought about significant changes in educational and care delivery methods, underscoring the importance of equipping caring professionals with the necessary skills to navigate current challenges and future uncertainties. Many educators in the caring professions encountered challenges in integrating effective web-based learning experiences, grappling with both technological and pedagogical hurdles as they prepared students for virtual work environments [10-13]. The pandemic prompted higher education institutions to reassess web-based education delivery within the caring professions and identify essential technological competencies for success in today's digital economy. The onset of COVID-19 pandemic emphasized the necessity for a structured, evidence-based

XSL•FO RenderX approach to develop and implement educational technologies in web-based teaching and learning contexts [2,10,14,15].

While some promising adaptations and strategies have been reported globally by higher education institutions [12,16-18], there is currently no empirical framework specifically designed for the web-based teaching and learning environment of caring professional education. Recent research underscores the need for such a framework to better understand the conditions fostering productive e-learning opportunities and to establish structured educational goals and methodologies that support the development of students' virtual caring skills [11,19-21].

While there is a pressing need for educators to promote the development of both interpersonal and digital skills essential for providing virtual care, incorporating digital technologies into web-based classrooms and virtual caring professional practice can increase the expenses, time commitment, energy, and effort needed to provide students with substantial educational experiences. Despite practical and educational hurdles associated with emerging technologies, faculty members can overcome these barriers by adopting a deliberate and strategic approach to their work. To our knowledge, no comprehensive frameworks have been developed or evaluated to outline the necessary conditions to create effective practices to foster productive e-learning opportunities to support the development of virtual care skills and competencies for students in caring professions.

#### **Research Aims**

The main aim of this research was to develop an evidence-informed framework supporting the teaching and learning of virtual caring skills and competencies. This framework can be used by (1) educators for planning, implementing, and evaluating teaching and learning strategies aimed at developing virtual caring skills and competencies; (2) students to assess their strengths and areas needing improvement in virtual caring skills and competencies; (3) institutional decision makers to inform key strategies related to teaching and learning virtual caring skills and competencies; and (4) employers to gain insight into the broad range of virtual caring skills and expertise that caring professionals can contribute to the workforce.

# Methods

#### **Data Sources**

We used an integrated knowledge translation approach [22] to develop our framework using a collaborative research model where researchers and knowledge users, including educators and students, worked together. Our multidisciplinary team included 2 students and 4 faculty members from diverse caring professions within the same institution. Together, we codeveloped the research questions, successfully secured research funding, and actively participated throughout the framework development process. In using this approach, which involved shared power and coproduction of knowledge, we aimed to generate more relevant and actionable findings with greater uptake across policy and practice. Our research used a mixed methods pragmatic approach [23], incorporating (1)

evidence synthesis, (2) surveys involving students and educators, (3) semistructured interviews with students and educators, and (4) consultations with key stakeholders.

#### **Evidence Synthesis**

We conducted a systematic review to identify web-based learning opportunities aimed at helping students in caring professions to develop and apply virtual caring skills and competencies in virtual caring environments. Our synthesis encompassed evidence from 38 studies, curriculum details, study outcomes, barriers and facilitators to technology integration, impacts on students, and effects on professional practice [24]. The findings from our review guided the formulation of surveys for students and educators, followed by subsequent semistructured interviews.

#### Surveys

Based on the results of our systematic review, we developed 2 surveys, 1 for students and 1 for educators, from caring professions within the same institution. These surveys included demographic items and questions about experiences with and perceptions of web-based teaching and learning technologies, instructional methods, and virtual caring skills. Items included closed and open text responses. Survey data were analyzed using descriptive statistics, with variations in distributions across the dataset summarized and presented in tables and graphs [25]. Inferential statistics were used to investigate potential relationships between demographic variables and satisfaction, preparedness, and the likelihood of using web-based teaching and learning technologies for developing virtual caring skills [25]. Open text responses were analyzed with interview data. There were 93 student and 82 educator survey respondents. The complete survey results are available in a separate publication [26,27].

#### Interviews

Students and educators in caring professions who agreed to be interviewed were purposively sampled based on survey results to ensure representation across disciplines, genders, and levels of experience. Semistructured interview guides consisted of open-ended questions designed to explore each participant's experiences and perspectives on web-based learning aimed at developing virtual caring skills and competencies. Interviews were conducted on the web via Zoom (Zoom Video Communications, Inc) and typically lasted between 20 and 45 minutes. All interviews were digitally recorded and transcribed verbatim for subsequent analysis. Data collection continued until all willing participants had completed their interviews. A total of 9 students and 8 educators participated in the semistructured interviews, which were thematically analyzed using an inductive approach to identify common interactive themes across the data [28,29]. The detailed findings from these interviews are published elsewhere [24].

#### **Mixed Methods Analysis**

Expanding upon our previous efforts and advancing from our prior research, we embarked on a process of cross-referencing our findings across different stages of the study using a mixed methods metamatrix [30]. This integration technique allowed us to comprehensively analyze all gathered data collectively. The implementation of a metamatrix enabled us to develop a robust visual framework, aiding in identifying patterns across various data types and establishing a clear documentation trail [30].

#### **Consultations With Knowledge Users**

Consultations with students and educators occurred iteratively throughout data collection, analysis, and framework development stages. During these consultations, which included presentations at national and international teaching and learning conferences, knowledge users were presented with emerging themes to solicit feedback on the relevance, gaps, and applicability of the framework. The feedback from knowledge users was collated by graduate student team members, shared with the broader research team, and integrated into the final framework.

#### Ethical Considerations

The institutional review board that granted the ethics approval for this study is the University of Calgary Conjoing Health Research Ethics Board (REB22-0748). Prior to participation, all participants were provided with a comprehensive consent form that provided a detailed explanation of the study, outlined the voluntary nature of the study, and reinforced participants' right to withdraw at any time, as well as any associated risks and benefits. All participants were assured that their confidentiality and privacy would be upheld in accordance with the ethics application. Informed consent was obtained from all study participants and no compensation was provided for participation.

# Results

#### Overview

The framework developed through this research process (Figure 1) is structured around 10 principles (outer ring) and consists of 4 major domains (center of framework), which are further divided into 18 subdomains. These subdomains encompass key considerations when teaching and learning virtual caring skills in web-based environments.



Figure 1. Virtual Caring framework.



#### **Principles for Teaching and Learning Virtual Caring** Skills

#### **Connection and Interaction**

Establishing connections and fostering interactions in virtual environments are crucial for building relationships, as the absence of such connections can noticeably diminish engagement. In virtual settings, dedicating time to understanding the perspectives and concerns of individual students, educators, colleagues, and clients becomes imperative, highlighting the crucial skill of fostering connections for caring professionals. Particularly in the context of virtual learning and caregiving practices, students and educators emphasize the importance of prioritizing personal connections with clients over technical and hands-on skills when delivering virtual care. Various methods, including in-class activities, group work, breakout rooms, allowing time for questions, sharing experiences, role-playing, and using multimodal content, can enhance

engagement and interaction. Educators can exemplify effective interaction strategies applicable to providing virtual care.

#### Compassion, Empathy, and Care

Creating learning experiences that prioritize compassion, empathy, and care, particularly in virtual settings, demands emotional labor and deliberate planning. Effectively integrating web-based teaching and learning technologies requires emotional bravery from educators to foster students' proficiency in virtual caring skills. Designing learning activities that center on social and emotional learning becomes crucial for promoting individual well-being. When it comes to teaching, learning, and offering virtual care, embracing and authentically displaying compassion, empathy, and care are fundamental elements.

#### **Vulnerability**

In adapting to new virtual environments, both students and educators should be open to exploring unfamiliar approaches, acknowledging that outcomes may not unfold as anticipated.



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The progress of virtual care may be hindered through a lack of willingness to embrace vulnerability or adopt novel strategies to provide care. Establishing safe and courageous learning and caring spaces is essential. Professionals in the caring field must cultivate a supportive atmosphere within virtual environments, breaking down barriers and nurturing relationships to advance virtual caring initiatives that meet clients' needs.

#### A Client-Centered Focus

Recognizing the importance of client-centeredness is crucial in virtual caring practices. In web-based learning and interactions, students and clients must perceive a sense of genuine care that prioritizes their well-being. A client-centered approach involves assessing individual client needs and adapting strategies to effectively address these within the virtual environment. This perspective not only informs the questions caring professionals may ask in these situations but also shapes the care provided to future remote clients. The pandemic has heightened our collective awareness of the intricate nature of human experiences, emphasizing the value of adopting a more holistic approach to the teaching and practice of virtual care.

#### Inclusivity and Accessibility

The advent of educational technology has enhanced inclusivity and accessibility in learning and caring, introducing innovative modes of engagement that are particularly beneficial for individuals who are members of marginalized groups. The transformative influence of online and virtual platforms in educational technology has significantly broadened the scope of inclusivity, accessibility, and equity in learning and caregiving. This technological advancement has expanded educational and caregiving opportunities to people residing outside urban areas, or managing diverse life responsibilities, or experiencing physical challenges, providing access that was previously limited. However, accessibility can still be hindered by challenges such as poor internet connectivity, limited web-based or computer literacy or access to appropriate electronic devices, and a lack of physical spaces conducive to web-based learning or accessing web-based care. As virtual caring continues to gain prominence in society and increases accessibility for some, it is important to recognize and support those who may find this mode of caregiving inaccessible.

#### Flexibility

Flexibility emerges as a fundamental principle in acquiring and applying virtual caring skills. The inherent nature of web-based learning provides crucial flexibility, allowing individuals to grasp content and skills at their preferred pace and schedule. This proficiency seamlessly extends to their virtual caring practice, empowering both students and clients to engage more effectively and customize their experiences according to their distinct needs and interests. Demonstrations of flexibility can manifest in various aspects, including accessibility, choice of topics, meeting times, and personalization of care.

## Four Major Domains

## Virtual Caring Skills

#### **Care Management**

Effectively managing virtual care requires the cultivation of critical thinking, organizational prowess, advocacy, adaptability, client education, assessment, documentation, and problem-solving skills-all crucial proficiencies for students pursuing careers in caring professions. Profound skills are required to organize client care effectively, conduct thorough client assessments, and advocate for accessing resources within virtual care environments. Caring professionals must excel in asking pertinent questions, discerning when to delve deeper, and adapting skillfully when necessary. These competencies enable them to navigate the complexities of virtual care delivery and ensure comprehensive and compassionate support for clients.

#### **Relational Skills**

In virtual care settings, fundamental relational skills—including effective communication, relationship building, ensuring psychological safety, and conveying empathy—play a crucial role in providing care. Emphasis must be placed on observing nonverbal cues and voice tone and practicing active listening when operating in virtual contexts. Although establishing rapport and building relationships with clients may present challenges in virtual environments, it remains an essential aspect of care. Nurturing psychological safety and expressing empathy during virtual care delivery can contribute significantly to clients feeling comfortable and at ease throughout the care process.

#### **Technology Literacy**

Proficiency in technology is vital for delivering virtual care. Students must acquire the skills and confidence to navigate diverse virtual care technology platforms. Being able to operate smoothly within these technological platforms enables students and professionals to redirect their focus to the client and their well-being. Additionally, a comprehensive understanding of the legal and ethical dimensions associated with providing virtual care, including aspects such as thorough documentation and privacy concerns, is of utmost importance.

#### **Teaching and Learning Methods**

#### **Collaborative Learning**

Collaborative web-based learning plays a pivotal role in fostering the development of virtual caring skills among students in caring professions. Through dynamic mechanisms such as class discussions, group work, and interdisciplinary collaboration, students engage in a rich educational experience that extends beyond individual perspectives. Collaborative learning environments provide a platform for students to share diverse insights, cultivate empathy, and refine their communication skills. In the context of caring professions, this collaborative approach can enable students to understand various dimensions of care, incorporating holistic perspectives from multiple disciplines. Moreover, the virtual nature of these interactions not only mirrors the evolving landscape of care provision but also equips students with digital communication



and teamwork skills crucial for contemporary professional practice.

#### **Experiential Learning**

Experiential web-based learning opportunities offer another avenue for nurturing virtual caring skills among students in caring professions. Engaging in virtual simulations, role-play, and case study scenarios allows students to immerse themselves in realistic yet controlled environments that mirror the challenges and dynamics of their future professions. This hands-on approach not only deepens their understanding of theoretical concepts but also hones their ability to navigate complex situations with empathy and sensitivity. Additionally, virtual practicum experiences can further provide students with authentic interactions with virtual clients. These immersive encounters enable students to apply their knowledge and skills in a safe and supervised web-based setting, fostering the development of virtual caring skills within the context of genuine client interactions.

#### **Observational Learning**

Observational learning in web-based settings plays a pivotal role in shaping the development of virtual caring skills among students in caring professions. By actively observing faculty members and engaging in virtual settings that simulate professional work, students gain valuable insights into the nuances of compassionate and effective care delivery. This learning approach allows them to witness real-world scenarios, model empathetic behavior, and internalize best practices in virtual care. Through this observational process, students not only grasp the theoretical underpinnings of their field but also cultivate a deeper understanding of the practical application of virtual caring skills. By emulating the actions and techniques demonstrated by experienced professionals in the web-based environment, students can refine their own approach to virtual care, laying the foundation for a compassionate and ethically grounded professional practice in the digital realm.

# Barriers to Teaching, Learning, and Providing Virtual Care

#### **Technological Challenges**

Certain technological challenges pose significant obstacles to teaching, learning, and delivering virtual care. These challenges encompass issues such as streaming disruptions, navigating unfamiliar technologies, and the inherent unreliability and unpredictability of technology. Caring professionals must acquire the skills not only to use technology themselves but also to guide clients in navigating unfamiliar technological terrain. Moreover, they need to adapt to and address technology failures as they arise. The hurdles associated with technology can have repercussions on both student learning and their capacity to deliver exceptional, appropriate, and timely care to clients.

# *Limited Access to Virtual Caring Equipment, Internet, and Technology*

The teaching, learning, and delivery of virtual care can be impeded by challenges such as limited accessibility, inadequate equipment, client web-based literacy, and insufficient internet

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connections. Scarce access to mobile devices and reliable internet connections not only affects student learning but also restricts the scope of care they can extend to clients, leading to diminished interactivity. These concerns are particularly significant when teaching and delivering virtual care to clients in rural and remote areas, underscoring issues related to unequal access to web-based resources and broader accessibility challenges for clients.

#### Sense of Disconnection

Delivering care in virtual settings may limit the capacity to form personal connections with clients or offer specific therapeutic services that rely on in-person interactions. For instance, therapeutic touch is a caring skill that is typically used in face-to-face interactions. The absence of a personal connection and the difficulty in fostering a sense of community with clients can pose a substantial obstacle to effective care provision. Moreover, delivering appropriately personalized care over the phone presents additional challenges due to the inability to convey messages through body language.

#### Time Constraints

The constraints of time pose significant challenges in the domains of teaching, learning, and delivering virtual care. Both students and clients may struggle to maintain prolonged engagement on the web, while educators face additional demands, especially when facilitating experiential learning for virtual care practices. These constraints underscore the need for efficient and focused approaches to ensure meaningful educational and caring interactions within the limitations of web-based environments.

#### Underdeveloped Virtual Caring Curricular Content

There is a noticeable gap in the availability of content for educators seeking to teach students about virtual caring. Faculty require more resources to adequately prepare students for engaging in virtual caring practices. Often, curricula are constrained and overloaded, with virtual care content treated as an afterthought. Virtual caring skills and competencies, considered specialized practices, may not be conventionally integrated into broader, generalist-focused curricula. However, with the advent of COVID-19 pandemic, virtual care has emerged as an essential skill set for many caring professions. The absence of dedicated curricula on virtual caring could potentially hinder students in caring professions from effectively providing virtual care in their future practices.

#### Lack of Engagement

Interruptions, decisions regarding the use of cameras, and difficulties in connecting with students, educators, colleagues, and clients can diminish levels of engagement. Active participation from clients in education and care settings is required to achieve intended outcomes. In virtual settings, the prevalence of interruptions and uncertainties about whether cameras should be on or off may prompt questions about presence and limit clients' and caregivers' overall sense of engagement. Negotiating these challenges is essential for fostering a more conducive web-based environment for providing virtual care.

# Facilitators of Teaching, Learning, and Providing Virtual Care

#### Technology Software and Support

Acquiring knowledge and purposefully using technology and virtual caring software can enhance the facilitation of teaching, learning, and delivering virtual care. Conducting orientation and skill development sessions to familiarize individuals with the technology can be beneficial. Despite the potential assistance of virtual care technology, without a thorough comprehension of its efficient and effective utilization, students and educators may encounter difficulties in establishing meaningful caring connections with clients.

#### **Teaching Support**

Support for teaching in web-based settings—from teaching and learning departments, colleagues, faculty members, or external networks—can significantly contribute to skill development in virtual care instruction. Continuous development and exchange of best practices serve as valuable avenues for fostering ongoing growth in confidence and competence when using virtual caring technology. Leveraging a collaborative approach ensures a sustained and progressive enhancement of teaching skills related to virtual care in web-based environments.

#### Stakeholder Engagement

Effective development of virtual caring skills relies on support and engagement from various stakeholders, including care providers, clients, students, educators, and institutions. The diversity of perspectives these stakeholders bring to virtual caring experiences is invaluable, and leveraging these viewpoints can enhance the effectiveness of teaching and learning about virtual care. Collaborating with and incorporating insights from these diverse stakeholders are essential for a comprehensive approach to virtual caring skill development.

#### **Expert Faculty**

Facilitating the learning of virtual caring skills necessitates the presence of expert faculty proficient in web-based education and experienced in delivering virtual care. These experts play a crucial role in modeling and promoting web-based etiquette, fostering psychological safety within the virtual classroom, and structuring interactive activities that contribute to a shared and enriching learning experience.

#### Virtual Care Curriculum

Recognizing virtual care as a current reality underscores the importance of integrating it into professional educational programs focused on teaching caring skills. Enhancing the effectiveness of teaching, learning, and delivering virtual care involves aligning virtual caring expectations, competencies, and learning objectives within the curriculum. Strategies can include developing a dedicated virtual care course or incorporating threaded virtual care topics throughout a curriculum.

#### Virtual Care Exposure

Gaining familiarity with virtual care through activities such as shadowing virtual care providers, practicing virtual caring skills with clients, watching web-based demonstrations, or engaging

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in role-play and simulated virtual care environments can significantly contribute to developing virtual care proficiency and deepening one's comprehension of the diverse scope of this mode of practice. Increased exposure to virtual care experiences can enhance the effectiveness of web-based learning.

# Discussion

#### **Principal Findings**

The findings from this multiphase and multifaceted study resulted in the development of an evidence-informed framework to support teaching and learning virtual caring skills and competencies. The components of this Virtual Caring framework are based on our previous research including an evidence synthesis, surveys, and interviews, and the framework was refined through stakeholder consultations. The Virtual Caring framework highlights key principles for virtual care, virtual caring skills, teaching and learning methods, and barriers to and facilitators for teaching, learning, and providing virtual care.

Teaching, learning, and providing virtual care can benefit greatly from incorporating key principles such as connection, interaction, compassion, empathy, care, vulnerability, client-centered approaches, inclusivity, accessibility, and flexibility. Creating a caring environment and cultivating relationships with clients in health care can facilitate shared decision-making, thereby improving client outcomes [31]. In a qualitative study exploring health care providers' experiences in building rapport in telehealth settings, caring professionals emphasized that building rapport with clients is essential for fostering positive, productive interactions with clients and their families [32]. Additionally, establishing meaningful connections and interactions in virtual environments is essential for nurturing a sense of community and trust among students [33]. Felton et al [33] stated that trust is fundamental in the educator-student relationship and crucial for students to feel psychologically safe. They recommended trust moves to help foster the trust of students, including strategies such as getting to know the students, demonstrating mastery of the content, engaging respectfully, and showing sensitivity to diverse identities [33].

Infusing compassion, empathy, and care into virtual interactions ensures that the human element remains integral in digital spaces, promoting a more client-centric and supportive care environment. Recognizing vulnerability as a strength rather than a weakness encourages open communication and collaboration, thereby deepening connections between care professionals and clients. Adopting a client-centered approach ensures that virtual care is tailored to each individual's unique needs and preferences, promoting the effectiveness and personalization of interventions. In a scoping review examining barriers and facilitators to telehealth implementation in populations at risk for health disparities, Baily et al [34] indicated that client-centered approaches serve as facilitators in delivering telehealth care and can help mitigate health disparities. Moreover, Health Canada [35] has underscored the importance of a client-centered and community-centered focus to achieve the quadruple aim in telehealth. Inclusivity and accessibility principles can ensure that virtual care remains accessible to everyone, regardless of diverse backgrounds, life

situations, or abilities. Finally, flexibility enables adaptation to the evolving landscape of virtual care, accommodating the dynamic needs of both learners and clients. By embracing these principles, educators, learners, and care providers can create virtual care environments that are not only effective and efficient but also empathetic, client-centered, and inclusive.

To effectively provide virtual care, students in caring professions require specific skills. Robust care management skills are paramount to ensuring that caring professionals can organize, coordinate, and optimize the delivery of care in the digital landscape. This includes proficiency in using virtual platforms for scheduling, monitoring client progress, and facilitating communication among the care team. Relational skills are equally important, enabling care providers to establish and maintain meaningful connections with clients through virtual channels. This involves cultivating effective communication, active listening, and empathy to create a supportive and trusting virtual care environment. Noddings [36,37], an education scholar, discussed the centrality of relationships and caring in education, emphasizing the importance of listening carefully and responding to expressed needs without assuming what students may require. The theoretical writings of Noddings [36,37] are applicable across various caring professions and can guide professionals in delivering client-centered care that is supported by relational skills. Additionally, technology literacy is foundational in virtual caring, equipping care providers with the competence to navigate and leverage digital tools effectively. Combining these skills enables the delivery of high-quality virtual care that is not only technologically proficient but also rooted in the principles of empathy, communication, and client-centeredness.

Collaborative, experiential, and observational learning form a robust triad that supports students in developing essential virtual caring skills. Through collaborative learning, students engage in collective exploration and discussion, fostering a diverse range of perspectives and insights that contribute to a holistic understanding of virtual care. Experiential learning, which includes virtual simulations and practical scenarios, allows students to actively apply theoretical knowledge in realistic contexts, enhancing their problem-solving abilities, and deepening their virtual caring skills. In a study examining the impact of virtual telehealth simulation on prelicensure community health nursing students, significant increases in knowledge, attitude, and confidence were observed following simulation-based education [38]. Students also rated the learning experience highly and found the content important to their learning [38]. Although virtual simulations have gained popularity in health care, this experiential learning modality may also prove valuable in other caring professions, such as social work [39]. Observational learning can further complement these approaches by providing students with the opportunity to witness seasoned professionals in action. This allows them to model empathetic behavior, effective communication, and other crucial skills in virtual care settings. Moreover, students need to see their educators as caring professionals who provide an environment conducive to their learning. This combined approach not only enhances students' proficiency in using digital platforms but also cultivates the interpersonal and technical

competencies required for successful and compassionate virtual care practice.

Several challenges can pose significant barriers to the effective teaching, learning, and provision of virtual care. Technological challenges can impede the seamless delivery of virtual care services and teaching and learning experiences. According to Ortega et al [40], limited access to the internet or technological devices can exacerbate disparities, preventing some individuals from participating in web-based learning or accessing virtual care. This limitation can create a pervasive sense of disconnection, stemming from the absence of face-to-face interactions, which affects both student engagement in learning and clients' perception of care. Time constraints further compound these issues, as professionals and learners may struggle to balance virtual care demands with other responsibilities. Moreover, maintaining engagement poses a challenge, as the virtual environment may not always capture the same level of attention and participation as in-person settings. Additionally, the underdeveloped nature of virtual caring curricula poses a barrier. Educators grapple with the task of aligning educational materials with the dynamic and evolving landscape of virtual care, potentially leaving gaps in essential skills and knowledge. Addressing these challenges is crucial for ensuring that virtual care education is inclusive, effective, and capable of meeting the diverse needs of both learners and care recipients.

The effective facilitation of teaching, learning, and the provision of virtual care hinges on several key factors. First and foremost, technology software and robust technical support are crucial in creating seamless virtual care experiences. Access to reliable platforms and assistance in navigating digital tools ensure that caring professionals and students can confidently engage in virtual care settings. Teaching support also plays a critical role. Educators benefit from training in web-based pedagogy and virtual care methodologies, which enhances the quality of instruction and fosters an environment conducive to optimal learning outcomes. Moreover, active stakeholder engagement is essential. Collaboration with care organizations, policy makers, and industry experts helps align virtual care education with real-world practices and expectations. Expert faculty with specialized knowledge in virtual care enriches the learning experience by offering valuable insights and mentorship. Exposure to diverse virtual care scenarios through simulation or practicum further enhances preparedness. Learners can apply theoretical concepts in practical settings and adapt to the complexities of digital care delivery [41]. In concert, these elements create a supportive framework that empowers both educators and learners to navigate the nuances of virtual care with confidence and proficiency.

#### **Practice Implications**

As workforce needs continue to shift, our Virtual Caring framework can support the development of virtual caring skills and competencies across various caring professions. We created this framework to serve as a tool for educators, students, and decision makers, enabling the systematic and intentional integration of virtual caring skill development into caring professions education. We anticipate that our framework will

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be useful to several target audiences across multiple organizational levels, including educators, students, decision makers, and practice partners. For example, educators and students can use this framework to facilitate discussions on teaching and learning strategies, establish plans for enhancing virtual caring skills, and promote critical reflection and career growth in virtual care practices. Institutional decision makers and teaching and learning centers can leverage the framework to guide the development of programs tailored to nurturing virtual caring skills among professional students. At a broader level, institutional, regional, national, and international associations can use the framework to amplify conversations and develop strategies aimed at fostering widespread cultural shifts in integrating virtual caring skills into caring professions education. Despite potential resource constraints in higher education institutions related to virtual care technology and teaching support, our framework offers a structured approach for administrators to strategically plan virtual caring initiatives that address the growing demands of caring professions. Additionally, educators can identify opportunities for collaboration with other caring professional programs, potentially creating synergies that enhance program offerings. Thus, our Virtual Caring framework catalyzes advancing the integration of virtual caring competencies across caring professions education, ensuring preparedness and responsiveness to evolving workforce needs.

#### **Strengths and Limitations**

This research reflects the global state of evidence on web-based learning opportunities designed to develop and apply virtual caring skills and competencies among students in caring professions. Our research, while underpinned by global literature, primarily focused on the perceptions and experiences of caring professions students and educators from one Canadian university, aiming to provide insights across various disciplines. The inclusion of participants from a range of disciplines strengthened this study, allowing for a deeper exploration of the complexities involved in web-based learning for developing virtual caring skills. The triangulation of data from different phases of this study into an evidence-informed framework strengthens the findings.

While our research followed a systematic and rigorous approach, this study is not without limitations and caveats. Despite a

comprehensive and systematic literature search, some relevant literature might have been missed. Additionally, variations in web-based teaching and learning methods regarding virtual caring skills posed challenges for direct comparisons, yet they also provided valuable insights into different approaches, benefits, and associated challenges. Moreover, although the literature informing this work is globally representative, the data collection from student and educator surveys and interviews was conducted at one research-intensive university in Canada, potentially limiting the generalizability of our findings to other institutions. However, stakeholder consultations at 3 different national and international events provided a broader perspective and validated the relevance of the framework beyond the study's specific context.

#### **Future Research**

Our study also underscores the need for further research with robust study designs to better understand how to effectively support the development and implementation of web-based learning opportunities that help students in caring professions in developing the required virtual caring skills and competencies. Existing research on teaching virtual caring skills in web-based settings may not be robust [41]; however, the need for caring professionals to develop virtual caring skills and competencies is clear [24,26]. Our comprehensive framework designed to facilitate the development and integration of web-based learning opportunities aimed at nurturing essential virtual caring skills across caring professions is novel. Rigorous evaluation of the use and impact of this framework is needed [41]. Future longitudinal studies could also investigate the sustained impact of virtual caring skills development over time.

#### Conclusions

This evidence-informed Virtual Caring framework was developed by educators for educators, specifically to support web-based teaching and learning of virtual caring skills and competencies among caring professional students. It serves as a tool for planning, promoting, and enhancing the development of virtual caring skills in web-based educational settings. Institutions can use this framework to inform their efforts in refining current strategies or developing new approaches aimed at fostering virtual caring skills development among their students.

#### **Conflicts of Interest**

None declared.

#### References

- 1. Dewart G, Corcoran L, Thirsk L, Petrovic K. Nursing education in a pandemic: academic challenges in response to COVID-19. Nurse Educ Today 2020 Sep;92:104471. [doi: 10.1016/j.nedt.2020.104471] [Medline: 32502723]
- 2. Müller AM, Goh C, Lim LZ, Gao X. COVID-19 emergency elearning and beyond: experiences and perspectives of university educators. Educ Sci 2021;11(1):19. [doi: 10.3390/educsci11010019]
- 3. Bogo M. Field education for clinical social work practice: best practices and contemporary challenges. Clin Soc Work J 2015 Sep;43(3):317-324. [doi: 10.1007/s10615-015-0526-5]
- 4. CEWIL Canada. URL: https://www.cewilcanada.ca/ [accessed 2020-12-18]

- Roskvist R, Eggleton K, Goodyear-Smith F. Provision of e-learning programmes to replace undergraduate medical students' clinical general practice attachments during COVID-19 stand-down. Educ Prim Care 2020 Jul;31(4):247-254. [doi: 10.1080/14739879.2020.1772123] [Medline: 32469632]
- 6. Van Nuland S, Mandzuk D, Tucker Petrick K, Cooper T. COVID-19 and its effects on teacher education in Ontario: a complex adaptive systems perspective. J Educ Teach 2020 Aug 7;46(4):442-451. [doi: 10.1080/02607476.2020.1803050]
- 7. Dede C, Jass Ketelhut D, Whitehouse P, Breit L, McCloskey EM. A research agenda for online teacher professional development. J Teach Educ 2009 Jan;60(1):8-19. [doi: 10.1177/0022487108327554]
- 8. Rhode J, Richter S, Miller T. Designing personalized online teaching professional development through self-assessment. TechTrends 2017 Sep;61(5):444-451. [doi: 10.1007/s11528-017-0211-3]
- 9. Darling-Hammond L, Hyler ME. Preparing educators for the time of COVID ... and beyond. Eur J Teach Educ 2020 Aug 7;43(4):457-465. [doi: 10.1080/02619768.2020.1816961]
- 10. Cleland J, McKimm J, Fuller R, Taylor D, Janczukowicz J, Gibbs T. Adapting to the impact of COVID-19: sharing stories, sharing practice. Med Teach 2020 Jul;42(7):772-775. [doi: 10.1080/0142159X.2020.1757635] [Medline: 32401079]
- 11. Ferri F, Grifoni P, Guzzo T. Online learning and emergency remote teaching: opportunities and challenges in emergency situations. Societies (Basel) 2020;10(4):86. [doi: 10.3390/soc10040086]
- 12. Kidd W, Murray J. The COVID-19 pandemic and its effects on teacher education in England: how teacher educators moved practicum learning online. Eur J Teach Educ 2020 Aug 7;43(4):542-558. [doi: <u>10.1080/02619768.2020.1820480</u>]
- 13. Sepulveda-Escobar P, Morrison A. Online teaching placement during the COVID-19 pandemic in Chile: challenges and opportunities. Eur J Teach Educ 2020 Aug 7;43(4):587-607. [doi: <u>10.1080/02619768.2020.1820981</u>]
- 14. Williamson B, Eynon R, Potter J. Pandemic politics, pedagogies and practices: digital technologies and distance education during the coronavirus emergency. Learn Media Technol 2020 Apr 2;45(2):107-114. [doi: 10.1080/17439884.2020.1761641]
- 15. Zhang W, Wang Y, Yang L, Wang C. Suspending classes without stopping learning: China's education emergency management policy in the COVID-19 outbreak. J Risk Financ Manage 2020;13(3):55. [doi: <u>10.3390/jrfm13030055</u>]
- 16. Bao W. COVID-19 and online teaching in higher education: a case study of Peking University. Hum Behav Emerg Technol 2020 Apr;2(2):113-115. [doi: 10.1002/hbe2.191] [Medline: 32510042]
- 17. Moorhouse BL. Adaptations to a face-to-face initial teacher education course 'forced' online due to the COVID-19 pandemic. J Educ Teach 2020 Aug 7;46(4):609-611. [doi: <u>10.1080/02607476.2020.1755205</u>]
- Mohamad Nasri N, Husnin H, Mahmud SND, Halim L. Mitigating the COVID-19 pandemic: a snapshot from Malaysia into the coping strategies for pre-service teachers' education. J Educ Teach 2020 Aug 7;46(4):546-553. [doi: 10.1080/02607476.2020.1802582]
- 19. Martinez L, Holley A, Brown S, Abid A. Addressing the rapidly increasing need for telemedicine education for future physicians. PRiMER 2020;4:16. [doi: 10.22454/PRiMER.2020.275245] [Medline: 33111043]
- Nowell L, Lorenzetti D, Jacobsen M, Lorenzetti L, Paolucci EO. Translating caring competencies to remote working environments: a systematic review protocol. BMJ Open 2021 May 19;11(5):e048459. [doi: <u>10.1136/bmjopen-2020-048459</u>] [Medline: <u>34011602</u>]
- 21. Woodcock S, Sisco A, Eady M. The learning experience: training teachers using online synchronous environments. J Educ Res Pract 2015;5(1):21-34. [doi: 10.5590/JERAP.2015.05.1.02]
- 22. Kothari A, McCutcheon C, Graham ID. Defining integrated knowledge translation and moving forward: a response to recent commentaries. Int J Health Policy Manag 2017 May 1;6(5):299-300. [doi: 10.15171/ijhpm.2017.15] [Medline: 28812820]
- 23. Creswell JW, Plano Clark VL. Designing and Conducting Mixed Methods Research, 3rd edition: SAGE; 2018.
- Nowell L, Dhingra S, Carless-Kane S, et al. A systematic review of online education initiatives to develop students remote caring skills and practices. Med Educ Online 2022 Dec;27(1):2088049. [doi: <u>10.1080/10872981.2022.2088049</u>] [Medline: <u>35694798</u>]
- 25. Polit D, Beck C. Nursing Research Generating and Assessing Evidence for Nursing Practice, 11th edition: Wolters Kluwer; 2021.
- 26. Nowell L, Dolan S, Johnston S, Jacobsen M, Lorenzetti D, Oddone Paolucci E. Exploring student perspectives and experiences of online opportunities for virtual care skills development: sequential explanatory mixed methods study. JMIR Nurs 2024 Aug 21;7:e53777. [doi: 10.2196/53777] [Medline: 39167789]
- 27. Nowell L, Johnston S, Dolan S, Jacobsen M, Lorenzetti DL, Oddone Paolucci E. Exploring educators' perceptions and experiences of online teaching to foster caring profession students' development of virtual caring skills: sequential explanatory mixed methods study. JMIR Nursing 2024;8:e64548. [doi: 10.2196/64548]
- 28. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2006 Jan;3(2):77-101. [doi: 10.1191/1478088706qp063oa]
- 29. Nowell LS, Norris JM, White DE, Moules NJ. Thematic analysis: striving to meet the trustworthiness criteria. Int J Qual Methods 2017;16(1):1-13. [doi: 10.1177/1609406917733847]
- 30. Wendler MC. Triangulation using a meta-matrix. J Adv Nurs 2001 Aug;35(4):521-525. [doi: 10.1046/j.1365-2648.2001.01869.x] [Medline: 11529951]

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- 31. Henry BW, Block DE, Ciesla JR, McGowan BA, Vozenilek JA. Clinician behaviors in telehealth care delivery: a systematic review. Adv Health Sci Educ Theory Pract 2017 Oct;22(4):869-888. [doi: 10.1007/s10459-016-9717-2] [Medline: 27696102]
- 32. English W, Robinson J, Gott M. Health professionals' experiences of rapport during telehealth encounters in community palliative care: an interpretive description study. Palliat Med 2023 Jul;37(7):975-983. [doi: 10.1177/02692163231172243] [Medline: 37129344]
- 33. Felten P, Forsyth R, Sutherland KA. Building trust in the classroom: a conceptual model for teachers, scholars, and academic developers in higher education. Teach Learn Inq 2023;11:July. [doi: <u>10.20343/teachlearninqu.11.20</u>]
- 34. Bailey JE, Gurgol C, Pan E, et al. Early patient-centered outcomes research experience with the use of telehealth to address disparities: scoping review. J Med Internet Res 2021 Dec 7;23(12):e28503. [doi: <u>10.2196/28503</u>] [Medline: <u>34878986</u>]
- 35. Virtual care—policy framework: a product of the federal, provincial, and territorial virtual care/digital table. Government of Canada. 2021. URL: <u>https://www.canada.ca/content/dam/hc-sc/documents/corporate/transparency/health-agreements/bilateral-agreement-pan-canadian-virtual-care-priorities-covid-19/policy-framework/policy-framework-eng.pdf</u> [accessed 2025-06-03]
- 36. Noddings N. The caring relation in teaching. Oxf Rev Educ 2012 Dec;38(6):771-781. [doi: 10.1080/03054985.2012.745047]
- 37. Noddings N. Fidelity in teaching, teacher education, and research for teaching. Harv Educ Rev 1986 Dec 1;56(4):496-511. [doi: 10.17763/haer.56.4.34738r7783h58050]
- 38. Ampadu JV, Perez A. Telehealth virtual simulation for community health nursing students. Clin Simul Nurs 2023 Oct;83:101442. [doi: 10.1016/j.ecns.2023.101442]
- Baker E, Jenney A. Virtual simulations to train social workers for competency-based learning: a scoping review. J Soc Work Educ 2023 Jan 2;59(1):8-31. [doi: <u>10.1080/10437797.2022.2039819</u>]
- 40. Ortega G, Rodriguez JA, Maurer LR, et al. Telemedicine, COVID-19, and disparities: policy implications. Health Policy Technol 2020 Sep;9(3):368-371. [doi: 10.1016/j.hlpt.2020.08.001] [Medline: 32837888]
- 41. Chike-Harris KE, Durham C, Logan A, Smith G, DuBose-Morris R. Integration of telehealth education into the health care provider curriculum: a review. Telemed J E Health 2021 Feb;27(2):137-149. [doi: <u>10.1089/tmj.2019.0261</u>] [Medline: <u>32250196</u>]

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# Gamification as a Tool for Understanding Mental Disorders in Nursing Students: Qualitative Study

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# Abstract

**Background:** Gamification has emerged as an innovative pedagogical strategy in the educational field, transferring game tools to the teaching-learning process to improve students' motivation and engagement.

**Objective:** This study aims to describe nursing students' perceptions of mental disorders using interactive cards as a gamification tool.

**Methods:** This research was carried out at the Nursing School of a University in Madrid, Spain, with the participation of 50 first-year students enrolled in the nursing degree's general and developmental psychology course. Data were collected through focus groups and reflective narratives with semistructured interview questions between March and April 2024. After data collection, transcripts were generated and subjected to thematic analysis following the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist.

**Results:** A total of three themes emerged from the analysis: (1) perception and stigma of mental disorders, (2) emotional connection and personal reflection in learning about mental disorders, and (3) gamification tools and their impact on learning.

**Conclusion:** Gamification, especially through interactive cards, is valuable for teaching psychology and mental disorders in nursing education. It enables students to gain a deeper clinical understanding of mental illnesses and explore their emotional and social dimensions. This methodology fosters emotional reflection, reduces stigma, and encourages active engagement, contributing to developing more empathetic, reflective, and better-prepared nursing professionals. Its integration into educational programs enhances academic and humanistic competencies essential for mental health care.

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#### **KEYWORDS**

gamification; mental health; nursing students; cognitive training; qualitative research

# Introduction

Over the past decade, gamification has emerged as an innovative educational strategy incorporating game dynamics, rules, and elements into non-game contexts, such as learning environments [1]. Its central aim is to transform traditional educational activities into interactive and engaging experiences, stimulating students' intrinsic motivation and promoting active learning. Gamification introduces game—like components into the classroom to foster more dynamic and effective learning

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processes [2]. This approach is particularly effective when students are internally motivated, as it encourages deeper engagement with their educational journey [3]. It has shown notable success in complex fields such as health care, where integrating theory and practice is essential for developing competent and empathetic professionals [4]. In nursing education, gamification provides a dynamic and immersive framework through which students can engage with real-world challenges, enhancing their clinical, cognitive, and emotional competencies [5,6].

Recent research has highlighted the growing potential of gamification-based mental health interventions to improve emotional well-being and reduce psychological symptoms such as anxiety, stress, and depression [7,8]. These interventions use game design principles to increase users' motivation, active participation, and engagement in their therapeutic processes. This innovative approach is not only transforming the way mental disorders are treated but also how their management is taught to health professionals. As an innovative strategy, gamification has applications in diverse educational contexts [5,6,9] and health interventions focused on people with mental health problems [8,10]. However, despite their advances and growing popularity, there is a notable gap in understanding how these gamified strategies impact both teaching and learning related to mental health.

One of the biggest challenges in nursing education is the understanding of mental disorders [11,12]. These pathologies require an in-depth knowledge of symptoms and an empathic ability to connect with patients' personal and subjective experiences [13]. By implementing game dynamics, such as using interactive cards, students can explore, in a safe and structured way, the inner world of people with mental illness [14]. This methodology helps transform theoretical knowledge into meaningful learning experiences by putting the learner at the center of the process and allowing them to somehow "live" the realities of their future patients [15].

In the specific context of teaching about mental disorders, interactive cards representing various pathologies, symptoms, or clinical scenarios enable students to engage with realistic and meaningful experiences. These cards often include narratives or descriptive vignettes simulating the lived experiences of individuals with conditions such as depression, anxiety, schizophrenia, or bipolar disorder [16]. Through reading and reflection, nursing students are encouraged to recognize the clinical features of these disorders and consider their personal and emotional significance for those affected. This pedagogical strategy supports the development of empathic competencies and enhances students' understanding of mental illness's psychological and social dimensions [17].

In addition, gamification in this context facilitates the development of a comprehensive understanding of the patient [8]. Students can interact more actively and critically with the content by using dynamics such as interactive cards, encouraging deep analysis of the emotions, behaviors, and thoughts that characterize each pathology. This type of tool allows personalization of learning since each student can interpret situations from their perspective, enriching the process by exchanging ideas and experiences with peers [3].

In nursing education, it is essential to move beyond the acquisition of technical skills and to cultivate nontechnical competencies such as empathy, emotional regulation, and effective communication. These attributes are fundamental for delivering holistic and patient-centered care. Gamification serves not only to enhance students' understanding of mental disorders but also to prepare them to engage with patients in an ethical, compassionate, and sensitive manner. Interactive cards, in particular, encourage future nurses to view patients as whole

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individuals—beyond their diagnoses—by considering their personal histories and social contexts. In this regard, gamified educational tools offer promising avenues for improving both the learning process and the depth of understanding related to mental health care.

This study aims to describe nursing students' perceptions of mental health disorders using interactive cards as a gamification tool.

# Methods

#### Design

An interpretive approach qualitative study [18] was conducted to investigate nursing students' perceptions and experiences during an interactive card gamification activity focused on mental disorders. This paradigm describes how people construct their social reality and knowledge by reconstructing their experiences [19].

#### **Experience or Role of Researchers**

A total of 9 investigators (4 women and 5 men) participated in this study, all with PhDs in health sciences and psychology, except for one nurse from the clinical setting with a specialty in mental health (PDP-H). A total of 4 investigators (EGC-B, AT-R, PDP-H, and ACH) had extensive experience conducting qualitative studies in health sciences. One of the investigators (PDP-H) was responsible for recruiting participants. The remaining authors had no prior contact with any of the student participants. The focus groups (FGs) were led by 2 researchers specializing in using gamification tools and active learning methodologies in mental disorders (PDP-H and AT-R). The researchers' positions were established regarding the theoretical framework, beliefs, previous experience, and motivations for participating. The entire team participated in the evaluation of each stage of the research process to reduce researcher bias. Data were triangulated with 3 external researchers (AM-S, RJ-V, and EC-S).

#### **Participants and Sampling**

This study was conducted at a university in the Community of Madrid, Spain, where the nursing degree spans 4 academic years. The course General and Developmental Psychology, part of the first-year curriculum, is a 6 European Credit Transfer System (ECTS) credit subject taught in the second semester. It includes both theoretical instruction and the development of subject-related competencies.

A purposive sampling strategy was used, selecting participants based on their ability to provide relevant insights aligned with the research questions [20]. Inclusion criteria were (1) first-year undergraduate nursing students and (2) an enrollment in the General and Developmental Psychology course at the participating university. Participation was voluntary and offered to all eligible students. Of the 53 students enrolled, 50 chose to participate (n=50). Recruitment continued until data saturation was reached [21], ensuring a comprehensive and information-rich sample.

All participants were first-year students with no formal mental health education; this course represented their initial academic

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exposure to related topics. While a few had previously experienced basic gamified activities during earlier stages of education, this study marked their first structured encounter with gamification as a pedagogical strategy within higher education.

#### **Teaching Strategy**

As part of the educational intervention through gamification, a group activity specifically designed to explore perceptions about eating disorders (EDs), personality disorders (PDs), and

#### Figure 1. Interactive card 1.

emotional instability, such as anxiety and depression, was proposed to students. This intervention was implemented through interactive cards (see Figures 1-4), symbolic tools to facilitate reflection and self-awareness around these mental disorders. During the intervention, a fundamental distinction was introduced between conflict graphs and reframing graphs. These were directly linked to analyzing how students perceive and emotionally process the characteristics and challenges associated with mental disorders.



Figure 2. Interactive card 2.





#### Figure 3. Interactive card 3.





Figure 4. Interactive card 4.



Conflict cards represent emotional challenges, internal obstacles, or situations that generate distress, anxiety, or confusion, common elements in disorders such as ED and PD. Through these, students could visually identify problem areas in their emotional lives or associate them with experiences observed in people with mental disorders, fostering a deeper and more empathetic understanding. This process allowed them to reflect on how these internal conflicts might be related to the symptoms and challenges faced by those with mental disorders.

Reframing graphs symbolize a new perspective or emotional solution, providing learners with an optimistic view or path to

resolution similar to the therapeutic goals of treatments for mental disorders. This exercise encouraged participants to project how to overcome the challenges represented by the conflict graphs, visualizing possible ways to cope with and manage anxiety, emotional instability, or challenges specific to ED and PD.

The interactive cards functioned as emotional metaphors, enabling students to explore their internal experiences in a tangible and visually expressive manner. This method allowed them to contextualize personal reflections within the broader framework of symptoms and lived experiences associated with

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various mental health conditions. Each student constructed the symbolic meaning of the cards individually, fostering a deeply introspective and subjective approach to emotional analysis. This personalized engagement supported the study's objective of enhancing students' understanding of and sensitivity toward mental disorders' complexities (see Multimedia Appendix 1).

The activity consisted of each group preparing a document that included the following elements:

First, the association of interactive cards with mental disorders; the students were asked to identify and justify which interactive card was associated with each of the disorders presented: eating disorders, personality disorders, anxiety, or depression, justifying this association. This task was intended to promote individual and collective reflection, encouraging participants to explore the symbolic relationship between the interactive cards and the disorders or emotions represented. This phase aimed to get students to deepen their symbolic analysis of the interactive cards and connect the images to their knowledge of mental disorders. The exercise encouraged group discussion, generating different interpretations and a shared understanding of the disorders from an emotional and visual perspective.

Second, the analysis of the abstraction and meaning of the interactive cards was conducted. After addressing the type of disorder and its impact on those who are diagnosed with it, we delved into introspective aspects of the students, such as whether they have ever felt similarly, their fears, problems, and their ideal or desired state. They also reflected on how they believe people with ED experience it and how they would feel if they experienced it personally or if someone close to them had gone through this situation.

The central objective of the gamification activity was to train students in understanding and managing mental disorders through interactive card-based experiences that promoted reflection and emotional analysis. This approach allowed students to develop nursing-specific competencies to address mental health-related situations effectively. For this purpose, a variety of interactive cards representing different mental disorders, such as eating disorders, anxiety, and depression, were used.

Before using the interactive cards, consent was requested from their creator, Alejandro Vera Casas, who approved their use and is knowledgeable about the study and intervention with the students.

#### **Data Collection**

To explore diverse viewpoints, FGs were convened along with the researchers' field notes and participants' written reflective narratives, which enriched the analysis. This qualitative methodology allowed for a nuanced and contextualized exploration of lived experiences during the interactive card-based gamification activity on mental disorders [22]. The FGs encouraged interaction among participants, fostering the emergence of varied opinions and perceptions regarding their feelings and learnings [20]. Data collection was conducted between March and April 2024, facilitating a detailed topic analysis [23].

Each group was composed of between 9 and 11 participants, guided by a moderator and accompanied by an observer. The FGs were developed at the university after the gamification activity, with participants seated and facing each other to encourage interaction, data collection, and direct observation. The moderator asked questions, and each participant responded in an orderly manner. The observer complemented the moderator's work, highlighting key points and taking notes. A thematic guide was used, which, although focused on obtaining information specific to the study area, allowed sufficient flexibility to promote discussion and interaction among participants (see Textbox 1). Due to the flexible nature of data collection in qualitative studies, the moderator explored additional themes that emerged from the participants' interventions and related to the research question. All FGs were audio-recorded with the participants' prior permission. A total of 5 FGs were conducted in which no new information emerged from the data analysis, with an average duration of 79 minutes. Before analysis, participants had the opportunity to review the transcripts. In addition, researchers' field notes were used as a secondary source of information.

Textbox 1. Semistructured interview questions.

- 1. How did you feel about the development of using interactive cards?
- 2. What has it helped you to relate to mental disorders or learning?
- 3. What has meant using interactive cards as a gamification tool for your learning?
- 4. How do you think you could use what you have learned in your professional future?
- 5. How have interactive cards helped you to integrate content?
- 6. Has it made it easier to understand?
- 7. Have you encountered any difficulties while doing the activity?
- 8. Would you feel comfortable doing the activity in a group or prefer to do it individually? Why?

The results were also triangulated with the 32 individual narratives written by the participants, in which they shared their experiences of managing mental disorders through interactive cards. These narratives included personal reflections and an in-depth analysis of their emotions.

#### **Data Analysis**

Verbatim transcriptions were made for each FG alongside researchers' field notes and reflective narratives. All data were carefully stored, managed, and organized using ATLAS.ti (version 24; Scientific Software Development GmbH), a qualitative data analysis software. An inductive thematic analysis [18] was conducted to identify relevant text segments addressing the research question systematically. The analysis began with open coding of the transcripts, during which researchers identified and labeled meaningful units of text. These initial codes were then grouped into categories based on shared meanings and thematic similarities. The categories were refined and organized into broader thematic groups through an iterative process of constant comparison. This interactive and reflective approach ultimately identified overarching themes that captured participants' experiences, offering a rich and nuanced understanding of their perceptions [24].

A total of 4 researchers (EGC-B, AT-R, PDP-H, and ACH), experts in qualitative research, developed the whole process of obtaining categories and subcategories independently, ending the process with the exchange of both and a consensus on the final decisions of the analysis. In case of divergence of opinions, the theme was identified by consensus among the research team members. In addition, memo writing and analytic discussions were used throughout the process to support reflexivity and maintain analytical rigor.

#### **Rigor and Trustworthiness**

The study followed the Consolidated Criteria for Qualitative Research Reporting (COREQ) [25]. The criteria to ensure the reliability of Guba and Lincoln were applied [21]. Data triangulation was used among the researchers involved in the analysis, and the analysis process was subjected to independent researcher review to ensure credibility. Transcripts were offered to participants, who were allowed to add any relevant information. Transferability was ensured by a detailed description of the research setting, participants, context, and method. Confirmability was achieved by introducing variability in participants' experiences. Each researcher conducted the reading and analysis independently, contrasting and agreeing on emerging themes and subthemes.

#### **Ethical Considerations**

Ethical authorization to conduct the research was obtained from the Research Ethics Committee of the Instituto de Investigación Sanitaria Fundación Jiménez Díaz (CEI\_PIC321-23\_FJD). All participants gave written consent before participating in this study. To ensure anonymity and confidentiality, a code was assigned to each participant in the FGs and reflective narratives. Participants were recruited through an open call disseminated through institutional channels, including emails and posters. They were informed in detail about the study, its objectives, and procedures, emphasizing that participating or not would not affect their academic career. It was made clear that participation in the study was entirely voluntary, would have no impact on their grades or academic evaluation, and they could withdraw at any time without any consequences on their academic performance or relationship with the university. Strict measures were implemented to ensure neutrality between teaching and research: data collection and interventions were anonymous and did not alter course dynamics, while academic results were managed independently. These actions fully protected students' learning rights.

# Results

#### **Participant Characteristics**

Of the 53 nursing students who met the inclusion criteria, only 50 participated in the study, representing a participation rate of 94.3% (50/53). A total of 3 students did not attend the gamification activity due to scheduling conflicts, work commitments, or other personal reasons. Most participants were female (44/50, 88%), while 6/50 (12%) were male. The average age of participants was 18.5 years (SD 1.28; range 17-23 years). The gender imbalance reflects broader enrollment trends in nursing programs across Spanish universities, where female students constitute the majority. All participants were first-year nursing students enrolled in the General and Developmental Psychology course.

#### Themes

From the interactions developed during the gamification activity, three thematic blocks were identified along with their respective categories (see Table 1): (1) Perception and stigma of mental disorders; (2) Emotional connection and personal reflection in learning about mental disorders; and (3) Gamification tools and their impact on learning.



Table . Thematic analysis overview: themes, categories, and subcategories.

Themes (T)	Categories	Subcategories
T1: Perception and stigma of mental disorders	<ul> <li>Beliefs</li> <li>Stereotypes and prejudices</li> <li>Understanding level</li> <li>Perception of interactive cards</li> </ul>	<ul> <li>Myths and initial beliefs</li> <li>Stigmas in the social environment, unconscious prejudices, and awareness of the impact</li> <li>Differentiation between disorders, understanding of severity, and identification of symptoms</li> <li>Emotional impact, learning transformation, open mind, usefulness, and difficulties encountered</li> </ul>
T2: Emotional connection and personal reflection in learning about mental disorders	<ul> <li>Personal and social environment</li> <li>Accompaniment and support networks</li> <li>Role of mental health professional</li> <li>Attitudes change</li> </ul>	<ul> <li>Influence of family expectations and close environment</li> <li>Family support, barriers, and support network</li> <li>Intervention strategies, therapeutic relationship, and more integral vision</li> <li>Awareness and sensitization</li> </ul>
T3: Gamification tools and their impact on learning	<ul> <li>Development of emotional and empathic skills</li> <li>Learning process assessment</li> <li>Introspection and self-knowl- edge</li> <li>Impact on empathy develop- ment</li> </ul>	<ul> <li>Improved emotional communication skills to identify emotions</li> <li>Better understanding, meaningful learning, and integration of knowledge</li> <li>Personal reflection, identification of experiences and biases, and insecurity</li> <li>Recognition of other people's emotions, desire to help, and emotional connection.</li> </ul>

# Theme 1: Perception and Stigma of Mental Disorders

#### Beliefs

This category explores initial myths and beliefs and changes in students' perception of mental disorders through their interaction with visual material, such as the interactive cards used in the activity. They highlight the pedagogical value of the images and interactive cards in understanding mental disorders more deeply.

In future courses, these cards can be employed as a resource to associate the mental pathologies we study. [FG 1]

When confronted with these resources, self-awareness has been awakened in them that has not only allowed them to rethink their beliefs about mental disorders but also their emotional well-being:

*I have questioned my own experiences.* [Participant 15]

#### **Stereotypes and Prejudices**

Through the activity, participants reflected on how these stigmas affect both how society perceives people with mental disorders and how these people see themselves. The reflections reveal a change in understanding and an increased awareness of the impact of prejudice on the lives of those affected. They have

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been able to reflect on the role that erroneous beliefs, unconscious biases, and social expectations play in how these people see themselves and how they feel judged by others.

We thought it may be a case of personality disorder due in large part to prejudice and lack of confidence. [FG 5, related to interactive card 1]

Through the interactive cards, the students observed that certain mental disorders, especially the most common ones, tend to be more stigmatized. This recognition allowed them to analyze how social stigma is disproportionately associated with certain disorders, which hinders access to help and adversely affects the well-being of those affected.

In the interactive cards, they observe the different types of disorders that are more stigmatized and more common. [Participant 46]

The free approach to the activity allowed them to deepen their understanding of mental disorders without being constrained by preconceived ideas, which contributed to a more open reflection on the associated prejudices and stigmas.

Being a flexible and free-viewing activity, it helps to think about how a person suffering from a disorder might feel. [Participant 12]

#### **Understanding Level**

Student reflections revealed varying levels of understanding, ranging from the recognition of symptoms to a deeper internalization of the emotions and thoughts associated with different mental disorders. Participants demonstrated the ability to distinguish among various conditions, a crucial step toward comprehending the unique severity and impact. As a student explained,

In the image, we see a connection between time and food... we were able to associate different foods with each hour of the day, and it is reflected with an obsession with scheduling, meticulous planning of food intake. [Participant 16]

This differentiation process enabled students to recognize specific symptoms and interpret how these disorders deeply affect the emotional and cognitive experiences of those who live with them. As one participant reflected,

Each time it tends to infinity; that infinity is like associating it with something chronic—of an eating disorder. [Participant 10]

Such reflections reveal a growing capacity for nuanced understanding that extends beyond surface-level identification, indicating the development of empathetic insight and clinically relevant perspectives.

As students progressed through the activity, they demonstrated an increasingly sophisticated understanding of the varying levels of severity associated with mental disorders—ranging from observable behaviors to more complex emotional and psychological dimensions. They moved beyond simply associating symptoms and behaviors, gaining insight into the emotional toll experienced by individuals living with these conditions, including struggles with control and the anxiety tied to rigid eating patterns. This multidimensional understanding highlights how interactive cards support theoretical learning and foster empathy and emotional connection with the lived reality of mental illness. As a student reflected,

Maybe she is aware that she is in that darkness, but she doesn't want to get out because even though she feels bad about herself, she doesn't feel bad—she's comfortable, she doesn't want to get out of there... [Participant 2]

#### **Perception of Interactive Cards**

The participants' perceptions highlight the value of using interactive cards as an educational tool in the study of psychology, particularly in enhancing understanding of mental disorders. The activity was widely appreciated for transforming theoretical content into a more accessible, engaging visual and interactive experience. A participant explained,

I found this way of integrating knowledge easier than a more theoretical one. When you see it in an image and have to reflect on its contents, you have to associate all the information you have given us in class to be able to put it into practice. [Participant 22] In addition, most participants emphasized the benefits of working in groups, noting that exchanging diverse interpretations and perspectives enriched the learning experience. Group interaction fostered an atmosphere of trust and respect, encouraging deeper reflection and more balanced conclusions. As one student stated,

We found it more comfortable to carry out the activity in a group because we were able to deepen our reflection on each interactive card since we had more than one point of view. [Participant 16]

While participants acknowledged the benefits of the activity, some also highlighted specific challenges—particularly related to the abstract nature of the images, which required considerable interpretative effort. The process of identifying and associating symbolic elements with specific mental disorders was perceived as complex, necessitating an open-minded, analytical, and reflective approach. A student observed,

I find it difficult to associate the interactive cards with a disease. I think it is complicated to diagnose, and maybe the signs given by the image have nothing to do with what the author of the photographs really intended. [Participant 21]

Despite these difficulties, participants recognized the pedagogical value of engaging with ambiguity, noting that it mirrored the interpretive and diagnostic complexities often faced in real clinical settings. The experience thus served as an essential formative exercise, encouraging the development of critical thinking and diagnostic sensitivity. Furthermore, the activity helped to strengthen their connection to the field of psychology, providing early exposure to its multifaceted nature and emphasizing its relevance to their future roles as health care professionals.

#### Theme 2: Emotional Connection and Personal Reflection in Learning About Mental Disorders

#### Personal and Social Environment

This category illustrates how personal and social environments significantly influence the emotional and mental experiences of individuals, particularly those living with mental disorders. When engaging with the interactive cards, participants frequently highlighted the distress and anxiety associated with being judged by others and how such judgments shape their self-perception and social behavior. An FG participant reflected,

We have felt very distressed and overwhelmed by how you are judged... It seems like a tunnel that looks like a labyrinth... when you are judged, the only thing you do is get lost in your thoughts... generating anxiety. [FG 2, related to interactive card 1]

Participants also emphasized the powerful impact of societal expectations on self-image. Their feelings of inadequacy or failure to meet imposed standards influence how individuals view themselves and present themselves in social contexts. The metaphor of "mirrors" represented the weight of external expectations, underscoring how individuals may feel lost or disconnected when constantly comparing themselves to idealized social norms. As a participant stated,



We interpret that the person may find themselves at a loss or judge by others' expectations... This influences the way he/she shows him/herself to society. [Participant 38]

These insights underscore the importance of understanding the relational and societal dimensions of mental health, highlighting how external judgment and social pressure can exacerbate emotional distress and contribute to the internal struggles faced by those with mental disorders.

Other participants highlighted the influence of society in the understanding of mental illnesses, recognizing how these pathologies affect not only the people who are affected from them but also their close environment.

We believe that interactive cards have allowed us to understand how mental illness affects people and how it can have an impact on the environment, the society. [FG 4]

Through various interpretations, the effects of mental health in the social context are valued, highlighting the importance of understanding the connections between self-image, food, and social perceptions.

#### Accompaniment and Support Networks

Participants reflect on the importance of accompaniment and support networks in the context of mental disorders. They highlight the challenges faced by people who lack family or social support and the crucial role of these networks in the recovery process. They acknowledge that the recovery process is not linear and that relapses may occur. However, they stress that, despite difficult moments, accompaniment and support can help the person to continue on the road to recovery:

You can fall because you are not in a good moment... there can be relapses, but in the end, everything leads to the same place, which follows the path. [Participant 9, related to interactive card 2]

A central theme in this category is the lack of support faced by many people with mental disorders. Several participants pointed out that those without support networks, whether family or social, tend to experience more difficulties in their recovery process. Lack of resources and isolation can negatively affect self-esteem and self-image, making it challenging to follow appropriate treatment.

She knows that what surrounds her is darkness; many people who have a mental pathology have no family, no resources, no means, in the end, that has an impact on the follow-up and her own self-esteem and self-image. [Participant 26]

Participants also reflect on the obstacles and barriers in readapting to a healthy routine, identifying relapses as moments in which external support is essential.

In addition, we consider that houses dirt roads could represent the 'stops, relapses or downs' of the process to readapt to a stable and healthy routine of meals. [Participant 8, related to interactive card 2]

#### Role of Mental Health Professional

Students reflected on the role they will assume as future mental health professionals, emphasizing the integration of the knowledge acquired during their training to enhance care for individuals with mental disorders. They identified their understanding of eating disorders, personality disorders, and trauma as essential foundations for their future clinical practice. As a participant expressed,

In our professional future, we could use this knowledge to address similar cases in the field of psychology... integrating the acquired knowledge of eating, personality disorders, and addressing trauma into our professional practice. [Participant 48]

The 2 central pillars frequently mentioned as critical to effective intervention were: establishing a strong therapeutic alliance and implementing evidence-based strategies. Participants acknowledged the need to combine empathy with scientifically supported methodologies to promote patients' emotional well-being and recovery.

This would include implementing evidence-based intervention strategies and establishing a strong therapeutic relationship to promote my patients' emotional well-being and recovery. [Participant 15]

Furthermore, students highlighted the value of adopting a holistic perspective in mental health care. Rather than focusing solely on visible symptoms or first impressions, they advocated for a more comprehensive approach that considers emotional, social, and psychological dimensions in an integrated manner. As stated in one FG,

Not to be so rigid with opinions and try to see beyond what we can appreciate at a glance, that is, not to stay only with the initial but to devote time and effort to see everything in a more holistic way. [FG 1]

These reflections demonstrate the development of a professional identity rooted in empathy, critical thinking, and a commitment to evidence-based, person-centered care.

#### Attitudes Change

Participants reported a shift in their attitudes toward greater empathy, particularly as they began to understand the anxiety and distress caused by the uncertainty surrounding recovery from EDs. The lack of a clear resolution to the struggle often leads to heightened emotional distress for affected individuals. This insight made students more aware of the profound emotional burden these disorders entail. As an FG participant reflected,

What we interpret from this image is that it represents a person who has hit rock bottom... the weight that food generates in his mind causes him nightmares. [FG 3, related to interactive card 3]

These reflections contributed to a notable change in how students perceive individuals with EDs, fostering a recognition of the diversity and complexity of their experiences and the importance of a nuanced and empathetic understanding. Several participants also expressed a deepened appreciation for the severity of EDs and other mental health conditions, with some

indicating a desire to explore the topic further to support those affected better. A student shared,

I have felt overwhelmed in general with the four interactive cards, as it considers mental pathologies as something serious and difficult, and I have to integrate myself into the subject to try to understand it. [Participant 36]

Through reflection and analysis of the lived experiences represented in the interactive cards, students developed a more empathetic and comprehensive perspective on the ongoing struggles and emotional challenges faced by individuals with mental disorders. This attitudinal shift underscores the value of sensitizing future health care professionals to the seriousness of mental illness and promoting an informed, compassionate approach to understanding and care.

# Theme 3: Gamification Tools and Their Impact on Learning

#### Impact on Empathy Development

Students' perceptions suggest that the activity functioned as a meaningful catalyst for deepening their understanding of mental disorders and enhancing their capacity for emotional recognition and connection with affected individuals. Many participants described experiencing a strong sense of identification through empathically placing themselves in the position of those living with such conditions. As an FG participant expressed, this involved, "putting themselves in the shoes of people suffering from different disorders, having identified eating disorders, anxiety, depression, and personality disorder" (FG 3).

Testimonials also revealed a profound sense of empathy and compassion, particularly when engaging with the images used in the activity. This emotional response often translated into a genuine desire to offer support:

"I feel empathy and compassion when viewing the images; it generates in me a desire to help and support those suffering from eating disorders, depression, and anxiety. [Participant 12]

Such responses suggest that the activity encouraged emotional resonance and identification with the challenges faced by others, but also inspired a meaningful commitment to action.

#### Introspection and Self-Knowledge

The results reveal that the activity has been a significant means of personal reflection for the students. The tool used has allowed them to express their emotions and share experiences in an intimate and personal way. On the one hand, it has helped them to reflect on themselves, highlighting the importance of self-knowledge in their emotional process:

They allow us to express our emotions and to pour ourselves out in a personal way. [FG 2]

Besides that, it has helped us to reflect on ourselves. [FG 3]

A participant mentioned that he identified with insecurities that he had experienced throughout his life, which highlights the relationship between the activities and the personal experiences of each individual:

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I find the interactive cards overwhelming as well as reflective, and they have caused me anguish, concern or even physical discomfort, since in some I have felt identified with insecurities that have arisen throughout my life. [Participant 8]

This suggests that the activity not only allows the expression of emotions but also invites them to confront and identify their personal experiences and biases. Likewise, the activity promoted reflection on the mental and emotional health of some participants, leading them to question their personal experiences:

The interactive cards generate intense emotions in me such as sadness, fear or discomfort, recalling my own struggles and challenges. [Participant 12]

It helps to express feelings, emotions that we do not know how to explain and shape, such as anxiety. [FG 1]

These findings suggest that the process of inspection and self-knowledge generated through the activity constitutes a valuable resource for emotional development.

#### Learning Process Assessment

They highlight the effectiveness of the activity in broadening the understanding of mental disorders and fostering critical reflection on them. Several noted that the activity allowed them to "broaden the mind and see beyond what is depicted on the interactive cards" (FG 5), promoting deep inquiry and reflection on the various layers of meaning in the images. They recognized that an image does not have a single meaning and that, like mental disorders, perceptions can vary significantly depending on the point of view. This experience helped them challenge the idea that a person with a mental disorder can be pigeonholed into a single experience or interpretation.

They allowed me to understand that an image does not have to have only one meaning...a single thing can represent a great variety of sensations and impressions depending on one's point of view. [Participant 12]

It emphasizes that each representation can evoke a variety of sensations and impressions depending on the observer's viewpoint. Testimonials also reflect the importance of approaching sensitive topics with care and respect. A participant emphasized the ability to "draw conclusions with a careful and thoughtful approach" (P27), suggesting that the activity focuses on theoretical understanding and the ethics of communicating about sensitive topics. This critical reflection is crucial for developing respectful and conscientious professional practice in the mental health field.

Likewise, it was mentioned that the activity is an excellent way to integrate the knowledge acquired in class:

...good activity to integrate the knowledge obtained in class, adding the sensations that each disorder can arouse in the viewer and therefore further ingraining the knowledge of the various disorders. [FG 1]

Integrating theoretical knowledge with practical, emotional experiences reinforces the understanding of the various disorders and facilitates a deeper connection with the material studied.

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Finally, the interactive cards' interpretation helped participants gain a "graphic view of the different mental disorders" (Participant 32) and the topics covered in the course, which translates into more meaningful and visual learning. They suggest the activity is a valuable resource to enhance learning and foster a more holistic and empathetic understanding of mental disorders.

#### Development of Emotional and Empathic Skills

Students reflected on how the activity significantly contributed to developing emotional skills for addressing mental disorders. Interactive cards were seen as an educational tool and a potential aid in clinical settings, facilitating patient openness and expression. An FG participant noted:

Through the interactive cards, the patient can become more open and share deeper aspects of their personal experience, such as when asked to draw themselves. [FG 1]

The value of creative dynamics in therapeutic processes was emphasized, particularly in enabling patients to express experiences and emotions that may be difficult to articulate verbally. Furthermore, participants recognized the potential of these tools for early detection and assessment:

The interactive cards can be valuable tools for early detection of mental health problems and for assessing the emotional state of patients. [FG 2]

These reflections underscore the broader applicability of the activity, not only in education but also in clinical practice and mental health research.

This perspective underscores the value of interactive cards within individual clinical contexts and as valuable tools in broader educational and research initiatives to deepen the understanding of mental disorders. Participants emphasized adopting a biopsychosocial framework when analyzing the interactive cards. This approach involves dedicating time and effort to constructing shared meanings beyond superficial interpretations. As an FG participant noted, it is vital "not to stay only with the initial but to dedicate time and effort to see everything in a more holistic and integrated way with a common meaning elaborated (FG 4).

Such an integrated perspective is essential for developing critical competencies in psychology. Encouraging students to consider emotional, psychological, and social dimensions together fosters a more comprehensive and empathetic understanding of patients' lived experiences. Ultimately, it cultivates reflective, thoughtful, and patient-centered mental health professionals.

These results reflect the complexity of understanding mental disorders through gamification as a learning tool. Figure 5 allows us to establish the following themes: the first theme deals with the perception and stigma of mental disorders. The second theme deals with emotional connection and personal reflection in learning about mental disorders. The third theme deals with gamification tools and their impact on learning. All of them are interrelated with each other through the ATLAS-TI program.



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Figure 5. Qualitative data analysis.



# Discussion

#### **Principal Findings**

This study explored nursing students' perceptions of the approach and management of mental disorders through gamification experiences, using interactive cards as an educational tool. Gamification is presented as an innovative pedagogical approach that transforms the learning process, providing students with an active and participatory experience that encourages critical reflection and meaningful learning [1,3,26,27]. Results suggest that using interactive cards not only stimulates students' critical reflection on mental disorders but also allows them to challenge their theoretical knowledge, thus promoting growth in their self-confidence and ability to cope with complex situations in the mental health field [28-30].

These findings can be interpreted within the experiential learning framework, as the gamified activity immerses students in realistic scenarios that demand active decision-making, emotional involvement, and reflection. By confronting stigmatizing beliefs and exploring different perspectives through role-play and interaction, students engage in a process that aligns with transformative learning theory, fostering a change in their mental models and attitudes toward individuals with mental health disorders [31]. In this way, gamification serves as a motivational tool and becomes a vehicle for deep personal and professional growth [26-29].

Currently, gamification is gaining ground in clinical practice as an innovative strategy in the treatment and prevention of certain mental disorders. Several studies have shown that gamified interventions can improve patient engagement and motivation, facilitating treatment adherence in disorders such as depression and anxiety [7,8,32]. These tools allow patients



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to perform self-care, emotional regulation, and coping skills exercises in an interactive way, which can reduce symptoms and improve overall well-being. In addition, gamification in mental health can be tailored to each patient's needs, personalizing the experience and promoting active, hands-on learning of life skills [8,32]. However, despite the proven benefits of mental health, gamification is still being implemented progressively in the academic training of health sciences students. These benefits highlight the importance of the intervention carried out in the present research, which addresses and studies the treatment of mental health disorders such as eating disorders, emotional instability, and personality disorders from a gamified approach.

Implementing these strategies in the classroom could facilitate the understanding and managing of these mental illnesses, promoting the development of practical skills and greater empathy in future nursing professionals. Currently, nursing students require alternative and innovative methods to maintain a high level of engagement in their learning process. Gamification has demonstrated significant benefits in the development of cross-cutting clinical competencies, favoring essential qualities such as resilience, confidence in teamwork, effective communication, resource management, and taking responsibility in collaborative roles [3,27]. These innovative approaches promote more dynamic learning and reinforce key skills needed in the clinical setting, with encouraging results [28,33]. Furthermore, gamification, by using game dynamics in educational contexts, motivates students to engage more deeply with the study material [3,26,34].

The research findings highlight that gamification, by incorporating emotional and realistic elements, maximizes the positive impact on students' professional and personal development [29]. Students' interest was stimulated by interactive cards representing different mental disorders. They could participate through FGs in in-depth and diverse discussions, which enriched their understanding of the topic and helped them develop essential interpersonal skills and emotional intelligence [3]. These skills include empathy, active listening, and effective communication, which are fundamental to establishing therapeutic relationships with patients [15,30,35].

Through the collaborative exploration of interactive cards, students were able to identify and critically analyze the signs and symptoms associated with eating disorders and emotional instability. This process facilitated the recognition of clinical manifestations and deepened their understanding of the emotional and social contexts that shape each mental health condition. By engaging with the complexities of mental disorders from multiple perspectives, students developed a more nuanced and empathetic appreciation of the lived experiences of individuals affected by these conditions [36].

Participants emphasized the importance of understanding the underlying motivations behind the behaviors of people with mental disorders. This reflects a more holistic and balanced approach that moves beyond a narrow focus on risk factors to acknowledge the role of protective factors. Such insights support the development of a comprehensive perspective on mental health, reinforcing the need for multidimensional assessments

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that integrate emotional, social, and clinical considerations in practice [36].

This level of insight is fostered through educational strategies that immerse students in emotionally meaningful and reflective learning experiences, aligning with the principles of experiential learning, as students are immersed in simulated, meaningful scenarios that demand reflection, analysis, and decision-making. Furthermore, the activity design fostered dialogical and spaces-through collaborative learning FGs and discussions-that facilitated the development of interpersonal skills such as empathy, active listening, and therapeutic communication [31]. Taken together, these processes also resonate with the principles of transformative education, as the students not only engaged in active, experience-based learning but also reported having questioned their preconceived ideas and developed a more nuanced and compassionate understanding of mental illness.

One of the key advantages of gamification lies in the positive perceptions students hold toward educational games, which enhance motivation and promote learning across cognitive and affective domains. When implemented in team-based formats, gamification also improves communication and social interaction among participants. It offers opportunities to build interpersonal connections, foster mutual respect, and develop teamwork and collaboration skills while simulating real-world professional challenges [26,27,37]. By sharing reflections and experiences, this collaborative learning process contributes to developing practical competencies. It positively influences students' perceptions of their field and future career aspirations [30,33].

The findings of this study highlight that gamification not only improves nursing students' competencies and confidence but also has a transformative impact on their career aspirations. Through gamification, students develop a deeper understanding of the complexity of managing mental disorders, which helps them approach mental health with a more empathetic and proactive attitude. Gamification is therefore established as a valuable tool in training future nursing professionals, promoting a holistic and positive approach to mental health care that will benefit students and patients.

#### **Practical and Research Implications**

The practical implications of this study highlight the importance of integrating gamification tools, such as interactive cards, into health sciences education, specifically in the training of nursing students. This approach improves understanding of mental disorders and fosters the development of emotional competencies and key skills, such as empathy, effective communication, and critical reflection, essential for providing comprehensive and humanized care. Incorporating these tools can also enhance students' ability to engage with patients more compassionately and informally, improving patient outcomes. Incorporating these tools can also enhance students' ability to engage with patients more compassionately and informally, improving patient outcomes. Likewise, the implementation of these strategies can be extended to clinical settings, where interactive tools could be adapted for patient education or used as support in therapeutic contexts. In addition, these activities

promote collaborative learning, creating a space for open discussion and exchange of perspectives among students, which enhances their preparedness to address complex situations in professional practice. This approach is also aligned with the principles of experiential learning, where students learn through direct practice and reflection on their experiences, reinforcing understanding and retention of key concepts.

In terms of research, this study opens the door to future explorations that evaluate the longitudinal impact of gamified tools on understanding and empathy toward mental disorders. It would be relevant to investigate how this approach influences the development of professional competencies over time. In addition, it is suggested that studies be conducted in different cultural and educational contexts to determine the transferability of the findings and compare the effectiveness of gamification versus traditional teaching methodologies. Research should also focus on developing and customizing gamified tools adapted to the specific needs of the students and disorders studied. Finally, exploring emerging technologies, such as virtual or augmented reality, could maximize immersion and enrich student learning in this field.

#### **Strengths and Limitations**

This study highlights 2 fundamental aspects. First, it proposes an innovative perspective on transforming the university educational model, advocating using gamification tools, such as interactive cards, to enrich understanding and reflection on mental disorders. Second, gamified strategies stimulate student interest and participation and facilitate more profound and meaningful learning.

Regarding the study's limitations, it is relevant to mention that it was conducted with nursing students from a university in Spain, which restricts the generalizability of the findings to other contexts or institutions. This study reflects students' perceptions of using interactive cards as a gamification tool to explore mental disorders. It would be valuable to extend qualitative research in a broader framework, incorporating a variety of gamification tools and complementing it with quantitative studies that measure the effectiveness of these innovative educational strategies.

#### Conclusions

This qualitative study has shown that gamification, used as a teaching strategy, can be an effective tool to improve the understanding of mental disorders among nursing students. Participants highlighted a higher degree of empathy, motivation, and commitment to learning, as well as a better internalization of content related to mental health. The results also reveal that nursing students face difficulties when participating in gamification activities related to mental disorders, mainly due to their limited prior experience in this field. In this context, implementing graphics as a gamified resource was shown to be an effective strategy to address these difficulties. These graphics, used as metaphors, provided an interactive and reflective framework that facilitated learning, allowing students to explore their emotions less directly and express them symbolically.

This visual approach helped participants reflect on their internal conflicts and project their goals and aspirations while developing self-assessment skills by identifying emotions, conflicts, and possible solutions. In this way, gamification serves to transmit knowledge and as a catalyst for students' personal and emotional growth in the mental health field. From a practical point of view, these findings suggest that including gamified dynamics-especially those with visual and symbolic components-in nursing training programs can facilitate a more meaningful, empathetic, and participatory approach to studying mental disorders.

As future lines of research, it is proposed to replicate this study with more extensive and more heterogeneous samples and to complement the qualitative approach with quantitative studies that evaluate the impact of gamification on variables such as academic performance, knowledge retention, or the development of emotional competencies. It would also be relevant to explore teachers' and clinicians' perceptions of integrating gamified methodologies in teaching content related to mental health.

#### Acknowledgments

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#### **Conflicts of Interest**

None declared.

Multimedia Appendix 1 Detailed descriptions of each interactive card. [DOCX File, 1718 KB - nursing\_v8i1e71921\_app1.docx]

#### References

- 1. Gentry SV, Gauthier A, L'Estrade Ehrstrom B, et al. Serious gaming and gamification education in health professions: systematic review. J Med Internet Res 2019 Mar 28;21(3):e12994. [doi: 10.2196/12994] [Medline: 30920375]
- García-Viola A, Garrido-Molina JM, Márquez-Hernández VV, Granados-Gámez G, Aguilera-Manrique G, Gutiérrez-Puertas L. The influence of gamification on decision making in nursing students. J Nurs Educ 2019 Dec 1;58(12):718-722. [doi: 10.3928/01484834-20191120-07] [Medline: <u>31794039</u>]

- Ropero-Padilla C, Rodriguez-Arrastia M, Martinez-Ortigosa A, Salas-Medina P, Folch Ayora A, Roman P. A gameful blended-learning experience in nursing: a qualitative focus group study. Nurse Educ Today 2021 Nov;106:105109. [doi: 10.1016/j.nedt.2021.105109] [Medline: 34450457]
- van Gaalen AEJ, Brouwer J, Schönrock-Adema J, Bouwkamp-Timmer T, Jaarsma ADC, Georgiadis JR. Gamification of health professions education: a systematic review. Adv Health Sci Educ Theory Pract 2021 May;26(2):683-711. [doi: 10.1007/s10459-020-10000-3] [Medline: 33128662]
- 5. Malicki A, Vergara FH, Van de Castle B, et al. Gamification in nursing education: an integrative literature review. J Contin Educ Nurs 2020 Nov 1;51(11):509-515. [doi: 10.3928/00220124-20201014-07] [Medline: 33104811]
- 6. Seymour A, Borggren M, Baker R. Escape the monotony: gamification enhances nursing education. J Emerg Nurs 2023 Nov;49(6):805-810. [doi: <u>10.1016/j.jen.2023.06.004</u>] [Medline: <u>37422743</u>]
- Castellano-Tejedor C, Cencerrado A. Gamification for mental health and health psychology: insights at the first quarter mark of the 21st century. Int J Environ Res Public Health 2024 Jul 28;21(8):990. [doi: <u>10.3390/ijerph21080990</u>] [Medline: <u>39200601</u>]
- 8. Cheng C, Ebrahimi OV. Gamification: a novel approach to mental health promotion. Curr Psychiatry Rep 2023 Nov;25(11):577-586. [doi: 10.1007/s11920-023-01453-5] [Medline: <u>37801212</u>]
- 9. Hope DL, Grant GD, Rogers GD, King MA. Gamification in pharmacy education: a systematic quantitative literature review. Int J Pharm Pract 2023 Mar 13;31(1):15-31. [doi: 10.1093/ijpp/riac099] [Medline: 36472962]
- Six SG, Byrne KA, Tibbett TP, Pericot-Valverde I. Examining the effectiveness of gamification in mental health apps for depression: systematic review and meta-analysis. JMIR Ment Health 2021 Nov 29;8(11):e32199. [doi: <u>10.2196/32199</u>] [Medline: <u>34847058</u>]
- 11. Harvey T. Embracing simulation in mental health nurse education: a bespoke approach to tackling genericism. Nurse Educ Pract 2023 Aug;71:103698. [doi: 10.1016/j.nepr.2023.103698] [Medline: 37422340]
- Lakeman R, Foster K, Happell B, Hazelton M, Moxham L, Hurley J. Informing the development of a fit-for-purpose mental health nursing curriculum: a survey of mental health nurse academics in Australia. Int J Ment Health Nurs 2024 Feb;33(1):93-103. [doi: 10.1111/inm.13226] [Medline: 37705299]
- 13. Kent KG. Psychotherapy skills for psychiatric mental health nurse practitioner students in the age of competency-based education. Nurs Educ Perspect 2024;45(5):316-318. [doi: 10.1097/01.NEP.00000000001311] [Medline: 39159252]
- 14. Mosalanejad L, Abdollahifard S, Abdian T. Psychiatry gamification from blended learning models and efficacy of this program on students. J Educ Health Promot 2020;9:68. [doi: 10.4103/jehp.jehp\_352\_19] [Medline: 32490003]
- Kim H, Kim B. Effects of situation-based flipped learning and gamification as combined methodologies in psychiatric nursing education: a quasi-experimental study. Healthcare (Basel) 2022 Mar 30;10(4):644. [doi: <u>10.3390/healthcare10040644</u>] [Medline: <u>35455822</u>]
- 16. Campillo Rodríguez M. Terapia narrativa de juego [Article in Spanish]. Haciendo Psicología 2013(2):1-30 [FREE Full text]
- 17. Lukka L, Palva JM. The development of game-based digital mental health interventions: bridging the paradigms of health care and entertainment. JMIR Serious Games 2023 Sep 4;11:e42173. [doi: <u>10.2196/42173</u>] [Medline: <u>37665624</u>]
- Jack SM, Phoenix M. Qualitative health research in the fields of developmental medicine and child neurology. Dev Med Child Neurol 2022 Jul;64(7):830-839. [doi: <u>10.1111/dmcn.15182</u>] [Medline: <u>35156198</u>]
- 19. Malterud K. Theory and interpretation in qualitative studies from general practice: why and how? Scand J Public Health 2016 Mar;44(2):120-129. [doi: 10.1177/1403494815621181] [Medline: 26647095]
- 20. Moser A, Korstjens I. Series: practical guidance to qualitative research. Part 3: sampling, data collection and analysis. Eur J Gen Pract 2018 Dec;24(1):9-18. [doi: 10.1080/13814788.2017.1375091] [Medline: 29199486]
- 21. Creswell JW, Poth CN. Qualitative Inquiry and Research Design: Choosing Among Five Approaches: SAGE Publications; 2018.
- 22. Wong LP. Focus group discussion: a tool for health and medical research. Singapore Med J 2008 Mar;49(3):256-260. [Medline: 18363011]
- 23. Hennink MM, Kaiser BN, Weber MB. What influences saturation? Estimating sample sizes in focus group research. Qual Health Res 2019 Aug;29(10):1483-1496. [doi: 10.1177/1049732318821692] [Medline: 30628545]
- 24. Nowell LS, Norris JM, White DE, Moules NJ. Thematic analysis: striving to meet the trustworthiness criteria. Int J Qual Methods 2017;16(1). [doi: 10.1177/1609406917733847]
- Tong A, Sainsbury P, Craig J. Consolidated Criteria for Reporting Qualitative Research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care 2007 Dec;19(6):349-357. [doi: <u>10.1093/intqhc/mzm042</u>] [Medline: <u>17872937</u>]
- 26. McEnroe-Petitte D, Farris C. Using gaming as an active teaching strategy in nursing education. Teaching and Learning in Nursing 2020 Jan;15(1):61-65. [doi: <u>10.1016/j.teln.2019.09.002</u>]
- Roman P, Rodriguez-Arrastia M, Molina-Torres G, Márquez-Hernández VV, Gutiérrez-Puertas L, Ropero-Padilla C. The escape room as evaluation method: a qualitative study of nursing students' experiences. Med Teach 2020 Apr;42(4):403-410. [doi: 10.1080/0142159X.2019.1687865] [Medline: 31738615]

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- 28. Kim HK, Jun M, Rhee S, Wreen M. Husserlian phenomenology in Korean nursing research: analysis, problems, and suggestions. J Educ Eval Health Prof 2020;17:13. [doi: 10.3352/jeehp.2020.17.13] [Medline: 32311867]
- Sakamoto SR, Dell'Acqua MCQ, Abbade LPF, Caldeira SM, Fusco SDF, Avila MD. Team-based learning: a randomized clinical trial in undergraduate nursing. Rev Bras Enferm 2020;73(2):e20180621. [doi: <u>10.1590/0034-7167-2018-0621</u>] [Medline: <u>32236370</u>]
- 30. Shorey S, Siew AL, Ang E. Experiences of nursing undergraduates on a redesigned blended communication module: a descriptive qualitative study. Nurse Educ Today 2018 Feb;61:77-82. [doi: <u>10.1016/j.nedt.2017.11.012</u>] [Medline: <u>29190535</u>]
- 31. Singer-Brodowski M. The potential of transformative learning for sustainability transitions: moving beyond formal learning environments. Environ Dev Sustain 2023. [doi: 10.1007/s10668-022-02444-x]
- 32. Jingili N, Oyelere SS, Nyström MBT, Anyshchenko L. A systematic review on the efficacy of virtual reality and gamification interventions for managing anxiety and depression. Front Digit Health 2023;5:1239435. [doi: 10.3389/fdgth.2023.1239435] [Medline: 38026832]
- Magnavita N, Chiorri C. Academic stress and active learning of nursing students: a cross-sectional study. Nurse Educ Today 2018 Sep;68:128-133. [doi: <u>10.1016/j.nedt.2018.06.003</u>] [Medline: <u>29906771</u>]
- 34. Gómez-Urquiza JL, Gómez-Salgado J, Albendín-García L, Correa-Rodríguez M, González-Jiménez E, Cañadas-De la Fuente GA. The impact on nursing students' opinions and motivation of using a "Nursing Escape Room" as a teaching game: a descriptive study. Nurse Educ Today 2019 Jan;72:73-76. [doi: 10.1016/j.nedt.2018.10.018] [Medline: 30453202]
- 35. Kim SJ, Kim B. Effects of communication empowerment program based on situated learning theory for nursing students. J Korean Acad Nurs 2018 Dec;48(6):708-719. [doi: <u>10.4040/jkan.2018.48.6.708</u>] [Medline: <u>30613058</u>]
- Buijs-Spanjers KR, Harmsen A, Hegge HH, Spook JE, de Rooij SE, Jaarsma D. The influence of a serious game's narrative on students' attitudes and learning experiences regarding delirium: an interview study. BMC Med Educ 2020 Sep 1;20(1):289. [doi: 10.1186/s12909-020-02210-5] [Medline: 32873285]
- 37. Akl EA, Sackett KM, Erdley WS, et al. Educational games for health professionals. Cochrane Database Syst Rev 2013 Jan 31;1(1):CD006411. [doi: 10.1002/14651858.CD006411.pub3] [Medline: 23440807]

# Abbreviations

COREQ: Consolidated Criteria for Reporting Qualitative ResearchED: eating disorderFG: focus groupPD: personality disorder

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# Fear of Missing Out, Social Media Addiction, and Personality Traits Among Nursing Students: Cross-Sectional Study

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# Abstract

**Background:** The growing use of social media has created concerns about addiction, and thus, it is necessary to explore how personality traits and fear of missing out (FOMO) can be utilized to predict social media addiction (SMA).

**Objectives:** The purpose of this study was to investigate the connection between personality traits, FOMO, and SMA in university students in Saudi Arabia.

**Methods:** In this cross-sectional study, data were collected from nursing students using the shortened version of the big five inventory, fear of missing out scale, and SMA scale from May to September 2024.

**Results:** The study achieved a response rate of 66.7% (414/620), finally including a total of 411 participants. The majority of participants (247/411, 60.1%) had low FOMO scores, while SMA scores showed a different pattern, with a larger proportion (261/411, 63.5%) of participants scoring in the moderate range. In terms of gender differences, male participants exhibited higher levels of FOMO (t=3.86, P<.001) and SMA (t=2.51, P=.013) compared to female participants. Additionally, male participants scored higher in neuroticism (t=3.30, P=.001) and openness (t=1.98, P=.048). Regression analysis revealed that both conscientiousness ( $\beta$ =.357, P<.01) and FOMO ( $\beta$ =.213, P<.01) positively predicted SMA, while neuroticism ( $\beta$ =-.223, P<.01) and being female ( $\beta$ =-.098, P<.05) were associated with lower levels of addiction. The resulting model accounted for 35.8% of the variance.

**Conclusions:** The study provides evidence that conscientiousness and FOMO are positive predictors of SMA, while neuroticism is negatively correlated with it. Moreover, male participants exhibited higher levels of both FOMO and SMA in comparison to female participants. These findings emphasize the impact of personality traits and FOMO on SMA among university students.

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# **KEYWORDS**

social media; personality; fear, neuroticism; conscientiousness; students; nursing

# Introduction

The proliferation of social media has revolutionized the way people connect and consume information. Yet, alongside the advantages of social media, several issues have been raised concerning its potential negative effects on a person's well-being [1]. Social media addiction (SMA), also described as problematic social media use, is exemplified by extreme and compulsive usage of social media that negatively impacts an individual's life. Like other forms of behavioral addictions, SMA enmeshes a loss of control over one's usage, social media activities preoccupation, and continued engagement despite adverse outcomes. Numerous studies have investigated the determinants and outcomes of SMA [2-5]. Factors such as personality traits, social influences, and fulfillment of psychological needs have been implicated in the development and maintenance of SMA [2,3]. Moreover, SMA has been associated with a range of negative outcomes, including

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impaired academic performance, diminished real-life social relationships, and increased risk of mental health problems such as depression and anxiety [4,5].

Fear of missing out (FOMO) refers to the apprehension or anxiety individuals experience when they believe that others are engaging in enjoyable activities or experiences from which they are excluded [6,7]. Research indicates that people with elevated FOMO have a high probability of engaging in excessive social media use, experience higher levels of stress and anxiety, and report lower levels of life satisfaction and well-being [7,8]. Additionally, FOMO has been linked to problematic behaviors such as compulsive smartphone checking, which can further exacerbate feelings of anxiety and dissatisfaction [9].

Personality traits have a considerable role in individuals' susceptibility to FOMO and SMA. Research has identified several personality traits that may contribute to these phenomena [7]. For example, individuals high in neuroticism, considered

by tendencies toward anxiety and other negative emotions, may be more prone to experiencing FOMO and engaging in excessive social media use as a means of stress-coping strategy [7,9]. Similarly, individuals with high levels of extraversion may also be at increased risk of developing problematic patterns of social media use, as they may seek social validation and affirmation through online interactions [3]. The interplay between FOMO, SMA, and personality traits is complex and multifaceted. Personality traits may influence individuals' susceptibility to FOMO and SMA, while these phenomena, in turn, may exacerbate underlying personality vulnerabilities. For instance, people high in neuroticism may be particularly susceptible to developing SMA as a means of alleviating feelings of anxiety and insecurity correlated with FOMO [9]. Few studies focus on personality types and their relation to FOMO [7,10]. Research suggests that neuroticism is positively correlated with FOMO, as people with higher levels of neuroticism have a high probability of experiencing fear, insecurity, and anxiety related to missing out on rewarding experiences [7]. While extraversion is typically associated with sociability and outgoing behavior, it can also be linked to FOMO, particularly in the context of social comparison and the desire for social validation. Extraverted individuals may be more likely to engage in social media use in order to stay connected with others and seek external validation, leading to higher levels of FOMO [10].

Openness to experience reflects individuals' receptivity to new ideas, experiences, and perspectives. While research on the relationship between openness and FOMO is limited, some studies suggest that individuals high in openness may be more motivated to seek out novel experiences and social interactions, potentially increasing their susceptibility to FOMO [11]. Conscientiousness is characterized by self-discipline, organization, and goal-directed behavior. Although less studied than other personality traits, conscientiousness may play a role in individuals' susceptibility to FOMO, particularly concerning academic and professional goals. High levels of conscientiousness may lead individuals to prioritize staying informed and connected with others, contributing to higher levels of FOMO [10]. Furthermore, research suggests that individuals may use social media as a means of seeking validation and approval from others, leading to heightened feelings of anxiety and insecurity related to missing out on social experiences [11].

The negative consequences of SMA and FOMO on the mental and physical health of university students were reported; studies have shown that the extreme use of social media is linked with symptoms of depression and poor physical activity, exacerbating mental illness [12]. Moreover, SMA has been associated with body image problems, because students compare themselves to unrealistic standards, which results in body dissatisfaction, and therefore, irrational attitudes [13,14]. SMA additionally warps weight perception, which is concerning for the reason that it affects students' lifestyle [15]. Furthermore, continuous exposure to social media may impact health behaviors, for instance, eating habits, which can lead to negative health effects [16]. Thus, the interaction of SMA and FOMO among university students may destroy physical and psychological well-being.

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Therefore, it is significant to explore SMA, FOMO, and personality traits among university students, as social media usage is progressively becoming more widespread and might negatively affect mental health, academic performance, and well-being. University students, as they are under the stress of academic and social comparison, are more vulnerable to social media impacts. Understanding how personality influences social media use can help identify students at risk of addiction and the ensuing mental challenges. It is vital to conduct this research to recommend interventions that promote healthier digital habits and improve students' overall well-being. Moreover, among nursing students in Saudi Arabia, little is known about the FOMO and SMA. Thus, this study aims to explore nursing students' personality traits and their relation to the FOMO and SMA in the era of rapid technology.

# Methods

# Site, Setting, and Design

A cross-sectional study was conducted at the College of Nursing, Imam Abdulrahman Bin Faisal University, located in the Eastern Province of Saudi Arabia, from May to September 2024.

# Sampling

The target population for this study comprised students enrolled in the College of Nursing. The inclusion criteria consisted of nursing students from the first to the fifth year. Students who had postponed their courses or withdrawn from the nursing college were excluded. A convenience sampling method was employed due to practical constraints, including limited access to a comprehensive student list and time restrictions. Given that the study aimed to explore associations rather than generalize findings to the entire population, nonprobability sampling was deemed appropriate. While probabilistic sampling enhances generalizability, its implementation was not feasible within the context of this research. The sample size was calculated based on the Raosoft calculator [17], based on the total population of 1129 people, 95% confidence level, and 5% margin. The sample of 287 nursing students was considered representative. Although the calculated sample size was 287, a total of 411 students responded to the survey, and all responses were valid.

Students were contacted via their university email by the registration office. A research pack was sent, which included an information sheet with detailed study information, along with a web-link and barcode to access the study questionnaires. A follow-up email was sent 2 weeks later to remind students to complete the questionnaires. The questionnaires took approximately 30 - 45 minutes to complete.

# **Study Tools**

# Fear of Missing Out

The FOMO scale [7] is a self-report instrument designed to measure individuals' tendencies to experience FOMO on rewarding experiences. The questionnaire consists of 10 items, each assessing different aspects of FOMO. Respondents rate their agreement with each item on a scale, typically ranging from 1 (strongly disagree) to 7 (strongly agree). Example items include "I fear others have more rewarding experiences than

me" and "I fear my friends have more rewarding experiences than me." The Cronbach  $\alpha$  coefficient for the FOMO scale has been reported to be around .85, indicating high internal consistency among its items. The scale validity and reliability were measured and confirmed to be appropriate for use in Arabic culture [18]. For this study, the Cronbach  $\alpha$  coefficient for the FOMO construct was calculated to be 0.757, while the McDonald  $\omega$  coefficient was determined to be 0.744.

# Personality Traits

The big five personality traits were assessed using a shortened version of the big five inventory, consisting of 44 Likert-scale items. Participants rated their agreement on a scale from 1 (strongly disagree) to 5 (strongly agree). This inventory encompasses five subscales: conscientiousness, extraversion, agreeableness, openness, and neuroticism [19]. Example items include "I see myself as someone who is talkative," "I see myself as someone who tends to find fault with others," and "I see myself as someone who does a thorough job." Validity and reliability assessments for the Arabic version were conducted, revealing Cronbach  $\alpha$  coefficients ranging from 0.84 to 0.68 across the subscales [20]. The Cronbach  $\alpha$  for the totality of personality traits was calculated to be 0.704, while the McDonald  $\omega$  was determined to be 0.653.

In addition, the students' sociodemographic data were collected using a form developed by the researchers, which included information such as age, gender, and marital status.

# SMA

The social media addiction scale [18] was employed to assess social media usage. This scale, derived from the internet addiction test [21], comprised 14 items tailored to gauge SMA specifically. Respondents rated these items on a 5-point Likert scale, ranging from strongly agree to strongly disagree, with corresponding scores of 5 to 1. Example items include "I often find myself using social media longer than intended" and "I often find life to be boring without social media." The validity and reliability of the social media addiction scale were examined and proven appropriate for use in Arabic culture [18]. The Cronbach  $\alpha$  coefficient for the SMA was 0.837, while the McDonald  $\omega$  coefficient was 0.841.

# **Ethical Considerations**

The study received ethical approval from the Institutional Review Board (IRB) at Imam Abdulrahman Bin Faisal University, under approval number IRB-2024–04-475. The IRB endorsed the study procedures and surveys prior to the initiation of participant recruitment. The participants consisted of nursing students from the College of Nursing at Imam Abdulrahman Bin Faisal University. Prior to participation, students were provided with a comprehensive information sheet that outlined the voluntary nature of the study, as well as their right to

withdraw at any time without compromising their academic standing or rights. Participants received a detailed explanation of the study, including its associated risks and benefits. They were assured that their confidentiality and privacy would be upheld in accordance with the study's established guidelines. The information sheet also delineated the research objectives, significance, and potential benefits of the study. Informed consent was obtained from all study participants.

# **Data Analysis**

Data were collected and analyzed utilizing SPSS (version 22; IBM Corp) and Microsoft Excel. Categorical variables were assessed through frequencies and percentages, whereas continuous variables were described using means and standard deviations. The reliability of the scales was evaluated using Cronbach  $\alpha$  coefficients. Differences between groups and relationships among variables were analyzed employing *t* tests. Correlation analysis was conducted to examine relationships between various variables. To predict SMA scores, a multiple stepwise regression analysis was conducted, incorporating demographic variables and personality traits, specifically extraversion, agreeableness, conscientiousness, and neuroticism, alongside the FOMO. A *P* value of less than .05 was deemed statistically significant.

Data cleaning and screening were performed utilizing SPSS and Microsoft Excel. The response rate yielded a 66.7% rate of participation, with a total of 414 individuals involved in the study. One participant was eliminated due to zero variance, indicating a lack of engagement, while 2 participants were excluded as outliers based on Mahalanobis distance [22]. The individual personality trait  $\alpha$  values were as follows: 0.640 for extraversion, 0.646 for agreeableness, 0.735 for conscientiousness, 0.819 for neuroticism, and 0.614 for openness. Reverse coding was applied where necessary. Both FOMO and SMA scales were categorized into three levels based on the calculated interval of (5 - 1)/3 = 1.33 [23]. The ranges were delineated as follows: a low score was defined as falling between 1 and 2.33, a moderate score was classified as ranging from 2.34 to 3.67, and a high score was indicated as any value exceeding 3.67.

# Results

Table 1 presents the demographic characteristics of the 411 study participants. A significant majority of the participants were female participants (302/411, 73.5%), with a predominant proportion identifying as single (395/411, 96.1%). The age distribution was relatively balanced, with 201/411 (48.9%) participants under the age of 20 years and 210/411 (51.1%) aged 20 or older. Regarding academic standing, 194/411 (47.2%) were first-year students, while 217/411 (52.8%) were enrolled in other academic years



Table . Characteristics of participants (N=411).

Variable	n (%)
Gender	
Male	109 (26.5)
Female	302 (73.5)
Marital status	
Single	395 (96.1)
Married	16 (3.9)
Age (years)	
<20	201 (48.9)
≥20	210 (51.1)
Education level	
1st year	194 (47.2)
Other years	217 (52.8)

Table 2 presents the distribution of FOMO and SMA scores among participants. The findings indicate that a majority of participants (247/411, 60.1%) exhibited low FOMO scores, while 155/411 (37.7%) fell within the moderate range, and only 9/411 (2.2%) attained high scores. This distribution reflects an overall lower prevalence of FOMO. In contrast, the analysis of SMA scores reveals that 124/411 (30.2%) of participants scored low, 261/411 (63.5%) were categorized within the moderate

range, and 26/411 (6.3%) achieved high scores. These results suggest that, although most participants displayed low to moderate levels of FOMO, a notable prevalence of SMA was observed, with a significant proportion reporting moderate to high levels of addiction. Additionally, participants exhibited moderate levels of extraversion, neuroticism, conscientiousness, and openness, while agreeableness recorded the lowest scores.

Table. Distribution of FOMO,<sup>a</sup> SMA,<sup>b</sup> and personality traits scores by frequency and percentage.

Variable	Value
FOMO, n (%)	
Low (≤2.33)	247 (60.1)
Moderate (2.34 - 3.67)	155 (37.7)
High (≥3.68)	9 (2.2)
SMA, n (%)	
Low (≤2.33)	124 (30.2)
Moderate (2.34 - 3.67)	261 (63.5)
High (≥3.68)	26 (6.3)
Personality traits, mean (SD)	
Extraversion	3.1 (0.5)
Agreeableness	2.0 (0.5)
Conscientiousness	2.8 (0.6)
Neuroticism	3.1 (0.8)
Openness	2.6 (0.5)

<sup>a</sup>FOMO: fear of missing out.

<sup>b</sup>SMA: social media addiction.

The analysis demonstrates substantial gender disparities in both FOMO and SMA. Male participants exhibited elevated levels of FOMO (mean 2.43, SD 0.61) in comparison to female participants (mean 2.16, SD 0.63), with a t statistic of 3.86 (P<.001). Likewise, males reported higher levels of SMA (mean

2.82, SD 0.62) than their female counterparts (mean 2.64, SD 0.65), with a *t* value of 2.51 (P=.013). Nevertheless, the analysis did not identify any significant differences in FOMO or SMA as a function of age or educational attainment (Table 3).

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Table . Group differences in fear of missing out and social media addiction by demographic variables.

Variables	FOMO			SMA		
	Mean (SD)	$t \text{ test } (df)^{a}$	<i>P</i> value	Mean (SD)	$t \text{ test } (df)^{\mathbf{a}}$	P value
Gender	·	3.86 (409)	<.001		2.51 (409)	.013
Male	2.43 (0.61)			2.82 (0.62)		
Female	2.16 (0.63)			2.64 (0.65)		
Age (years)		-1.53 (409)	.128		-1.30 (409)	.193
<20	2.18 (0.63)			2.64 (0.63)		
≥20	2.28 (0.64)			2.73 (0.65)		
Education level		-0.93 (409)	.351		-0.24 (409)	.810
1st year	2.20 (0.62)			2.68 (0.63)		
Other years	2.26 (0.65)			2.69 (0.66)		

# <sup>a</sup>Two-tailed

Table 4 delineates notable gender differences in specific personality traits. Male participants exhibited significantly higher scores than female participants in both neuroticism and openness. These findings indicate that gender may influence

the development of certain personality dimensions among nursing students. Additionally, no significant differences were detected across age groups or educational levels with regard to any of the assessed personality traits.

Table . Group differences in personality traits by gender, marital status, age, and education level.

Variables or categ	gories	Gender		Age (years)		Education level	
		Male	Female	<20	≥20	1st year	Other years
Extraversion	Mean (SD)	3.12 (0.46)	3.06 (0.47)	3.06 (0.47)	3.08 (0.47)	3.05 (0.47)	3.09 (0.47)
	$t \text{ test } (df)^{a}$	1.23 (409)		-0.45 (409)		-0.84 (409)	
	P value	.22		.656		.401	
Agreeableness	Mean (SD)	2.04 (0.47)	1.98 (0.47)	2.02 (0.49)	1.97 (0.44)	2.01 (0.49)	1.99 (0.45)
	$t \text{ test } (df)^{a}$	1.06 (409)		1.13 (409)		0.39 (409)	
	P value	.29		.26		.696	
Conscientious-	Mean (SD)	2.8 (0.47)	2.73 (0.57)	2.77 (0.56)	2.73 (0.54)	2.79 (0.57)	2.72 (0.53)
ness	t test ( $df$ )	1.2 (409)		0.85 (409)		1.22 (409)	
	P value	.232		.397		.224	
Neuroticism	Mean (SD)	3.25 (0.68)	2.98 (0.76)	2.99 (0.74)	3.11 (0.75)	2.98 (0.76)	3.11 (0.73)
	t test (df)	3.3 (409)		-1.57 (409)		-1.66 (409)	
	P value	.001		.111		.098	
Openness	Mean (SD)	2.67 (0.48)	2.56 (0.51)	2.59 (0.50)	2.58 (0.51)	2.58 (0.51)	2.6 (0.50)
	t test ( $df$ )	1.98 (409)		0.12 (409)		-0.39 (409)	
	P value	.048		.908		.696	

### <sup>a</sup>Two tailed

Table 5 revealed the correlations among FOMO, SMA, and various personality traits. FOMO exhibited a positive correlation with conscientiousness, agreeableness, and SMA, suggesting that individuals displaying elevated levels of FOMO tend to be more conscientious, agreeable, and report increased social media usage. Conversely, FOMO demonstrated a negative correlation with neuroticism. SMA displayed positive correlations with

conscientiousness, agreeableness, openness, and extraversion, indicating that these personality traits are associated with heightened levels of SMA. In contrast, neuroticism was negatively correlated with SMA, suggesting that individuals with higher levels of neuroticism reported diminished addiction to social media.



Variables	Statistical test	Extraversion	Agreeableness	Conscientious- ness	Neuroticism	Openness	SMA
FOMO	r <sup>a</sup>	-0.076	0.137	0.261	-0.237	0.077	0.378
	P value	.122	.005	<.001	<.001	.117	<.001
SMA	r	0.116	0.308	0.500	-0.389	0.160	1
	P value	.018	<.001	<.001	<.001	<.001	_b

Table . Correlation analysis between fear of missing out, social media addiction, and personality traits.

<sup>a</sup>r: Pearson Correlation

<sup>b</sup>not applicable

Table 6 demonstrates that the regression model significantly predicts SMA, accounting for 35.8% of its variance ( $R^2=0.358$ , P<.001). Conscientiousness and FOMO emerged as robust positive predictors, whereas neuroticism and female gender

were correlated with lower levels of addiction. Notably, conscientiousness exhibited the most substantial effect among all predictors.

Table . Multiple stepwise regression analysis<sup>a</sup> of predictors of social media addiction.

Predictor	В	SE B	β	$t \text{ test } (df)^{\mathbf{b}}$	P value	95% CI for B
Constant	1.738	0.249	_	6.977 (4, 406)	<.001	1.248 to 2.227
Conscientiousness	0.421	0.051	.357	8.176 (4, 406)	<.001	0.320 to 0.522
Fear of missing out	0.217	0.043	.213	4.996 (4, 406)	<.001	0.131 to 0.302
Neuroticism	-0.193	0.038	223	-5.022 (4, 406)	<.001	-0.268 to -0.117
Gender (female)	-0.143	0.061	098	-2.349 (4, 406)	.019	-0.262 to -0.023

<sup>a</sup>model summary: R<sup>2</sup>=0.358, Adjusted R<sup>2</sup>=0.352, F (4, 410)=56.622, P<.001 <sup>b</sup>Two tailed

# Discussion

# Principal Findings and Comparison With Previous Works

The purpose of this study was to investigate the connection between personality traits, FOMO, and SMA in university students, with a specific focus on identifying the main predictors of SMA. The majority of participants had low FOMO scores, whereas SMA scores followed a different pattern, with a larger proportion of participants scoring in the moderate range. In terms of gender differences, male participants exhibited higher levels of both FOMO and SMA compared to female participants. Additionally, male participants scored higher in neuroticism and openness. Regression analysis revealed that both conscientiousness and FOMO positively predicted SMA, while neuroticism and being female were associated with lower levels of addiction.

The results of this study reveal considerable divergence between nursing students' SMA and FOMO scores. Although most nursing students had low FOMO scores, implying that they do not excessively worry about missing out on things online, more participants had moderate SMA scores. This mirrors findings in other countries. For instance, Turkish nursing students reported moderate degrees of SMA, with lower degrees of FOMO [24]. Another Turkish study did not find a significant correlation between the use of smartphones, FOMO, and care behavior, which implies that FOMO may not always be highly associated with SMA among nursing students [25]. In contrast,

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in China [26] and in Egypt [27], FOMO was significantly linked to increased SMA, especially among university students, opposite to the present findings. The study's results can be explained by Saudi cultural norms prioritizing close family and face-to-face interactions, which reduce the emotional impact of FOMO [28]. However, students still engage in social media due to habits, stress relief, and peer pressure, leading to moderate addiction scores [29]. Social media usage is part of life in Saudi Arabia, and though students may not experience extreme FOMO, they may still be affected by the flow of information and social interaction that sites provide. Therefore, future studies are highly recommended to explore the link between FOMO and SMA among nursing students in different cultures.

Additionally, the study reveals gender differences, with male participants exhibiting higher levels of both FOMO and SMA compared to female participants. A previous study has also confirmed a positive correlation between FOMO and SMA. For example, Brailovskaia et al [30] found that, among 745 social media users in Germany, male participants exhibited higher FOMO and addiction, attributing this to their greater need for social validation. However, Kargın et al [28] found no significant gender differences in FOMO and internet addiction among Turkish nursing students, while Li et al [31] reported similar FOMO levels in both sexes in China among university students. These differences could be attributed to cultural and contextual factors, as in Saudi Arabia, where men may experience more pressure to maintain a social image, potentially explaining their higher FOMO and addiction scores compared to women.

Furthermore, the study's findings indicate that male participants scored higher in neuroticism and openness. Neuroticism is exemplified by emotional instability and heightened sensitivity to stress and, therefore, anxiety. Young male participants, in particular, may have stronger emotional responses to social media use. These emotional responses may lead them to seek validation or manage negative emotions through social media, which can lead to addiction. The positive relationship between neuroticism and SMA was reported [32,33]. A study by Tekin and Turhan [32] found that individuals with high neuroticism are more likely to experience negative emotions on social media, contributing to compulsive use driven by envy and jealousy. Their tendency to overanalyze and engage in social comparison further increases the desire for social media use, raising the risk of addiction. Additionally, male participants with high openness are more inclined to explore new experiences and engage with dynamic content on social media, driven by curiosity and a desire for trends and self-expression [3]. This ongoing engagement can contribute to addiction-like behavior. Therefore, further research about gender and personality traits is encouraged.

Regression analysis revealed that both conscientiousness and FOMO positively predicted SMA, while neuroticism and being female were associated with lower levels of addiction. This finding is inconsistent with a meta-analysis study by Rajesh and Bangaiah [34], which found a negative relation between conscientiousness and Facebook addiction. Furthermore, among university students in Mexico, while SMA is positively associated with neuroticism, it is negatively associated with conscientiousness [35]. Additionally, conscientiousness, openness to experience, and agreeableness were identified as negative predictors of Facebook addiction among Turkish university students [36]. Moreover, a meta-analysis found that neuroticism was positively associated with internet addiction, while openness, agreeableness, extraversion, and conscientiousness were negatively associated [37]. However, in the United States, among 337 college students, none of the personality traits were found to have a relationship with addiction on Facebook, Instagram, and Snapchat [38]. The current study result can be explained by that conscientious nursing students would use social media to stay organized or updated and thus use it more regularly, while FOMO makes people stay connected and not miss social life, thus increasing addiction vulnerability. Nevertheless, neurotic nursing students would experience negative feelings through the use of social media, and hence reduce their use and weaken their addiction. The lower addiction rates among female participants could reflect more balanced and responsible use, potentially due to different usage patterns or social norms.

Based on the results of this study, there is a vital implication for nursing practice that needs to be considered. Students should be directed to various social, artistic, and sporting activities that aim to support the use of the internet for the benefit of students, provide effective training in social communication and internet awareness, and reduce excessive time spent in social media environments. Psychiatric nurses working in units where primary health care services are provided are known to have an important role in combating addiction, and are also in a key position in the training that will be provided to students in this area. More research should be conducted to identify factors associated with the severity of FOMO.

Likewise, nursing practitioners and educators should be aware of the degree to which social media use is driven by personality traits and how such use impacts mental health. Low conscientiousness or high neuroticism may predispose students to increase SMA as they seek incentives or prevent adverse effects. Being aware of these tendencies may allow nursing educators to provide better care for vulnerable students. Interventions may include integrating digital well-being into nursing education, teaching students how to balance social media use, and promoting healthy coping strategies for managing FOMO. By addressing these issues, nursing schools can not only improve the overall well-being of their students but also equip future healthcare professionals with the skills they need to manage their mental well-being and be an example to patients they will interact with.

# Limitations

Several limitations should be acknowledged. First, the data were collected using self-reported questions, which may introduce bias. Second, the responses are subject to recall bias. Additionally, the study measured SMA at a specific point in time, without considering other temporal factors that might influence social media use. Furthermore, the use of a convenience sampling technique may limit the diversity of the sample. Finally, data were gathered only from a nursing college at one university, which may limit the generalizability of the findings.

#### Conclusion

This study aimed to explore the relationship between personality traits, FOMO, and SMA among Saudi nursing university students. The results indicate that conscientiousness and FOMO are positive predictors of SMA, while neuroticism is negatively associated. Furthermore, male participants tend to have higher levels of both FOMO and SMA than female participants. These findings highlight the influence of personality traits and FOMO on SMA in university students. Thus, strategies that help nursing students in getting the optimum benefits from social media need to be examined and implemented.

# **Data Availability**

The data are available from the corresponding author upon request.



# **Conflicts of Interest**

None declared.

# References

- Oberst U, Wegmann E, Stodt B, Brand M, Chamarro A. Negative consequences from heavy social networking in adolescents: the mediating role of fear of missing out. J Adolesc 2017 Feb;55(1):51-60. [doi: <u>10.1016/j.adolescence.2016.12.008</u>] [Medline: <u>28033503</u>]
- 2. Andreassen CS, Billieux J, Griffiths MD, et al. The relationship between addictive use of social media and video games and symptoms of psychiatric disorders: A large-scale cross-sectional study. Psychol Addict Behav 2016 Mar;30(2):252-262. [doi: 10.1037/adb0000160]
- 3. Kuss DJ, Griffiths MD. Social networking sites and addiction: ten lessons learned. Int J Environ Res Public Health 2017 Mar 17;14(3):311. [doi: 10.3390/ijerph14030311] [Medline: 28304359]
- 4. Turel O, Qahri-Saremi H. Problematic use of social networking sites: antecedents and consequence from a dual-system theory perspective. Journal of Management Information Systems 2016 Oct;33(4):1087-1116. [doi: 10.1080/07421222.2016.1267529]
- 5. Woods HC, Scott H. #Sleepyteens: social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. J Adolesc 2016 Aug;51(1):41-49. [doi: 10.1016/j.adolescence.2016.05.008] [Medline: 27294324]
- Akbari M, Seydavi M, Palmieri S, Mansueto G, Caselli G, Spada MM. Fear of missing out (FoMO) and internet use: A comprehensive systematic review and meta-analysis. J Behav Addict 2021 Dec 17;10(4):879-900. [doi: 10.1556/2006.2021.00083] [Medline: 34935633]
- 7. Przybylski AK, Murayama K, DeHaan CR, Gladwell V. Motivational, emotional, and behavioral correlates of fear of missing out. Comput Human Behav 2013 Jul;29(4):1841-1848. [doi: 10.1016/j.chb.2013.02.014]
- Beyens I, Frison E, Eggermont S. "I don't want to miss a thing": Adolescents' fear of missing out and its relationship to adolescents' social needs, Facebook use, and Facebook related stress. Comput Human Behav 2016 Nov;64:1-8. [doi: 10.1016/j.chb.2016.05.083]
- 9. Elhai JD, Levine JC, Dvorak RD, Hall BJ. Fear of missing out, need for touch, anxiety and depression are related to problematic smartphone use. Comput Human Behav 2016 Oct;63:509-516. [doi: <u>10.1016/j.chb.2016.05.079</u>]
- Davenport SW, Bergman SM, Bergman JZ, Fearrington ME. Twitter versus Facebook: Exploring the role of narcissism in the motives and usage of different social media platforms. Comput Human Behav 2014 Mar;32:212-220. [doi: 10.1016/j.chb.2013.12.011]
- Frison E, Eggermont S. Browsing, posting, and liking on Instagram: the reciprocal relationships between different types of instagram use and adolescents' depressed mood. Cyberpsychol Behav Soc Netw 2017 Oct;20(10):603-609. [doi: 10.1089/cyber.2017.0156] [Medline: 29039700]
- 12. Brailovskaia J, Margraf J. Relationship between depression symptoms, physical activity, and addictive social media use. Cyberpsychol Behav Soc Netw 2020 Dec;23(12):818-822. [doi: 10.1089/cyber.2020.0255] [Medline: 32813562]
- 13. Çakmak S, Tanriöver Ö. Is obesity and body perception disturbance related to social media addiction among university students? J Am Coll Health 2024 Jan;72(1):302-309. [doi: 10.1080/07448481.2022.2034832] [Medline: 35157558]
- 14. Rounsefell K, Gibson S, McLean S, et al. Social media, body image and food choices in healthy young adults: a mixed methods systematic review. Nutr Diet 2020 Feb;77(1):19-40. [doi: 10.1111/1747-0080.12581] [Medline: 31583837]
- Patiño-Jaimes V, Giraldo-Suarez MC, Mendoza-Catalán GS, Angel-Garcia J, Estrada-Luna D, Jiménez-Osorio AS. Association of social media addiction, weight perception, and lifestyle in Mexican nursing students. Soc Sci (Basel) 2024 Dec;13(12):673. [doi: 10.3390/socsci13120673]
- Sahu M, Gandhi S, Kumar Sharma M, Marimuthu P. Social media use and health promoting lifestyle: an exploration among Indian nursing students. Invest Educ Enferm 2020 Jul;38(2):2. [doi: <u>10.17533/udea.iee.v38n2e12</u>] [Medline: <u>33047555</u>]
   Den G, UBL
- 17. Raosoft. URL: <u>www.raosoft.com</u> [accessed 2025-05-14]
- Al-Menayes J. Psychometric properties and validation of the Arabic social media addiction scale. J Addict 2015;2015:291743. [doi: <u>10.1155/2015/291743</u>] [Medline: <u>26347848</u>]
- 19. John OP, Donahue EM, Kentle RL. The Big Five Inventory--Versions 4a and 54: Berkeley, CA: University of California, Berkeley, Institute of Personality and Social Research; 1991. [doi: <u>10.1037/t07550-000</u>]
- 20. Al-Dababi K, Al- Dababi R, abdelrahman A. Causal relationship modeling of the big-five factors, self-efficacy, and happiness of Jordan university of science and technology students. Journal of Educational and Psychological Studies 2019 Jan;13(1):46-64. [doi: 10.53543/jeps.vol13iss1pp46-64]
- 21. Young KS. Internet Addiction Test: Center for on-line addictions; 2009. URL: <u>https://netaddiction.com/internet-addiction-test/</u> [accessed 2024-03-01]
- 22. Li X, Deng S, Li L, Jiang Y. Outlier detection based on robust mahalanobis distance and its application. OJS 2019;09(1):15-26. [doi: 10.4236/ojs.2019.91002]
- 23. Alkharusi H. A descriptive analysis and interpretation of data from Likert scales in educational and psychological research. Indian Journal of Psychology and Education 2022;12(2):13-16.



- Eskin Bacaksiz F, Tuna R, Alan H. Nomophobia, netlessphobia, and fear of missing out in nursing students: a cross-sectional study in distance education. Nurse Educ Today 2022 Nov;118:105523. [doi: <u>10.1016/j.nedt.2022.105523</u>] [Medline: <u>36058115</u>]
- 25. Çatıker A, Büyüksoy GDB, Özdi L K. Is there a relationship between nursing students' smartphone use, their fear of missing out and their care-related behaviour? Nurse Educ Pract 2021 Jul;54:103111. [doi: <u>10.1016/j.nepr.2021.103111</u>] [Medline: <u>34118778</u>]
- Zhu X, Xiong Z. Exploring association between social media addiction, fear of missing out, and self-presentation online among university students: a cross-sectional study. Front Psychiatry 2022;13:896762. [doi: <u>10.3389/fpsyt.2022.896762</u>] [Medline: <u>35633794</u>]
- 27. Gaber Hamzaa H, Atta MHR, Elghareap Hassan Elmetwally Omar M, Reda Fathy Abdel Majeed Machaly E, Mohamed Amin S, Mohamed Ibrahim Wahba N. Examining nursing students' prevalence of nomophobia, and psychological alienation and their correlates with fear of missing out: a multisites survey. SAGE Open Nurs 2024;10:23779608241301223. [doi: 10.1177/23779608241301223] [Medline: <u>39691625</u>]
- 28. Kargın M, Türkben Polat H, Coşkun Şimşek D. Evaluation of internet addiction and fear of missing out among nursing students. Perspect Psychiatr Care 2020 Jul;56(3):726-731. [doi: 10.1111/ppc.12488] [Medline: 32068267]
- 29. Çevik Aktura S, Özden G, Çıtlık Sarıtaş S. Undergraduate nursing students' stress and fear of missing out. J Nurs Educ 2021 Oct;60(10):559-565. [doi: 10.3928/01484834-20210729-02] [Medline: 34605692]
- Brailovskaia J, Ozimek P, Rohmann E, Bierhoff HW. Vulnerable narcissism, fear of missing out (FoMO) and addictive social media use: a gender comparison from Germany. Comput Human Behav 2023 Jul;144:107725. [doi: 10.1016/j.chb.2023.107725]
- 31. Li L, Niu Z, Mei S, Griffiths MD. A network analysis approach to the relationship between fear of missing out (FoMO), smartphone addiction, and social networking site use among A sample of Chinese university students. Comput Human Behav 2022 Mar;128:107086. [doi: 10.1016/j.chb.2021.107086]
- 32. Tekin OA, Turhan AA. Does social media addiction differ by personality traits? A study on undergraduate tourism students. JoTS 2021 Jun;12(22):23-41. [doi: 10.29036/jots.v12i22.220]
- Marengo D, Poletti I, Settanni M. The interplay between neuroticism, extraversion, and social media addiction in young adult Facebook users: testing the mediating role of online activity using objective data. Addict Behav 2020 Mar;102:106150. [doi: 10.1016/j.addbeh.2019.106150] [Medline: 31706139]
- 34. Rajesh T, Rangaiah B. Relationship between personality traits and facebook addiction: a meta-analysis. Heliyon 2022 Aug;8(8):e10315. [doi: 10.1016/j.heliyon.2022.e10315] [Medline: 36061026]
- 35. López Rosales F, Becerra Guajardo JR, Jasso Medrano JL. Addictive behavior to social networks and five personality traits in young people. Psychol Stud 2021 Mar;66(1):92-96. [doi: <u>10.1007/s12646-020-00591-7</u>]
- Horzum MB, Canan Güngören Ö, Gür Erdoğan D. The influence of chronotype, personality, sex, and sleep duration on Facebook addiction of university students in Turkey. Biol Rhythm Res 2022 Jul 3;53(7):1105-1115. [doi: 10.1080/09291016.2021.1907508]
- 37. Kayiş AR, Satici SA, Yilmaz MF, Şimşek D, Ceyhan E, Bakioğlu F. Big five-personality trait and internet addiction: a meta-analytic review. Comput Human Behav 2016 Oct;63:35-40. [doi: 10.1016/j.chb.2016.05.012]
- Sheldon P, Antony MG, Sykes B. Predictors of problematic social media use: personality and life-position indicators. Psychol Rep 2021 Jun;124(3):1110-1133. [doi: 10.1177/0033294120934706] [Medline: 32580682]

# Abbreviations

**FOMO:** fear of missing out **SMA:** social media addiction

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# Readiness and Acceptance of Nursing Students Regarding AI-Based Health Care Technology on the Training of Nursing Skills in Saudi Arabia: Cross-Sectional Study

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# Abstract

**Background:** The rapid advancements in artificial intelligence (AI) technologies across various sectors, including health care, necessitate the need for a comprehensive understanding of their applications. Specifically, the acceptance and readiness of nursing students as future health care professionals to adopt AI-based health care technologies, along with the factors influencing these attitudes, are critical for facilitating the effective integration of AI in health care settings.

**Objective:** This study aimed to assess the readiness and acceptance of nursing students regarding the use of AI-based health care technologies in the nursing skills training in Saudi Arabia.

**Methods:** A descriptive cross-sectional research design was used. A convenience sampling technique was applied to recruit 322 participants. Data were collected between June and September 2023 using a self-administered questionnaire that included the technology readiness index (TRI) and the technology acceptance scale.

**Results:** Approximately 92.2% (297/322) of participants exhibited positive attitudes toward AI, and 74.8% (241/322) demonstrated innovativeness, indicating a generally favorable perception of AI. However, more than half of the students (59% [190/322] and 59.3% [191/322], respectively) reported feelings of discomfort and negative perceptions regarding AI use. Regarding TRI, 69.6% (224/322) of participants showed moderate readiness, while 30.4% (98/322) exhibited a high level of TRI. A substantial majority (320/322 99.4%) expressed acceptance of AI-based technologies in their training, with only 0.6% (2/322) reporting nonacceptance. Older students (aged >22 y) exhibited significantly higher levels of AI acceptance and readiness compared to younger students (P<.001). In addition, female students demonstrated significantly greater readiness and acceptance levels than male students (P=.003). Further, third-level students reported the highest mean scores in both acceptance and readiness (66.77 and 16.69, respectively; P=.002), while first-level students had the lowest (60.59 and 15.15). Among course groups, students enrolled in Maternal and Child Health Nursing reported the highest mean scores (65.19 and 16.30), whereas those in Community Health Nursing reported the lowest (57.50 and 14.38; P<.001).

**Conclusions:** The findings indicate that nursing students demonstrated a generally positive level of readiness and acceptance toward the use of AI and related technologies in education and training. However, these levels remained moderate overall, highlighting the need to enhance awareness and deepen students' understanding of AI's potential to improve training effectiveness and health care quality.

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#### **KEYWORDS** artificial intelligence: technology: read

artificial intelligence; technology; readiness; acceptance

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# Introduction

Artificial intelligence (AI) refers to the development of computer systems capable of performing tasks that typically require human intelligence. AI is currently one of the most transformative forces globally, with a particularly significant impact on the health care sector. It holds the potential to revolutionize various aspects of health care, from hospital operations and clinical trials to pharmaceutical development. These applications aim to improve health care delivery and reduce costs for both institutions and patients [1]. In this context, readiness refers to individuals' preparedness to adopt and effectively use new technologies. In the context of education, the emergence of new behavioral change is closely linked to the student's level of readiness. Readiness plays a critical role in enabling nursing students to adapt to future advancements in health care technologies. It is particularly essential for the effective integration of AI into nursing education and clinical practice, as it equips students to navigate a technology-driven health care environment. Therefore, assessing nursing students' readiness and attitudes is important for the successful integration of AI into their future professional roles [2].

The AI market in health care, valued at US \$15.4 billion in 2022, is projected to grow at a compound annual growth rate of 37.5% from 2023 to 2030. This rapid expansion is driven by several key factors, including the increasing volume of digital patient health data, a rising demand for personalized treatment, and the need to reduce health care costs [3]. Over the past 5 years, the impact of AI technologies on nurse educators, nursing students, and practicing nurses has been the focus of extensive research, highlighting the transformative potential of AI in nursing education and clinical practice [4,5]. To effectively disseminate knowledge about AI algorithms and their applications, which are expected to play a significant role in both medical and nursing fields, it is recommended that medical and nursing schools integrate AI into their curricula [6-8]. A systematic review and meta-analysis by Amiri et al [9] examined the attitudes and knowledge of medical, dental, and nursing students toward AI in health care. The findings revealed a moderate level of knowledge (3736/8491, 44%) and a generally positive attitude (5519/8491, 65%), suggesting a promising level of acceptance of AI technologies among health care students.

In situations where clinical coaching opportunities are limited, the integration of innovative technologies significantly enhances nursing education by supporting professional skill development and effective training [10,11]. Nurse educators must become both knowledgeable and confident in the use of emerging AI health technologies. In addition, practicing nurses require an urgent need for upskilling to effectively integrate AI health technologies into clinical practice [12]. While technological advancements in nursing have been substantial, the impact of is particularly transformative. Examples include AI medication-dispensing robots, companion robots for individuals with special needs, and AI systems used for population health management and care coordination [13]. Registered nurses must understand the role of AI in modern health care delivery. Therefore, nursing education must clearly define the

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competencies required for integrating AI into practice to ensure its optimal use and value [14].

An Egyptian study conducted at Cairo University revealed that fourth-year nursing students held moderate attitudes toward AI [15]. A systematic mapping review of 22 articles indicated that virtual reality simulations are used for diverse educational purposes, including procedural skills training, emergency response training, and psychomotor skills development [16]. In addition, a scoping review of 131 papers on AI technologies showed that AI is already impacting nursing roles, workflows, and nurse-patient interactions, suggesting that AI-powered solutions have the potential to improve nursing practice. However, nurses must proactively ensure that person-centered, compassionate care remains in the integration of AI [17].

Student nurses' attitudes and intentions regarding AI use are influenced by their perceptions of its role in nursing practice [18]. To successfully integrate AI into clinical settings, it is essential to understand nurses' attitudes and behaviors toward both current and anticipated AI applications.

Evaluating their current level of AI knowledge is crucial to identify future training needs [19]. Although nursing attitudes significantly affect AI acceptability and adoption, research in this domain remains limited [18]. Thus, this study aims to assess the readiness and acceptance of nursing students in Saudi Arabia regarding the use of AI in the nursing skills training. This investigation seeks to provide valuable insights into the factors that influence nursing students' preparedness and acceptance to embrace AI in their education. Despite a growing global interest in integration of AI in health care, there remains a significant knowledge gap in Saudi Arabia, where only a limited number of studies have explored this area. Addressing this gap is essential to effectively align health care education within international best practices and emerging technological trends. Given the global shift toward integrating AI into both health care and nursing education, it is particularly important to understand nursing students' readiness and acceptance of this technology. Ultimately, this study will contribute to ensuring that future nursing graduates are equipped to adopt AI technologies in clinical settings, thereby enhancing the quality of patient care in line with international standards.

# Methods

# **Study Design and Settings**

This study used a descriptive cross-sectional research design and was conducted at 3 universities in Saudi Arabia among undergraduate nursing students. Data collection took place between June and September of the 2023 academic year.

To ensure accessibility, data were collected using a self-administered online survey developed in Arabic via Google Forms. The survey link was disseminated through various social media platforms, including WhatsApp (Meta), Instagram (Meta), and Facebook (Meta), by coinvestigators at each participating university. Participants were instructed to complete only one version of the survey to maintain data integrity and prevent duplicate responses.

#### Sample Size

A convenience sampling technique was used to collect the data from a total of 322 undergraduate nursing students enrolled in 3 Saudi universities. These universities were initially selected using a multistage probability sampling technique. The required sample size was calculated using the open-source calculator OpenEpi, Version 7, based on a total population of 1983 nursing students. The sample size calculation was based on an expected frequency of 50%, a 5% margin of error, and a 95% confidence level, resulting in a minimum sample size of 322 students. Proportional allocation was used to determine the number of participants from each university: (100 students from Al-Baha University (population =618), 44 students from Al-Jouf University (population =265), and 178 students from Al-Shamal Faculty of Nursing (population =1100).

#### **Tool of the Study**

The questionnaires used for data collection were divided into 3 sections. Section one collected sociodemographic data from nursing students, including age, gender, academic level, and specialty training course. Section 2 consisted of the Technology Readiness Index (TRI), a tool originally developed by Parasuraman and Colby [20] and adapted for this study. This section included 16 items designed to measure technology readiness across four dimensions: for optimism (4 items), innovativeness (4 items), discomfort (4 items), and insecurity (4 items). Each item was rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Optimism and innovativeness reflect positive predispositions toward technology, while discomfort and insecurity represent negative tendencies. To calculate the overall total TRI Score, the negatively worded dimensions (insecurity and discomfort) were reverse coded by subtracting each item score from 6. The final TRI score was computed using the formula: TRI =  $(Innovative+Optimism+(6-Insecurity) + (6-Discomfort)) \div 4).$ The score ranges from 1.0 to 5.0, with higher scores indicating greater technology readiness. For interpretation, readiness levels were categorized as follows: low (<2.0), moderate (<3.5), and high (>3.5).

Section three focused on the technology acceptance model (TAM), originally developed by Davis [21] and adapted by the researcher of this study. This section included 16 items grouped into 3 key constructs to measure technology acceptance: Perceived usefulness (6 items), perceived ease of use (6 items), and intention to use (4 items). All items were rated on a 5-point Likert scale ranging from 1 = extremely unlikely to 5 =extremely likely. To calculate the average perception score, the total score of all TAM items was summed for each participant. This raw score was then converted into a percentage by dividing it by the maximum possible score and multiplying by 100. The average percentage was computed across all participants to determine the overall mean perception score. Perception levels were categorized as follows: low (<65%), moderate (65% to <80%), and high ( $\geq80\%$ ). For interpretive purposes, scores <40% were considered not accepted, while scores >40% were considered accepted.

To ensure clarity for comprehension for all nursing students, the survey was initially translated into Arabic and then

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back-translated into English to verify accuracy and consistency. Content validity was evaluated by a panel of five experts, all holding PhDs in nursing. The experts were requested to evaluate the relevance and clarity of each item, provide suggestions for improvement, and determine whether the items appropriately reflected the objectives of the study. Reliability of the instruments was assessed using Cronbach  $\alpha$ . For TRI, which consisted of 16 items, the reliability coefficient was  $\alpha = .820$ . For TAM, also comprising 16 items, the reliability coefficient was  $\alpha = .782$ .

### **Pilot Study**

A pilot study was carried out on 10% of the study sample (N=32) to assess the clarity, feasibility, and applicability of the survey tools. Participants in the pilot study were excluded from the final sample to avoid bias. The average time to complete the survey ranged from 15 to 20 minutes. The study was conducted across three universities: Al-Baha University (n=618), Al-Jouf University (n=265), Al-Shamal Faculty of Nursing (n=1100).

#### **Ethical Considerations**

Ethical approval for this study was obtained from the Research Ethics Committee, Faculty of Nursing, Al-Baha University (approval number 44127970). In addition, official permission letters were secured from the Faculty of Nursing in each sitting Al-Baha University, Al-Jouf University, and Al-Shamal Faculty of Nursing to conduct the study and collect data. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Participation in the study was entirely voluntary, with no academic consequences for students who chose to participate. Anonymity and confidentiality were strictly maintained by not collecting names or any personally identifiable information. All data was securely stored and used exclusively for research proposals. Before participation, written informed consent was obtained from all participants.

There were no consequences or effects on grades for not participating; participation was completely voluntary. Participant anonymity was guaranteed by withholding names or any other personally identifying information. All data was safely stored and used solely for this study. Every participant gave their written informed consent.

#### Statistical Analysis

Data were analyzed using IBM SPSS software, version 20.0. The Kolmogorov-Smirnov test was used to assess the normality of data distribution. Quantitative variables were summarized using range (minimum and maximum), mean, and SD. Statistical significance was determined at P value <.05. For inferential statistics, the student's t test was used to compare between 2 independent groups for normally distributed data, while a one-way Analysis of Variance (F test) was applied to compare means among more than 2 groups. To identify which group differed significantly, post hoc analyses were conducted using the Tukey HSD test.

# Results

Table 1 presents the demographic characteristics of the study participants. The age of participants ranged from 18 years to over 22 years. Approximately half of students (154/322, 47.8%) were aged between 18 and 22 years, while a low percentage (49/322, 15.2%) were older than 22 years. Regarding gender, 47.2% (152/322) of the participants were male, and 52.8% (170/322) were female. In terms of academic level, the majority of students were in their second year (133/322, 41.3%) and third year (103/322, 32.0%). A smaller percentage was in their first year (27/322, 8.4%), while (59/322, 18.3%) were in their fourth year. In addition, nearly half of the participants (150/322, 46.6%) were enrolled in administrative nursing specialty training, while one quadrant (82/322, 25.5%) was in adult nursing specialty training. On the other hand, the lowest percentage (14/322, 4.3%) of participants was in Psychiatric nursing specialty training.

Table 2 illustrates the TRI findings among the nursing students. The majority of students reported high levels of optimism (297/322, 92.2%) and innovativeness (241/322, 74.8%), reflecting positive attitudes regarding the use of technology. Conversely, more than half of the participants reported moderate feelings of discomfort (190/322, 59.0%) and insecurity (191/322, 59.3%), indicating some negative feelings regarding technology. In addition, approximately 69.6% (224/322) of the participants reported moderate TRI, while 30.4% showed high TRI. Furthermore, the mean TRI score across all participants was 3.30 (SD =0.46), suggesting moderate levels of readiness to use technology in nursing skills training.

Table 3 presents participants' levels of acceptance regarding various dimensions of technology use. A majority (187/322, 58.1%) exhibited high acceptance in terms of perceived usefulness of technology, while 29.2% (94/322) showed moderate acceptance and 12.7% (41/322) reported low acceptance in this domain. Regarding perceived ease of use, about half of the participants reported low acceptance, whereas 25.2% (81/322) and 18.6% (60/322) showed moderate and high acceptance, respectively. Concerning the intention to use or adapt the technology, 40.7% (131/322) showed high acceptance,

while 34.8% (112/322) and 24.5% (79/322) reported moderate and low acceptance, respectively. Overall, 34.8% (112/322) of the participants demonstrated high technology acceptance, 40.1% (129/322) had moderate acceptance, and 25.2% (81/322) showed low acceptance.

reveals that the vast majority of students (320/322, 99.4%) reported overall acceptance of using technology, while only a small fraction (2/322, 0.6%) indicating no acceptance.

Table 4 compares nursing students' acceptance and readiness to use AI and modern technology. The results indicate that students exhibited higher acceptance of technology and AI, with SD of 61.80±9.08, 65.34 (SD 10.27), and 67.37 (SD 10.49), respectively, while their readiness scores were comparatively lower at (15.45 SD 2.27,16.33 SD 2.57, 16.84 SD 2.62). A significant difference was observed with respect to age: students older than 22 years showed a greater acceptance and readiness compared to younger students aged 18 - 20 or 20-22 years, with statistical significance (P < .001). In addition, women show a high level of acceptance and preparedness to use technology and artificial intelligence, with a statistical significance of (0.003). The mean for females was (16.38 SD 2.38, 65.51 SD 9.50) compared to males (15.55 SD 2.55, 62.21 SD 10.21). Our findings reveal that third-level students exhibited the greatest acceptance and readiness (66.77 SD 10.04, 16.69 SD 2.51), while first-level students exhibited the lowest (60.59 SD 10.44, 15.15 SD 2.61), showing a statistical significance of (P=.002). Moreover, students participating in the Maternal and Child Health Nursing course exhibited the highest levels of acceptance and readiness (65.19 SD 9.41, 16.30 SD 2.35), while those in the Community Health Nursing course displayed the least acceptance (57.50 SD 7.93, 14.38 SD 1.98), with a statistical significance of (P<.001).

Turkey HSD Post hoc showed that students >20 years had significantly higher AI readiness and acceptance compared to those aged 18 - 20. Third-year students had significantly greater AI readiness and acceptance than first- and second-year students. Students in the administrative nursing specialty showed significantly higher AI readiness and technology acceptance than those in other specialties.



Table . Distribution of the studied nursing students according to demographic data (n=322).

Demographic data	Values, n (%)
Age (years)	
18 - 20	154 (47.8)
20 - 22	119 (37.0)
>22	49 (15.2)
Sex	
Male	152 (47.2)
Female	170 (52.8)
Academic level	
First-year	27 (8.4)
Second year	133 (41.3)
Third year	103 (32.0)
Fourth year	59 (18.3)
Specialty	
Maternal and child nursing	26 (8.1)
Psychiatric nursing	14 (4.3)
Community nursing	26 (8.1)
Critical nursing	24 (7.5)
Administrative nursing	150 (46.6)
Adult nursing	82 (25.5)

Table . Distribution of the studied nursing students according to overall artificial intelligence readiness items (n=322).

Artificial intelli-	Low	Moderate	High	Score range	Total score, mean	Average score
	(<2), n (%)	(2–3.5), n (%)	(≥3.5), n (%)		(52)	(1–5), mean (SD)
Optimism	1 (0.3)	24 (7.5)	297 (92.2)	4–20	17.88 (2.63)	4.47 (0.66)
Innovativeness	3 (0.9)	78 (24.2)	241 (74.8)	4–20	16.02 (3.37)	4.01 (0.84)
Discomfort	80 (24.8)	190 (59)	52 (16.1)	4–20	9.81 (3.98)	2.45 (1.0)
Insecurity	100 (31.1)	191 (59.3)	31 (9.6)	4–20	9.08 (3.45)	2.27 (0.86)
Overall	0 (0)	224 (69.6)	98 (30.4)	16-80	15.99 (2.49)	3.30 (0.46)

Table . Distribution of the studied nursing students according to overall technology acceptance items (n=322).

Technology accep- tance	Low (<65%), n (%)	Moderate (65% -80%), n (%)	High (≥80%), n (%)	Score range	Total score, mean (SD)	Average score (1–5), mean (SD)
Perceived useful- ness	41 (12.7)	94 (29.2)	187 (58.1)	6–30	26.09 (4.09)	4.35 (0.68)
Perceived Ease of Use	181 (56.2)	81 (25.2)	60 (18.6)	6–30	21.64 (4.53)	3.61 (0.75)
Intention to use	79 (24.5)	112 (34.8)	131 (40.7)	4–20	16.22 (2.98)	4.05 (0.74)
Overall	81 (25.2)	129 (40.1)	112 (34.8)	16-80	63.95 (9.96)	4.0 (0.62)



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Table .	Relation between to	tal score for overal	(Artificial	Intelligence	Readiness,	Technology	acceptance)	with demographic	e data (n=322)
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Demographic data	n	Artificial Intelligence readiness, mean (SD)	Technology acceptance, mean (SD)
Age (years)			
18 - 20	154	15.45 (2.27)	61.80 (9.08)
20 - 22	119	16.33 (2.57)	65.34 (10.27)
>22	49	16.84 (2.62)	67.37 (10.49)
$F^{a}(P)^{b}$		7.952 <sup>c</sup> (<.001 <sup>c</sup> )	7.952 <sup>c</sup> (<.001 <sup>c</sup> )
Sex			
Male	152	15.55 (2.55)	62.21 (10.21)
Female	170	16.38 (2.38)	65.51 (9.50)
t <sup>d</sup> (P)		$3.005^{\circ} (.003^{\circ})$	3.005 <sup>c</sup> (.003 <sup>c</sup> )
Academic level			
First-year	27	15.15 (2.61)	60.59 (10.44)
Second year	133	15.59 (2.30)	62.37 (9.20)
Third year	103	16.69 (2.51)	66.77 (10.04)
Fourth year	59	16.04 (2.57)	64.15 (10.29)
F ( <i>P</i> )		5.077 <sup>c</sup> (.002 <sup>c</sup> )	$5.077^{\rm c} (.002^{\rm c})$
Specialty			
Maternal and child nursing	26	16.30 (2.35)	65.19 (9.41)
Psychiatric Nursing	14	15.93 (2.80)	63.71 (11.21)
Community Nursing	26	14.38 (1.98)	57.50 (7.93)
Critical nursing	24	15.02 (2.86)	60.08 (11.44)
Administrative nursing	150	16.74 (2.19)	66.95 (8.78)
Adult nursing	82	15.33 (2.57)	61.30 (10.29)
F ( <i>P</i> )		7.552 <sup>c</sup> (<.001 <sup>c</sup> )	$7.552^{\rm c} (<.001^{\rm c})$

<sup>a</sup>F: F for One way ANOVA test

<sup>b</sup>*P*: *P* value for comparison between the studied categories

<sup>c</sup>Statistically significant at P≤.05

<sup>d</sup> t:Student *t*-test

# Discussion

# **Principal Findlings**

This study examined the readiness and acceptance of nursing students in Saudi Arabia regarding the use of artificial intelligence-based health care technology for nursing skills training. The findings indicate that most students are optimistic about incorporating AI into their education, with 69.6% reporting moderate readiness to adopt AI-related technological interventions. These results align with previous research showing that nurses generally hold positive attitudes and intentions toward the utilization of AI technologies in their practice and education [14,18]. Therefore, it is essential to incorporate specific courses on AI, promote student engagement with emerging technologies, and encourage faculty members to stay current with advancements in AI and its applications in nursing care [22].

Moreover, the study demonstrated that more than half of the participants (59% [190/322] and 59.3% [191/322]) experienced moderate discomfort and insecurity regarding the use of AI technologies. This highlights the need for increased efforts to educate nursing students about the efficacy and value of AI in training. In addition, participants demonstrated moderate techno-readiness toward adopting AI technologies. Sensitization initiatives should emphasize the benefits of AI, such as improving patient safety, enhancing the quality of clinical decision-making, and increasing efficiency in healthcare processes, including patient monitoring [15]. Furthermore, the moderate levels of techno-readiness highlight the need to increase nursing students' exposure to technology in order to enhance their attitudes and perceptions of its value in nursing practice.

The overall technology acceptance among participants indicated that the majority exhibited moderate to high levels of acceptance. The findings reflect generally favorable attitudes

toward the usefulness of technology, with more variability in perceived ease of use and intention to adopt it. While 58.1% of participants showed high acceptance regarding the perceived usefulness of technology, a notable proportion reported moderate to low acceptance. These findings highlight the need to foster greater engagement and raise awareness about the benefits and value of integrating technology into nursing education. As noted by Swan [14], such awareness is vital for facilitating positive shifts in perceptions and attitudes [22,23]. Additionally, perceived usefulness and ease of use of technological interventions, such as AI, have been consistently identified as strong predictors of willingness to adopt these technologies in nursing practice [14,17,20]. The results further indicate that most participants perceive the ease of use of AI technology as moderate to high. These findings are consistent with a study conducted in Nepal, which reported their moderate levels of digital literacy among nursing students [24]. However, they contrast with the findings of Stellesfson et al [25], who observed insufficient e-health literacy among college learners. This insufficiency is largely attributed to current curricula that often do not adequately incorporate the use of technologies such as AI in nursing and clinical education.

Additionally, the results indicate that the vast majority of participants (99.4%) accepted the use of technology, with only a small percentage (0.6%) reporting no acceptance. This underscores the importance of integrating innovative curricula at the undergraduate level to enhance nursing students' exposure to emerging technologies such as AI. Early and structured exposure is crucial for building technological competency and fostering positive attitudes towards the use of AI in clinical practice [15]. Moreover, the study found no statistically significant differences in technology readiness and acceptance based on demographic variables such as age, gender, academic level, and specialty. This suggests that training programs should adopt a universal approach, targeting all nursing students equally. Such an inclusive strategy simplifies implementation,

enhances cost-effectiveness, and supports the use of varied teaching methods to promote AI literacy. Educators can incorporate various methods such as role-plays, debates, panel discussions, and hands-on activities to enhance understanding of AI's value and applications.

Furthermore, increasing students' clinical exposure to AI technologies may positively shape their perceptions and encourage proactive engagement. Such shifts in perception are vital for fostering continuous learning and the development of essential nursing competencies in an AI-integrated environment. Nonetheless, several limitations should be acknowledged. First, the cross-sectional design restricts the ability to detect causal relationship between variables, making it challenging to determine the directionality of these correlations and understand how they might evolve over time. Second, the use of self-reported measures may introduce bias, as participants might provide socially desirable answers or may not accurately recall their experiences. Furthermore, while online survey distribution offers convenience, it may inadvertently exclude certain student groups, particularly those with limited access to or familiarity with digital platforms, thus potentially affecting the representativeness of the sample.

# Conclusion

The findings indicate that nursing students demonstrated a generally positive readiness and acceptance regarding the use of AI and technology in education and training. However, this readiness and acceptance were at a moderate level, highlighting the need for enhanced awareness and a deeper understanding of AI's potential to improve training efficiency and the quality of healthcare delivery. To address this gap, nursing education programs should integrate AI-related content into their curricula, thereby fostering students' familiarity, competence, and confidence in using emerging technologies in clinical and educational contexts.

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# Data Availability

The data used to support the research results are accessible to the corresponding author upon request.

# **Authors' Contributions**

Conceptualization: KA, TAM. Data curation: RAA. Formal analysis: RAA. Investigation: KA. Methodology: KA, ANA, BS. Project administration: KA, MSAH. Resources: ASG, HHA. Software: TAM, ANA. Supervision: KABS, TAM. Validation: ANA, FAAR. Visualization: HHA, MSAH, TAM, FAAR, BS. Writing – review & editing: All authors.

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# **Conflicts of Interest**

None declared.

# References

- Ronquillo CE, Peltonen LM, Pruinelli L, et al. Artificial intelligence in nursing: Priorities and opportunities from an international invitational think-tank of the Nursing and Artificial Intelligence Leadership Collaborative. J Adv Nurs 2021 Sep;77(9):3707-3717. [doi: 10.1111/jan.14855] [Medline: 34003504]
- 2. Yalcinkaya T, Ergin E, Yucel SC. Exploring nursing students' attitudes and readiness for artificial intelligence: a cross-sectional study. Teaching and Learning in Nursing 2024 Oct;19(4):e722-e728. [doi: 10.1016/j.teln.2024.07.008]
- Robert N. How artificial intelligence is changing nursing. Nurs Manage 2019 Sep;50(9):30-39. [doi: 10.1097/01.NUMA.0000578988.56622.21] [Medline: 31425440]
- 4. Winterson J. 12 Bytes: How Artificial Intelligence Will Change the Way We Live and Love: Random House; 2021.
- 5. Tuohy T. Artificial Intelligence Health Care Information Technology Total Value Delivery: Lulu.com; 2019. URL: <u>https://www.lulu.com/shop/timothy-tuohy/artificial-intelligence-health-care-information-technology-total-value-delivery/paperback/product-1wkeq8r9.</u>

html?srsltid=AfmBOoqP-Pqd\_NXKkGULDXihktJoVGDmhHAfmz\_b6nY6ABgOffu9rgs3&page=1&pageSize=4 [accessed 2025-07-21]

- 6. Briganti G, Le Moine O. Artificial intelligence in medicine: today and tomorrow. Front Med (Lausanne) 2020;7:27. [doi: 10.3389/fmed.2020.00027] [Medline: 32118012]
- 7. Dermody G, Fritz R. A conceptual framework for clinicians working with artificial intelligence and health-assistive Smart Homes. Nurs Inq 2019 Jan;26(1):e12267. [doi: 10.1111/nin.12267] [Medline: 30417510]
- Hegde S, Ajila V, Zhu W, Zeng C. Artificial intelligence in early diagnosis and prevention of oral cancer. Asia Pac J Oncol Nurs 2022 Dec;9(12):100133. [doi: 10.1016/j.apjon.2022.100133] [Medline: 36389623]
- Amiri H, Peiravi S, Rezazadeh Shojaee SS, et al. Medical, dental, and nursing students' attitudes and knowledge towards artificial intelligence: a systematic review and meta-analysis. BMC Med Educ 2024 Apr 15;24(1):412. [doi: 10.1186/s12909-024-05406-1] [Medline: 38622577]
- 10. Chang CY, Lai CL, Hwang GJ. Trends and research issues of mobile learning studies in nursing education: A review of academic publications from 1971 to 2016. Comput Educ 2018 Jan;116:28-48. [doi: <u>10.1016/j.compedu.2017.09.001</u>]
- 11. Salameh BS, Salameh BS. Self-confidence and satisfaction among nursing students with the use of high fidelity simulation at arab american university, palestine. Lijhls 2017 Sep 1;3(2):15-23. [doi: 10.20319/lijhls.2017.32.1523]
- 12. Russell S. Human Compatible: Artificial Intelligence and the Problem of Control: Penguin Random House; 2019. URL: https://www.penguinrandomhouse.com/books/566677/human-compatible-by-stuart-russell/ #:~:text=Book%20Description&text=Russell%20begins%20by%20exploring%20the,before%20we%20reach%20superhuman%20AI [accessed 2025-07-21]
- Harmon J, Pitt V, Summons P, Inder KJ. Use of artificial intelligence and virtual reality within clinical simulation for nursing pain education: A scoping review. Nurse Educ Today 2021 Feb;97:104700. [doi: <u>10.1016/j.nedt.2020.104700</u>] [Medline: <u>33341064</u>]
- 14. Swan BA. Assessing the knowledge and attitudes of registered nurses about artificial intelligence in nursing and health care. Nurs Economic 2021;39(3):139. [doi: <u>10.62116/NEC.2021.39.3.139</u>]
- 15. Hassan Mekawy S, Ali Mohamed Ismail S, Zayed Mohamed M. Digital health literacy (DHL) levels among nursing baccalaureate students and their perception and attitudes toward the application of artificial intelligence (AI) In nursing. Egyptian Journal of Health Care 2020 Mar 1;11(1):1266-1277. [doi: 10.21608/ejhc.2020.274757]
- Plotzky C, Lindwedel U, Sorber M, et al. Virtual reality simulations in nurse education: a systematic mapping review. Nurse Educ Today 2021 Jun;101:104868. [doi: <u>10.1016/j.nedt.2021.104868</u>] [Medline: <u>33798987</u>]
- 17. Buchanan C, Howitt ML, Wilson R, Booth RG, Risling T, Bamford M. Predicted influences of artificial intelligence on the domains of nursing: scoping review. JMIR Nurs 2020 Dec 17;3(1):e23939. [doi: <u>10.2196/23939</u>] [Medline: <u>34406963</u>]
- Labrague LJ, Aguilar-Rosales R, Yboa BC, Sabio JB, de Los Santos JA. Student nurses' attitudes, perceived utilization, and intention to adopt artificial intelligence (AI) technology in nursing practice: A cross-sectional study. Nurse Educ Pract 2023 Nov;73:103815. [doi: 10.1016/j.nepr.2023.103815] [Medline: <u>37922736</u>]
- Abuzaid MM, Elshami W, Fadden SM. Integration of artificial intelligence into nursing practice. Health Technol (Berl) 2022;12(6):1109-1115. [doi: <u>10.1007/s12553-022-00697-0</u>] [Medline: <u>36117522</u>]
- 20. Parasuraman A, Colby CL. An updated and streamlined technology readiness index. Journal of Service Research 2015 Feb;18(1):59-74. [doi: 10.1177/1094670514539730]
- 21. Davis FD. A technology acceptance model for empirically testing new end-user information systems: theory and results," Phd thesis. : Massachusetts Institute of Technology; 1985.
- 22. Salameh B, Ewais A, Salameh O. Integrating m-learning in teaching ECG reading and arrhythmia management for undergraduate nursing students. Int J Interact Mob Technol 2020;14(1):82. [doi: <u>10.3991/ijim.v14i01.11417</u>]

- 23. Salameh B, Qaddumi J, Hammad B, et al. Nursing students' attitudes toward artificial intelligence: palestinian perspectives. SAGE Open Nurs 2025;11:23779608251343297. [doi: 10.1177/23779608251343297] [Medline: 40386173]
- 24. Sharma S, Oli N, Thapa B. Electronic health-literacy skills among nursing students. Adv Med Educ Pract 2019;10:527-532. [doi: <u>10.2147/AMEP.S207353</u>] [Medline: <u>31410077</u>]
- Stellefson M, Hanik B, Chaney B, Chaney D, Tennant B, Chavarria EA. eHealth literacy among college students: a systematic review with implications for eHealth education. J Med Internet Res 2011 Dec 1;13(4):e102. [doi: <u>10.2196/jmir.1703</u>] [Medline: <u>22155629</u>]

# Abbreviations

AI: artificial intelligence TAM: Technology Acceptance Model TRI: technology readiness index

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# Original Paper

# Exploring Educators' Perceptions and Experiences of Online Teaching to Foster Caring Profession Students' Development of Virtual Caring Skills: Sequential Explanatory Mixed Methods Study

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# Abstract

**Background:** Professionals in caring disciplines have been pivotal in advancing virtual care, which leverages remote technologies to deliver effective support and services from a distance. Educators in these caring professions are required to teach students the skills and competencies needed to provide high-quality and effective care. As virtual care becomes more integral, educators must equip students in these fields with both interpersonal and technological skills, bridging traditional hands-on learning with digital literacy. However, there is a gap in evidence exploring educators' perceptions and experiences of teaching caring profession students about virtual caring skills within online environments.

**Objective:** This study aims to better understand caring profession educators' online teaching experiences to foster student development of virtual caring skills and competencies.

**Methods:** We used a sequential explanatory mixed methods approach that integrated a cross-sectional survey and individual interviews with educators from caring professions to better understand caring professional educators' online teaching experiences to foster student development of virtual caring skills and competencies. The survey's primary objectives were to examine the various elements of existing e-learning opportunities, delve into educators' perspectives and encounters with these opportunities, and identify the factors that either facilitated or hindered online teaching practices to support students in developing virtual caring skills and competencies. The individual interview guides were based on survey findings and a systematic review of the evidence to gain deeper insights into educators' experiences and perspectives.

**Results:** A total of 82 survey participants and 8 interview participants were drawn from educators in the fields of education, medicine, nursing, and social work. Various instructional methods were used to help students develop virtual caring skills, including reflections on learning, online modules, online discussion boards, demonstrations of remote care, and consultation with clients. There was a statistically significant difference between educators' level of experience teaching online and their satisfaction with online teaching and learning technologies (P<.001) and between educators' faculties (departments) and their satisfaction with online teaching and learning technologies (P=.001). Participants identified barriers (time constraints, underdeveloped curriculum, decreased student engagement, and limited access to virtual caring equipment and technology), facilitators (clearly defined learning virtual caring skills in online environments (connection, interaction, compassion, empathy, care, and vulnerability).

**Conclusions:** Our study identifies the barriers, facilitators, and principles in teaching virtual caring skills, offering practical strategies for educators in caring professions. This study contributes to the growing body of educational research on virtual caring skills by offering educator insights and suggestions for improved teaching and learning strategies in caring professions' programs.

As educational practices evolve, future research should explore how traditionally in-person educators can effectively teach virtual caring skills across diverse contexts.

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#### **KEYWORDS**

health care education; virtual care; telehealth; online teaching; mixed methods study; student; teaching; virtual caring skills; cross-sectional survey; interview

# Introduction

# Background

Professionals in caring fields, including educators, physicians, nurses, and social workers, have played a crucial role in the ongoing development of virtual care where remote information technologies are used to ensure quality and effective care. The shift to virtual care has paved the way for innovative approaches to delivering care services, such as online teaching; remote health care and social services; and remote assistance for individuals, families, and communities to improve their social functioning, all from a distance. These virtual interactions demand digital literacy skills and comfort with technology, skills that traditionally may not have been intentionally integrated into formal education.

As virtual caring practices become integral to care provision, it is imperative that educators support caring profession students in acquiring the interpersonal and technological competencies necessary for providing virtual care. Traditionally, educators in caring professions relied on face-to-face lectures and seminar-style instruction with work-integrated learning placements, where students gained hands-on skills and collaborated with experienced educators and practicing health professionals in settings such as K-12 classrooms, hospitals, and counseling centers [1,2].

The shift to virtual teaching and care settings has challenged caring profession educators to incorporate alternative strategies for providing essential educational experiences to students [3-5] and placed added responsibilities on caring professionals to implement virtual care effectively in practice [2,3]. While the literature has long emphasized the need to support educators in meeting students' requirements [6,7], this need has become even more critical with the increasing prevalence of virtual care environments [8,9].

Higher education institutions have an opportunity to re-evaluate their approach to delivering online education in caring professions and identify the essential technological competencies necessary for success in today's virtual world. Given the significant transformation in education and care delivery, it is imperative that caring professionals possess the requisite skills and competencies to adapt and thrive in these new virtual environments. However, many caring profession educators face challenges when creating effective online learning experiences to prepare students for new virtual work environments, including limited bandwidth, the lack of technological devices, unfamiliarity with technological platforms, a lack of connection with students, and a lack of student engagement [10-13]. Learning new technologies can be cumbersome and frustrating

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XSL•F() RenderX [14], and technical issues can disrupt interactions that typically occur face-to-face [15-19]. These challenges underscore the necessity for a structured, evidence-based approach to developing and implementing educational technologies in online teaching and learning contexts to support virtual caring skill development [10,20-22].

The authors recently completed a systematic review from which they identified innovative online education initiatives that harnessed learning technologies for the education of caring professionals and demonstrated a growing emphasis on assisting students in cultivating effective virtual caring practices suitable for today's virtual environments [23]. The systematic review [23] highlighted a pressing need for greater emphasis on assessing and training educators to immerse students in digital technologies, thus fostering the development of both interpersonal and digital skills essential for delivering virtual care. More research is needed regarding educators' experiences and perceptions of teaching virtual caring skills.

#### This Study

Adding to the limited body of literature would potentially enhance the understanding of best practices in online instruction to promote the development of virtual caring skills. Therefore, we conducted this study to answer the following research questions: (1) How do caring professions' educators *describe* the online instructional methods used that support student development of virtual caring skills and competencies? (2) What are caring professions' educators' *experiences and perceptions* of online learning opportunities for helping students develop virtual caring skills and competencies? and (3) What are the *facilitators and barriers* to creating and engaging in online teaching that supports students' development of virtual caring skills and competencies?

# Methods

# Design

We adopted a sequential explanatory mixed methods study design [24] to gather, analyze, and integrate quantitative and qualitative data. We used a cross-sectional survey and conducted individual interviews to gain insights into the online teaching experiences of educators in caring professions in supporting students to develop virtual caring skills and competencies. The integration of the 2 research phases became apparent when the design of the interview guide was informed by the survey findings, enabling us to delve deeper into the results obtained from the survey. Furthermore, integration occurred as we used the qualitative findings to better understand the quantitative findings, ultimately forming interpretations from the integrated findings.

### **Sample and Participants**

Voluntary participation was sought from educators in caring professions, including education, medicine, nursing, and social work (including those cross appointed to arts and veterinary medicine) across a midsized research-intensive institution in western Canada. Any self-reported educators from the abovementioned faculties were included in the study. No completed surveys or interviews were excluded.

# **Data Collection**

We crafted a survey using established methods as outlined by Rattray and Jones [25]. The survey's primary objectives were to examine the various elements of existing e-learning opportunities, delve into educators' perspectives and encounters with these opportunities, and identify the factors that either facilitated or hindered online teaching practices to support students in developing virtual caring skills and competencies. The survey encompassed a combination of Likert scale, closed-ended, and open-ended questions, covering demographics, experiences, instructional methods, satisfaction levels, technology use, effectiveness, and readiness. To ensure the survey's validity, both in terms of face and content, we conducted a pilot study with a sample of 10 educators who did not participate in the study. Their suggested edits were incorporated into the survey before its dissemination.

To distribute the survey securely, we used an online platform, Qualtrics (Qualtrics International Inc). Our recruitment efforts spanned various channels such as email, Twitter (subsequently rebranded as X), Instagram (Meta Platforms), and Facebook (Meta Platforms), mirroring the methods used in prior studies [26,27]. Completion of the survey was considered as an indication of informed consent. In addition, we invited all survey participants to share their email addresses if they were interested in participating in a follow-up interview.

To gain deeper insights into educators' experiences and perspectives, we developed a semistructured interview guide based on the findings from a systematic review [23] and the responses received in the survey. We reached out to all survey participants who provided their email addresses and conducted interviews lasting between 30 and 60 minutes via the Zoom (Zoom Communications) platform. Before each interview, we confirmed oral consent, and the sessions were audio-recorded and transcribed verbatim.

# **Data Analysis**

The closed-ended survey responses were obtained from Qualtrics and subsequently imported into the SPSS (version 28; IBM Corp) statistical software package for analysis. Descriptive statistics were calculated to summarize the characteristics of the study sample, including factors such as age, gender, faculty affiliation, length of time in current position, and previous experience with online teaching and learning technologies. Variations in data distribution were summarized and visually presented through tables and graphical representations, following the guidelines outlined by Polit and Beck [28]. In addition, 1-way ANOVA and Kruskal-Wallis *H* tests were conducted to analyze differences in satisfaction and likelihood to use online teaching and learning technologies in the future to support

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XSL•F() RenderX students in developing virtual caring skills. These analyses were conducted as deemed appropriate, following the recommendations of Polit and Beck [28]. To enhance readability and facilitate subsequent post hoc analyses, participant-reported ages were collapsed into 4 categories:  $\leq$ 39, 40-49, 60-59, and  $\geq$ 60 years. Team members with experience in statistical analysis met and contributed to ensure the accuracy of these findings.

For the analysis of open-ended survey responses and interview transcripts, each was assigned a unique identifier and imported into NVivo (version 14; Lumivero) to manage qualitative data. Our qualitative data analysis followed a thematic approach using an inductive process, aligning with the methods proposed by Braun and Clarke [29] and Nowell et al [30]. To gain a comprehensive understanding of the data, 2 researchers (LN and SJ) independently reviewed the entire qualitative dataset. Consensus coding was completed as both researchers coded the same transcripts and compared results on a one-to-one basis. Each researcher assigned sections of text to relevant codes, and the coding was then merged and discussed. Regular monthly meetings were held to establish and ensure a shared understanding of initial codes.

Larger team meetings, involving all authors, were conducted to collectively scrutinize and further refine emerging patterns in the qualitative data, ultimately confirming the identified themes and subthemes. Throughout the analysis process, written memos and meeting minutes were maintained to document our approach and decisions. Adhering to research and reporting standards, we followed the Standards for Reporting Qualitative Research outlined by O'Brien et al [31] when reporting this study.

# **Data Integration**

Integration occurred at 2 points in this study. First, the quantitative findings were used to inform the qualitative interview guide. Following an independent analysis of all qualitative and quantitative data, the data were integrated using a joint display as an analysis tool. During this analysis, qualitative data were used to explain and corroborate quantitative findings [32]. Quantitative findings were compared to qualitative themes to examine similarities and differences. Through this methodology, we were able to develop interpretations regarding educators' perceptions and experiences.

#### **Ethical Considerations**

We obtained approval from our local Conjoint Health Research Ethics Board (REB22-0748) to carry out this study. Educators were offered the opportunity to join the study voluntarily, with the assurance that their involvement in the survey would remain anonymous and would not affect their university employment status or career advancement. Completion and submission of the online surveys implied consent. Before participating in interviews, all respondents gave informed verbal consent. Interviews were administered by a graduate student who had no prior supervisory relationship with the participants. To protect participant anonymity, distinct identifiers were assigned to each participant, and the data were aggregated accordingly. No compensation was provided to participants for participating in this study.

# Rigor

We used several techniques to ensure the rigor of our study. Regular team meetings provided opportunities for debriefing, introspection, and deliberate questioning of our interpretations, as suggested by Morse [33]. We maintained a comprehensive audit trail that included codebooks, meeting minutes, and shared files to document all study-related decisions, following the guidelines proposed by Carnevale [34]. While 2 researchers were responsible for coding all qualitative data, the broader research team assessed and deliberated on decisions related to themes and subthemes. We revisited the raw survey and interview data to further validate our findings and ensure that they authentically represented the voices of the educator participants.

# Results

# **Participant Demographics**

A total of 82 educators started the survey, and 72 (88%) completed the entire survey. The 10 (12%) participants who did not complete the entire survey completed up to the final 5 survey items. We included all responses provided by participants in our final analysis as they yielded valuable insights and contributed to our overall study findings. Of the 82 survey participants, 19 (23%) agreed to be contacted for a follow-up interview of which 8 (10%) responded and completed an interview. Table 1 provides participant demographics for the survey and interviews.

Table 1.	Participant	demographics.
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Demographic and demographic subcategory	ographic and demographic subcategory Survey (n=82), n (%)			
Age (y)				
<39	11 (13)	0 (0)		
40-49	25 (30)	1 (13)		
50-59	29 (35)	3 (38)		
>60	16 (20)	4 (50)		
No response	1 (1)	0 (0)		
Gender				
Men	18 (22)	2 (25)		
Women	58 (71)	6 (75)		
Gender diverse <sup>a</sup>	6 (7)	0 (0)		
Faculty				
Education	21 (26)	3 (38)		
Medicine	34 (41)	3 (38)		
Nursing	16 (20)	2 (25)		
Social work	7 (9)	0 (0)		
Other (joint appointments)	4 (5)	0 (0)		
Experience <sup>b</sup>				
Beginner	35 (43)	3 (38)		
Intermediate	24 (29)	2 (25)		
Expert	23 (28)	3 (38)		

<sup>a</sup>Gender diverse included gender fluid, nonbinary, queer, and individuals who prefer not to disclose. Some categories were collapsed due to the need to maintain anonymity, particularly with small numbers in particular subcategories.

<sup>b</sup>Beginner=taught <4 online courses; intermediate=taught 5-7 online courses; expert=taught  $\geq$ 8 online courses.

# **Quantitative Results**

# Overview

Educator survey respondents (n=82) indicated that a variety of online instructional methods were used to help students develop virtual caring skills in a *select all that apply* survey item (Figure 1). The most frequently reported online instructional methods included using reflections on learning (50/82, 61%), online

modules (35/82, 43%), and online discussion boards (49/82, 60%). Educators reported using demonstrations of remote care (23/82, 28%) and consultation with clients (21/82, 26%). Respondents that used the option of *other* (7/82, 9%) described using verbal check-ins, synchronous meetings, simulations, social media, and flipped classrooms. Some respondents indicated that they have not used any online instructional methods to develop virtual caring skills (17/82, 21%).

Figure 1. Overview of themes, subthemes, and implications.

Barriers to teaching about virtual care in online environments	<ul> <li>Time constraints</li> <li>Underdeveloped virtual caring curricular content</li> <li>Lack of engagement</li> <li>Limited access to virtual caring equipment and technology</li> </ul>	Institutions and educators should strive to mitigate barriers to ensure high-quality teaching
Facilitators of teaching about virtual care in online environments	<ul> <li>Clearly defined learning objectives</li> <li>Technology software and support</li> <li>Teaching support</li> <li>Stakeholder engagement</li> <li>Flexibility</li> </ul>	Institutions and educators should leverage facilitators to foster virtual caring skill development
Principles of virtual care	<ul> <li>Connection and interaction</li> <li>Compassion, empathy, and care</li> <li>Vulnerability</li> </ul>	Educators should be role models and incorporate these principles in their online teaching practice

# Satisfaction With Online Teaching and Learning Strategies

Survey participants (n=80) reported their level of satisfaction with online teaching and learning strategies, with 71 (89%) participants indicating that they were either satisfied or somewhat satisfied with the approaches used in their classrooms. However, a notable proportion, approximately 11% (9/80) of the participants, reported dissatisfaction.

# Likelihood of Using Online Teaching and Learning Technologies

Among educators who responded to the question (n=70) about the likelihood of using online teaching and learning technologies to support students in developing virtual caring skills in the future, 53 (76%) indicated that they were very likely or somewhat likely to engage in this modality. Conversely, 17 (24%) educators responded that they were not likely to use online teaching and learning for the development of virtual caring skills in the future.

We conducted 1-way ANOVA tests to explore potential differences in satisfaction and likelihood to use technology scores among groups based on gender, age, faculty, years of experience in current position, or experience with online teaching and learning technologies. Table 2 summarizes the ANOVA test results.

In the survey, an expert was defined as an educator who had designed and taught  $\geq 8$  classes. There was a statistically significant difference between educators' level of experience teaching online and their satisfaction with online teaching and learning technologies ( $F_{2,77}=11.465$ ; P<.001), with a large effect size ( $\eta^2=0.23$ ) [28]. A Bonferroni post hoc analysis demonstrated that educators with expert experience with

demonstrated that educators with expert experience with teaching using technology reported significantly higher satisfaction (mean 2.82, SD 0.39) compared to those at beginner (mean 2.06, SD 0.69) or intermediate levels (mean 2.21, SD

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0.59). No statistically significant difference was found between those at beginner and intermediate levels. A statistically significant difference was found between educators' faculties (departments) and their satisfaction with online teaching and learning technologies ( $F_{4,75}$ =5.119; P=.001), with a large effect size ( $\eta^2$ =0.21). A Bonferroni post hoc analysis found that educators from the faculty of education (mean 2.75, SD 0.44) rated their satisfaction with online teaching and learning technologies significantly higher than faculty from medicine (mean 2.12, SD 0.64) or nursing (mean 2.07, SD 0.70). There were no statistically significant differences found between social work and the remaining faculties. Notably, all other comparisons via 1-way ANOVA tests yielded no statistically significant results.

Through Levene tests, two 1-way ANOVA test pairings were found to have unequal variances: (1) faculties and likelihood of using online teaching and learning technology and (2) years of experience and likelihood to use online teaching and learning technology. The Kruskal-Wallis H test, a nonparametric equivalent, was used to examine those relationships. A Kruskal-Wallis H test demonstrated that there was a statistically significant difference in the likelihood of using online teaching and learning technologies and the different faculties ( $H_4$ =13.44; P=.009), with a mean rank likelihood of 52.0 for the faculty of social work, 43.2 for the faculty of nursing, 36.8 for the faculty of education, 34.6 for other faculties, and 27.0 for the faculty of medicine. A pairwise comparison revealed that educators from the faculty of social work had a significantly higher likelihood of using online teaching and learning technologies than the faculty of medicine when considering the Bonferroni correction for multiple tests, P=.01. This was the only significant relationship found in the pairwise comparison after applying the Bonferroni correction. Kruskal-Wallis H test demonstrated that there was no statistically significant difference in the likelihood of using online teaching and learning technologies and years of experience ( $H_5=3.956$ ; P=.56).

Table 2. ANOVA test results.

Variable comparison	Descriptive statistic	Descriptive statistics		ANOVA		
	Participants, n (%)	Mean (SD)	F test ( $df$ )	$\eta^2$	P value	
Gender and satisfaction (n=80)			1.38 (2, 77)	0.04	.26	
Men	18 (23)	2.11 (0.68)				
Women	56 (70)	2.39 (0.65)				
Gender diverse	6 (8)	2.17 (0.75)				
Age (y) and satisfaction (n=80)			0.31 (3, 74)	0.01	.82	
0-39	10 (13)	2.40 (0.52)				
40-49	25 (31)	2.24 (0.66)				
50-59	29 (36)	2.28 (0.80)				
>60	14 (18)	2.43 (0.51)				
Faculty and satisfaction (n=80)			5.12 (4, 75)	0.21	.001	
Education	20 (25)	2.75 (0.44)				
Medicine	34 (43)	2.13 (0.64)				
Nursing	15 (19)	2.07 (0.70)				
Social work	7 (9)	2.71 (0.49)				
Other	4 (5)	2.00 (0.82)				
Experience (y) and satisfaction (n=	80)		0.99 (5, 74)	0.06	.43	
<1	5 (6)	2.20 (0.84)				
1-5	28 (35)	2.39 (0.63)				
6-10	21 (26)	2.43 (0.68)				
11-15	12 (15)	2.33 (0.65)				
16-20	5 (6)	1.80 (0.84)				
>20	9 (11)	2.11 (0.60)				
Online experience and satisfaction (n=80)		11.46 (2, 77)	0.23	<.001		
Beginner	34 (42)	2.06 (0.69)				
Intermediate	24 (30)	2.21 (0.59)				
Expert	22 (28)	2.82 (0.39)				
Gender and likelihood to use (n=70	)		1.68 (2, 67)	0.05	.20	
Men	14 (20)	2.07 (0.92)				
Women	52 (74)	2.38 (0.80)				
Gender diverse	4 (6)	1.75 (0.96)				
Age (y) and likelihood to use (n=70)		0.28 (3, 36)	0.01	.84		
0-39	6 (9)	2.50 (0.55)				
40-49	22 (31)	2.18 (0.91)				
50-59	26 (37)	2.35 (0.89)				
>60	14 (20)	2.29 (0.73)				
Online experience and likelihood to use (n=70)		1.92 (2, 67)	0.05	.16		
Beginner	27 (39)	2.11 (0.89)				
Intermediate	22 (31)	2.23 (0.81)				
Expert	21 (30)	2.57 (0.75)				



# **Qualitative Findings**

# Overview

Figure 1 offers a summary of 3 overarching themes and their associated 12 subthemes, which were identified when analyzing the qualitative data. It also highlights potential recommendations for supporting online teaching to enhance the development of virtual caring skills. The subsequent sections delve deeper into the exploration of these findings.

# Barriers to Teaching About Virtual Care in Online Environments

Educators identified several barriers that were encountered for online teaching and learning related to the development of virtual caring skills, including time constraints, underdeveloped virtual caring curricular content, a lack of engagement, and limited access to virtual caring equipment and technology. Despite these barriers, participants often highlighted their adaptability in addressing the needs of their students and teaching contexts.

# Time Constraints

Participants reported time constraints as a concern, citing challenges such as the increased duration of virtual interactivity and the need to adapt clinical experiences for online platforms. Educators discussed time constraints as a limiting factor for teaching duration and described the need for adjustments. One participant shared the following:

Another barrier is always time, right?...For it not to be just text heavy and kind of interactive, you need time, and you don't necessarily have that. [P6, interview, education educator]

In some cases, the concern expressed was for students who could not be online for extended durations:

*Clinical online, it's eight hours online. We made a decision that was too much for the students to be online.* [P1, interview, nursing educator]

In addition to teaching time constraints, educators noted that additional time was required when offering experiential learning in practice:

*Timing was always an issue. It seemed to take longer to do virtual appointments than in person.* [P8, interview, medicine educator]

The shift to virtual teaching and learning spaces prompted educators to be mindful of time constraints and their impacts. Despite these challenges, all participants adjusted to better cater to the needs of their students and those they would be caring for in practice.

# Underdeveloped Virtual Caring Curricular Content

Educators reported difficulties in identifying key content related to virtual caring. As noted by a nursing educator, virtual caring content was often missing from the curriculum due to curricular overload:

Actually, I would say one of the things that I feel that is missing from the clinical practice for [this context] is the education part. We do a little bit of in the

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clinical, but to do the total education...we have to do it that way because there's no time to include absolutely everything. [P1, interview, nursing educator]

Virtual caring skills and competencies were often considered a specialized practice and were therefore not traditionally incorporated into more generalist-focused curricula. However, the onset of the COVID-19 pandemic made virtual care a crucial competency for many caring professions. An educator from the faculty of education noted how students tried to balance the unknown of virtual care expectations with how they may be expected to practice virtually when they graduated:

...but [students] don't necessarily know what they're getting into because you're asking them to look at an area that is somebody else's whole specialization, and yet we expect all teachers to know this information. [P3, interview, education educator]

These responses demonstrated the challenges educators faced due to the lack of virtual caring curricular content, potentially negatively impacting students' ability to provide virtual care in their future practice.

# Lack of Engagement

Educators expressed concerns regarding the lack of student engagement they encountered in online settings when teaching about virtual care. They cited interruptions, decisions about cameras being on or off, and struggles connecting with students and colleagues as factors negatively impacting student engagement levels. The online environment posed a complex challenge, with frequent connectivity issues and interruptions. One interview participant noted the following:

We had cats and dogs. We had children interrupting...every time a student would come in [to the Zoom call], the doorbell [chime] would ring and [their] dog would go berserk. [They'd] be constantly shutting mute on, and then have to do something about that dog. So, [they]'d disappear from the screen and then come back. [P1, interview, nursing educator]]

The debate over whether students should have their cameras switched on or switched off during virtual learning was raised, particularly in terms of establishing a sense of presence:

To providing an ethic of care is the cameras on cameras off issue...the preference for students to have their cameras off makes for a very difficult teaching environment...I can't see your face; I can't see your reaction. [P3, interview, education educator]

Beyond visible student presence in a virtual class, educators also raised a concern about how virtual caring challenged their own engagement and sensory perceptions:

I can't sense what's going on for them...You can't feel the energy in the room, right? You can't see body language. You can't see nonverbal communication...These are professions where we rely on all of our senses. And in a virtual environment, they're not all there. [P6, interview, education educator]

One survey respondent identified the following:

I can't see faces or check in with people who might show signs of confusion the same way I can in person. You can't "read the room" online. [P23, survey, medical educator]

# *Limited Access to Virtual Caring Equipment and Technology*

Educators expressed concerns about the limited access to virtual caring equipment and technology, which had a detrimental impact on interactivity. For one educator in medicine, the lack of equipment was an ongoing challenge:

I would say that the interaction suffered. We struggled with not having enough private computer space in the hospital. We struggled with not having cameras for the learners, and microphones, and that went on for quite a while. [P8, interview, medicine educator]

For a nursing educator, the lack of student internet access was a challenge in teaching virtual care and creating environments for students to practice their virtual caring skills:

And there was one student who had to do [Zoom] on [their] cell phone, and she was using her minutes on her phone. It was getting too expensive. It was so much better if [they] just didn't use [their] cell phone...there were other students, their internet would go down. [P1, interview, nursing educator]

Teaching and providing virtual care in rural and remote areas brought attention to the privilege of internet access and resources as well as the challenges faced by clients:

There are limitations in some of the other countries about their access to Wi-Fi...many people do not have access to Wi-Fi at home. Therefore, the scheduling is important. I think many centers then also have interruptions of their Wi-Fi and are constantly on and off, on and off, and that creates some problems for them. And finally, there's a few centers that the reason for that happening is that they lose electricity. [P5, interview, medicine educator]

Remote learning in rural areas, it all depends on bandwidth...At the beginning, I didn't realize the reason why people weren't turning their cameras on...Tech is always a barrier...whether it's bandwidth, whether it's Zoom not working, whether our own internet. [P6, interview, education educator]

The challenges, such as lack of equipment and poor internet accessibility, directly impacted educators' ability to teach students virtual caring skills and competencies. These considerations can also be challenges in working with experts or patients outside of the virtual classroom.

# Facilitators to Teaching About Virtual Care in Online Environments

Educators identified several facilitators for online teaching and learning related to virtual caring skills. These facilitators included well-defined learning objectives, supportive technology software and assistance, effective teaching support, active stakeholder engagement, and a commitment to flexibility.

# **Clearly Defined Learning Objectives**

Educators brought up their awareness of key graduate expectations, competencies, and learning objectives in both the open-ended survey questions and interview responses. Some educators were challenged in aligning new virtual contexts with previously defined learning competencies:

I've had to reconsider how my own caring is conveyed and recognized in different circumstances. I've also begun to theorize about how caring is connected to key graduate learning expectations and competencies. [P66, survey, education educator]

Other participants, like this one from medicine, asserted that the learning objectives should remain consistent despite the shift to online learning:

I don't think we've changed the learning objectives. I think that they remain relatively constant, it's how you achieve them. And with the remote learning, the remote learning has allowed the interaction, but it's the interaction I think that's more important than the virtual way of doing things. [P5, interview, medicine educator]

Other educators spoke about how the processes of learning caring competencies might not change in virtual contexts, but students may struggle to see the value of acquiring virtual caring skills:

If they [students] don't care about something, it doesn't become part of a learning repertoire. Then what you have to then wonder if you're just covering material for the sake of covering...it's not enough that I care about the ideas, I need to get them to care about the ideas as well. [P4, interview, education educator]

Despite the various viewpoints on how learning objectives were achieved, there was consistent support across the participants for the development and use of clear learning objectives related to virtual care. Particularly for participants who had relied previously on in-person assessments of learning objectives, there was an intentionality to focus and be explicit on what the learning objective was and how virtual care considerations were necessary.

# Technology Software and Support

Participants identified that possessing knowledge and intentionally using technology and virtual caring software could enhance the development of virtual caring skills. Others identified the benefits of providing orientation and skill development sessions to familiarize individuals with the use of technology:

Some of the [online] programs demanded a lot of interaction...so it started off with teaching people how to do things [in the online programs]. [P5, interview, medicine educator]

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Furthermore, survey participants asserted that ongoing technical assistance was important to successfully integrate new technologies into the virtual caring curriculum. One survey participant commented on the positive advancement of technology and its influence on education. They wrote, "The technology has come so far that teaching online is often equivalent to in person" (P51, survey, social work). Some of the examples of technology use included telehealth, podcasting, video creation, Zoom, and virtual simulations.

In one example with clinical practice, learners were actively engaged with a particular client population online. Students were tasked with using technology and software to interact with the client. Experimenting with the various features of the technology provided an additional way for students to learn new ways to establish connections with clients:

They hear the [diagnosis], and they're like, oh, they can't do anything. But they were having fun with the little apps that turn your hair green, or give you bunny ears, and stuff like that. So, they're going through and playing with all that kind of stuff. I don't even know where half that stuff is or how they find it. But it's hilarious and it's fun to watch. So, it becomes a medium and a tool kind of thing. [P7, interview, nursing educator]

It is important for students to gain a clear understanding of how to use virtual caring technologies efficiently and effectively to make meaningful caring connections with clients. The perspective from both survey and interview participants reinforced that having access to the tools was important, with support and familiarity requiring time and resources for tool use competency.

# **Teaching Support**

Educators identified that various teaching supports were necessary for fostering initial self-awareness and skill development when teaching in virtual settings. Ongoing development and the exchange of best practices helped build and sustain confidence and competence in using virtual caring technology. Many educators turned to others for teaching support, including teaching and learning departments and teams, or external networks to help support their personal learning needs. Others found teaching support from within their own faculty and professional organizations:

My colleagues and my own field professional organization was better in terms of teaching strategies or things to do within a lesson. [P6, interview, education educator]

Overall, educators were motivated to seek out ways to enhance their teaching practice of virtual caring skills.

# Stakeholder Engagement

Study participants identified stakeholder support and engagement as important to virtual caring skill development. One survey respondent contributed that "online teaching is forcing me to get creative...I learned to rely more on facilitating students' own motivation and initiative to seek community involvement" (P40, survey, medicine educator). Educators sought to encourage students to engage with clients in the community to help inform their virtual caring practices. Another survey participant indicated the importance of consulting various stakeholders, including students and educators, regarding their experiences with virtual caring technology by suggesting faculties should do the following:

[Engage in] consultation with students to understand their experiences as the end user/recipient of any technologies used for developing caring skills; [develop] a long-term vision/strategy for implementing, evaluating, and updating technology; [and link] technology use to program intent/pedagogy so that it makes sense to teachers/learners and is not just used for the sake of it. [P5, survey, nursing educator]

Others highlighted the value of engaging with a range of stakeholders, including caregivers, clients, students, and instructors, in the virtual care setting:

We would invite the clients and the caregivers, or whoever was in the home to set up the screen and make sure that all of the controls were kind of off so that we could control it. And so as long as they could log in, we could get them into a breakout room. We would put the student in there with them. We would put a mentor from the [organization] in there with them. And then as instructors, we would go into each breakout room and just listen, make sure everything was okay, answer any questions, and then go to the next one and kind of wander through that way. And it worked really well. [P7, interview, nursing educator]

Participants indicated that various stakeholders bring valuable and diverse perspectives to virtual caring experiences and harnessing these viewpoints can help facilitate more effective teaching and learning about virtual care.

# Flexibility

Educators identified various ways that they chose to adjust, alter, change, or remain open to alternative ways of engaging in their practices for teaching, learning, and providing virtual care. The theme of flexibility emerged prominently in the survey responses, with a focus on being flexible with students. One survey participant emphasized the importance of "just being open and available and allowing students to set the stage for how they want to show up and learn and to be open if they are finding the online approach to learning challenging" (P79, survey, social work educator). Another perspective on flexibility was that it "allowed for more flexible scheduling and allow(ed) me to reach international students easier" (P15, survey, medicine educator). The connection to students in conducting, developing, or framing the learning space was recognized as a key element in building the flexibility to permit learning that incorporated virtual learning skills. This flexibility contributed to a more dynamic and inclusive learning environment.

# Principles of Virtual Care

In our analysis, we identified principles of virtual care that reflect what educators reported as important considerations to how they approached teaching and learning virtual caring skills.

These principles include emphasis on connection and interaction; compassion, empathy, and care; and vulnerability.

# **Connection and Interaction**

Educators identified how important connections and interactions were for teaching about and providing virtual care. This perspective was particularly present for a nursing educator who described how technical nursing skills were not as important as making personal connections with the clients, which is vital when providing virtual care:

[Students] felt that they were missing out on some of those skills, like IV starts because obviously we didn't do that [in a virtual environment]. But no, those are not the most important skills in nursing. It's the interaction. It's the education...nursing is not all about skills. [P1, interview, nursing educator]

Some educators were thoughtful in their approach to providing students with purposeful opportunities to develop connections with clients:

I would want to be in a different room, with my camera off, observing the whole encounter...be the fly on the wall...and then be able to deliver feedback after the appointment. [P8, interview, medicine educator]

All educators identified through the interviews that personal connections and prioritizing interactions were desired, and even necessary, before skill development in virtual environments.

# Compassion, Empathy, and Care

Educators shared how emotional labor and intentional considerations are required to design learning experiences around compassion, empathy, and care, particularly in virtual contexts. One survey respondent suggested that "students of any caring profession know they need emotional bravery and an ability to handle very difficult situations with empathy and calmness even when they do not feel that way" (P34, survey, social work educator). Participants also indicated they needed this emotional bravery to successfully implement online teaching and learning technologies to support students in developing virtual caring skills. Educators acknowledged the impact and challenges associated with emotional labor and considered their role as educators in addressing issues like compassion fatigue:

Emotional labor and compassion fatigue...because those aspects impact the degree to which somebody wants to try something new or continue a practice that used to work, that doesn't seem to be working now. [P3, interview, education educator]

One interview participant considered the impact of learning activities with a focus on social and emotional learning for individual well-being:

I also am a very active and dynamic facilitator, even online, so I use teaching strategies that I would use in the classroom and I get my students to actually get up and do things if I'm talking about a social emotional learning activity, something that's for wellbeing, because taking care of yourself is as important as you know what you're teaching, and you

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will impact the wellbeing of your own students or patients by the way you are as well. So, if I'm talking about just a simple social-emotional piece where it is maybe a five, four, three, two mindfulness activity, I do it with them. [P6, interview, education educator]

Compassion, empathy, and care were viewed as important considerations in teaching, learning, and providing virtual care. These qualities could manifest authentically in a variety of ways, depending on the context of the teacher, learner, or client.

# Vulnerability

The theme of care extended to include a focus on educator vulnerability and the willingness to embrace new approaches, recognizing that things might not always go as planned. However, this willingness by the educator required creating safer learning and caring spaces:

In caring skills and competencies, there's a level of vulnerability there that you must have. And so, when you're starting out with online courses, you need to build that caring atmosphere within your virtual online environment in a way that students feel safe.

If you have a course, you have the time, and you utilize facilitation methods that are similar to what you are expecting them to be able to do as well, then that's helpful, right? I guess it comes back to that theory practice piece. [P6, interview, education educator]

Another participant spoke about the need to break down barriers by creating relationships that push virtual caring efforts to meet clients' needs:

They [clients] put up their own barriers, to be perfectly honest. Because if you want it, you'll find a way to do it. But...If you have the goal in mind that, then all you need to do is figure out how to get there. It's a lot easier...I mean, create relationships. Ask people if they want to try something. And don't think you can't do it just because nobody's done it before...See if it works. Not everything works the first time. Well, I know that's why this is important too, right? It's like you evaluate and you figure out what works, what doesn't work. [P7, interview, nursing educator]

There was a shared sense among participants that without the educator's sense of vulnerability and willingness to try something new and create intentional efforts toward connection through compassion and care, educational practice for virtual care would not be able to move forward.

# Discussion

# **Principal Findings**

In this sequential explanatory mixed methods study [24] we explored the experiences and perceptions of educators in caring professions as they navigated online teaching to facilitate the development of virtual caring skills and competencies among students. Educators identified both barriers and facilitators to

engaging in this mode of teaching and learning as well as identified key principles underlying virtual caring.

Quantitative and qualitative data were integrated following individual analysis. The most common online instructional methods used to teach virtual caring skills were reflection, online modules, and online discussion boards. Only 26% (21/80) of the participants indicated that they provided experiential learning via consultation with clients on the quantitative survey. In qualitative interviews, participants discussed barriers to this educational modality, such as lack of time, indicating that providing virtual caring experiences could be less efficient than providing in-person clinical learning. Furthermore, 21% (17/80) of the educators indicated that they had not used online technology to teach virtual caring skills. This was reflected in the qualitative data when participants discussed the challenges of fitting more content into an already crowded curriculum. As virtual environments increase in the caring professions, it is important that virtual caring curriculum becomes a more permanent fixture within program curricula [35], rather than treated as a specialty consideration that can be included if time permits. This highlights the attention for program-level considerations for technological literacy and use development. It is not enough for educators to be able to use the technology effectively and use tools in one course; instead, there is a need to identify opportunities across a program to support the learning and development of digital literacy and technology-use competencies.

Educators had varying levels of satisfaction with their online teaching and learning strategies to enhance virtual caring skills. Less than half of the participants (34/80, 43%) indicated that they were satisfied with their online teaching and learning strategies, with other educators indicating that they were either somewhat satisfied or not satisfied. Through the qualitative survey and interview data, educators expressed frustration regarding the lack of engagement or connection with their students, which created difficult teaching environments. Educators also expressed concern regarding students' access to technology devices and reliable internet. Bolster et al [35] expanded this idea when discussing that clinical patients that might have limited access to virtual caring technologies or may lack digital literacy. In this study, the challenges discussed by educators may have influenced their overall satisfaction with their ability to execute effective teaching and learning strategies. In the survey qualitative responses, those that were "satisfied" (34/80, 43%) often cited reasons such as the smooth functioning of technology and active student engagement. Educator and student interactions with technology appear to be influential to educators' satisfaction with the teaching experience. Leaders from across the United States emphasized the importance of optimizing the logistics of technology when they met for a symposium titled Crossing the Virtual Chasm: Rethinking Curriculum, Competency, and Culture in the Virtual Care Era [35]. They reported that the need to optimize logistics, including providing equitable technology access and user software training, was one of the levers that can improve virtual care education [35].

Although educators' likelihood to use online teaching and learning technology was mixed in quantitative surveys, there

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was notable support to develop learning objectives to enhance virtual caring skills. Educators discussed facilitators that could enhance the teaching and learning of virtual caring skills in interviews. Survey respondents who identified as very likely to use online teaching and learning technologies (37/70, 53%) indicated via qualitative responses that teaching support through professional development, ongoing technology assistance, and student engagement was essential to support students in developing virtual caring skills. Addressing challenges that arise while teaching and learning virtual caring skills in an online environment can be beneficial to student outcomes and educators' satisfaction and increase their likelihood to use such technologies. Although higher education institutions are working to keep up with evolving technologies, specialized attention will be required in the virtual caring education context [35].

Surveys and interviews were undertaken with educators across caring professions, including education, medicine, nursing, and social work, within a research-intensive educational institution in western Canada. Quantitative analysis revealed interesting insights into educators' satisfaction with online teaching and learning strategies and their likelihood to use online teaching and learning technologies. Overall, educators were somewhat satisfied with the online teaching and learning strategies they were using in their classrooms. Furthermore, they felt that they were somewhat likely to use online teaching and learning technology to support student learning of virtual caring skills. Through inferential analysis, we found that educators with experience designing and teaching  $\geq 8$  classes (considered expert level) had statistically greater satisfaction with the teaching and learning techniques they used in online learning environments. This finding indicates that educators could benefit from more experience in online teaching. This is congruent with the findings reported by Rhode et al [7], indicating that educators with more experience teaching in online environments had more positive attitudes toward online teaching and learning.

In addition, we found that educators from the faculty of education reported significantly higher satisfaction levels in teaching virtual care in an online modality compared to their counterparts in medicine or nursing. This may be largely due to the longer history that education faculties may have had in providing instruction in an online environment. This finding highlights the importance of offering additional support and professional development to educators in traditionally in-person programs, enabling them to effectively meet the needs of an increasingly online student population. In an integrative review, Cutri and Mena [36] discuss the cultural and structural challenges of traditionally in-person educators transitioning to online teaching and learning, including the workload required and readiness to transition to the online environment. Considering these challenges, academic institutions should consider implementing robust professional development programs to better support faculty engaging in online teaching and learning, ensuring optimal support for students learning virtual caring skills.

Educators identified several barriers to online teaching and learning related to the development of virtual caring skills, including time constraints, underdeveloped virtual caring curricular content, lack of engagement, and limited access to

virtual caring equipment and technology. Time constraints may pose a significant challenge for educators as they strive to cover comprehensive content within limited time frames. Furthermore, educators may struggle to find room for virtual caring skills within their current curriculum, recognizing that to include additional content, other content will have to be reduced or eliminated. The underdeveloped nature of virtual caring curricular content may result in teaching and learning practices that lack the depth and breadth required to adequately prepare students for the nuances of virtual care. A notable barrier to teaching virtual caring skills in online environments, seen in this study and the literature, is the struggle to maintain student engagement, as online settings often hinder active participation and interaction. Students are more likely to be engaged when they have active learning opportunities, a positive learning climate, and meaningful interaction with faculty and peers [37]. Furthermore, limited access to virtual caring equipment and technology has exacerbated the challenge of teaching online [38] and hindered caring professionals' practical application of virtual care concepts [39]. Addressing these barriers is crucial to ensuring a robust and effective virtual care education within online learning environments.

Educators in this study identified several facilitators of online teaching and learning related to virtual caring skills, such as clearly defined learning objectives, technology software and support, teaching support, stakeholder engagement, and flexibility. Clear and well-defined learning objectives play a pivotal role in ensuring quality education, providing a road map for both educators and students to navigate curriculum with clarity and purpose. Adequate technology software and support are essential facilitators, enabling seamless integration of virtual caring skills into the online environment. Teaching support, including resources, training, and guidance, enhances educators' ability to effectively convey virtual caring concepts. In a grounded theory study, Shepherd et al [40] explored medical faculty and learner experiences regarding the learning of virtual caring skills during the COVID-19 pandemic. Despite medical faculty recognizing how virtual care can benefit patients, they were reluctant to continue to teach in virtual clinics, due to barriers at the individual, institutional, and systemic levels, citing challenging technology platforms and a lack of professional development as 2 of the limitations [40]. Stakeholder engagement, involving collaboration with health care professionals, institutions, and communities, may foster a more holistic approach to virtual care education. In addition, flexibility in instructional methods and assessment allows for adaptive learning experiences, catering to diverse student needs and optimizing the acquisition of virtual caring skills in an online setting.

Educators identified connection and interaction; compassion, empathy, and care; and vulnerability as key considerations when developing online teaching and learning experiences to support students in developing virtual caring skills. Fostering meaningful connections and interactions within the virtual learning space is essential for educators to create engaging and supportive learning environments. Encouraging compassionate and empathetic attitudes is fundamental, as these qualities are at the core of effective virtual care. Our findings mirrored the assertion

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by Bolster et al [35] that connection in virtual care is an essential component of "webside manner," indicating the importance of rapport building through technology. Integrating opportunities for students to understand and express vulnerability is equally important, as it promotes authenticity and a deeper understanding of the human aspect of health care. By prioritizing these elements, online educational experiences can transcend physical barriers, providing a rich and holistic foundation for students to develop the interpersonal skills necessary for effective virtual caring [16,41-44].

This study is part of a larger multistudy research project intended to provide a framework for virtual caring skill development in higher education. This study explores the educator's perspectives, while another study explores the student's perspectives. The final integrated findings will inform a framework to guide educators from varied professions as they develop virtual caring curricula. By gaining educator and student perspectives, we aim to provide a comprehensive view of core principles, competencies, teaching methods, facilitators, and barriers to teaching and learning virtual caring skills.

#### **Strengths and Limitations**

Our sequential explanatory mixed methods study provided a thorough examination of caring profession educators' perceptions of virtual caring skill development within a specific educational institution. The inclusion of participants from various caring professions offered diverse perspectives, enhancing the study's comprehensiveness. By incorporating surveys and interviews, the research amalgamated quantitative and qualitative data, enabling a more profound insight into educators' experiences and perspectives in online teaching related to virtual care. However, it is essential to acknowledge the study's limitations, warranting caution in interpreting the findings. The focus on a singular institution may limit the generalizability of these findings to broader contexts. Furthermore, the participant pool from a single institution may lack diversity, potentially affecting the external validity and transferability of findings to a more varied population. Despite these constraints, this study lays the groundwork for exploring virtual caring skill development, inspiring further research, and offering potential insights for enhancing the delivery of virtual care in educational settings.

#### Conclusions

Educators in caring professions require specialized knowledge and skills to effectively teach and support students in developing virtual caring skills and competencies. Our study highlights the barriers, facilitators, and principles of teaching virtual caring skills online. As we contribute to the growing body of educational research on virtual caring skills, we share insights from caring profession educators. Future research should continue to explore how educators in more traditionally in-person teaching and learning can be supported to meet modern-day needs. In addition, more evidence is needed to explore effective teaching and learning strategies to teach virtual caring skills in a variety of contexts. Our findings offer practical strategies to enhance teaching and learning within educational programs for caring professions.

# **Conflicts of Interest**

None declared.

- 1. Bogo M. Field education for clinical social work practice: best practices and contemporary challenges. Clin Soc Work J 2015 Mar 18;43(3):317-324 [FREE Full text] [doi: 10.1007/S10615-015-0526-5]
- 2. Leading work-integrated learning in Canada. Future Skills Center. URL: <u>https://www.cewilcanada.ca/</u> [accessed 2020-12-17]
- Dewart G, Corcoran L, Thirsk L, Petrovic K. Nursing education in a pandemic: academic challenges in response to COVID-19. Nurse Educ Today 2020 Sep;92:104471 [FREE Full text] [doi: 10.1016/j.nedt.2020.104471] [Medline: 32502723]
- 4. Roskvist R, Eggleton K, Goodyear-Smith F. Provision of e-learning programmes to replace undergraduate medical students' clinical general practice attachments during COVID-19 stand-down. Educ Prim Care 2020 Jul;31(4):247-254 [FREE Full text] [doi: 10.1080/14739879.2020.1772123] [Medline: 32469632]
- Van Nuland S, Mandzuk D, Tucker Petrick K, Cooper T. COVID-19 and its effects on teacher education in Ontario: a complex adaptive systems perspective. J Educ Teach 2020 Aug 06;46(4):442-451 [FREE Full text] [doi: 10.1080/02607476.2020.1803050]
- Dede C, Jass Ketelhut D, Whitehouse P, Breit L, McCloskey EM. A research agenda for online teacher professional development. J Teach Educ 2008 Nov 26;60(1):8-19 [FREE Full text] [doi: <u>10.1177/0022487108327554</u>]
- Rhode J, Richter S, Miller T. Designing personalized online teaching professional development through self-assessment. TechTrends 2017 Jun 21;61(5):444-451 [FREE Full text] [doi: 10.1007/S11528-017-0211-3]
- 8. Darling-Hammond L, Hyler ME. Preparing educators for the time of COVID ... and beyond. Eur J Teach Educ 2020 Sep 04;43(4):457-465 [FREE Full text] [doi: 10.1080/02619768.2020.1816961]
- 9. Quezada RL, Talbot C, Quezada-Parker KB. From bricks and mortar to remote teaching: a teacher education program's response to COVID-19. J Educ Teach 2020 Aug 02;46(4):472-483 [FREE Full text] [doi: 10.1080/02607476.2020.1801330]
- Cleland J, McKimm J, Fuller R, Taylor D, Janczukowicz J, Gibbs T. Adapting to the impact of COVID-19: sharing stories, sharing practice. Med Teach 2020 Jul 13;42(7):772-775 [FREE Full text] [doi: 10.1080/0142159X.2020.1757635] [Medline: 32401079]
- 11. Ferri F, Grifoni P, Guzzo T. Online learning and emergency remote teaching: opportunities and challenges in emergency situations. Societies 2020 Nov 13;10(4):86 [FREE Full text] [doi: 10.3390/soc10040086]
- Kidd W, Murray J. The COVID-19 pandemic and its effects on teacher education in England: how teacher educators moved practicum learning online. Eur J Teach Educ 2020 Sep 09;43(4):542-558 [FREE Full text] [doi: 10.1080/02619768.2020.1820480]
- 13. Sepulveda-Escobar P, Morrison A. Online teaching placement during the COVID-19 pandemic in Chile: challenges and opportunities. Eur J Teach Educ 2020 Sep 09;43(4):587-607 [FREE Full text] [doi: 10.1080/02619768.2020.1820981]
- 14. Chittleborough G. Learning how to teach chemistry with technology: pre-service teachers' experiences with integrating technology into their learning and teaching. J Sci Teach Educ 2017 Feb 21;25(4):373-393 [FREE Full text] [doi: 10.1007/S10972-014-9387-Y]
- Cantone RE, Palmer R, Dodson LG, Biagioli FE. Insomnia telemedicine OSCE (TeleOSCE): a simulated standardized patient video-visit case for clerkship students. MedEdPORTAL 2019 Dec 27;15:10867 [FREE Full text] [doi: 10.15766/mep\_2374-8265.10867] [Medline: 32051850]
- Lister M, Vaughn J, Brennan-Cook M, Molloy M, Kuszajewski M, Shaw RJ. Telehealth and telenursing using simulation for pre-licensure USA students. Nurse Educ Pract 2018 Mar;29:59-63 [FREE Full text] [doi: 10.1016/j.nepr.2017.10.031] [Medline: 29180228]
- 17. Love R, Carrington JM. Introducing telehealth skills into the Doctor of Nursing practice curriculum. J Am Assoc Nurse Pract 2020 Oct 07;33(11):1030-1034. [doi: 10.1097/JXX.000000000000505] [Medline: 33038114]
- O'Connor EA, Worman T. Designing for interactivity, while scaffolding student entry, within immersive virtual reality environments. J Educ Technol Syst 2018 Dec 11;47(3):292-317 [FREE Full text] [doi: 10.1177/0047239518817545]
- Woodcock S, Sisco A, Eady M. The learning experience: training teachers using online synchronous environments. J Educ Res Inst 2015 Mar 04;5(1):52 [FREE Full text] [doi: 10.5590/jerap.2015.05.1.02]
- Müller AM, Goh C, Lim LZ, Gao X. COVID-19 emergency eLearning and beyond: experiences and perspectives of university educators. Education Sciences 2021 Jan 05;11(1):19 [FREE Full text] [doi: <u>10.3390/educsci11010019</u>]
- Williamson B, Eynon R, Potter J. Pandemic politics, pedagogies and practices: digital technologies and distance education during the coronavirus emergency. Learn Media Technol 2020 May 21;45(2):107-114 [FREE Full text] [doi: 10.1080/17439884.2020.1761641]
- 22. Zhang W, Wang Y, Yang L, Wang C. Suspending classes without stopping learning: China's education emergency management policy in the COVID-19 outbreak. J Risk Financial Manag 2020 Mar 13;13(3):55 [FREE Full text] [doi: 10.3390/jrfm13030055]

- Nowell L, Dhingra S, Carless-Kane S, McGuinness C, Paolucci A, Jacobsen M, et al. A systematic review of online education initiatives to develop students remote caring skills and practices. Med Educ Online 2022 Dec 12;27(1):2088049 [FREE Full text] [doi: 10.1080/10872981.2022.2088049] [Medline: 35694798]
- 24. Creswell JW. A Concise Introduction to Mixed Methods Research, 2nd Edition. Thousand Oaks, CA: Sage Publications; 2020.
- 25. Rattray J, Jones MC. Essential elements of questionnaire design and development. J Clin Nurs 2007 Feb;16(2):234-243 [FREE Full text] [doi: 10.1111/j.1365-2702.2006.01573.x] [Medline: 17239058]
- 26. Topolovec-Vranic J, Natarajan K. The use of social media in recruitment for medical research studies: a scoping review. J Med Internet Res 2016 Nov 07;18(11):e286 [FREE Full text] [doi: 10.2196/jmir.5698] [Medline: 27821383]
- 27. Yuan P, Bare MG, Johnson MO, Saberi P. Using online social media for recruitment of human immunodeficiency virus-positive participants: a cross-sectional survey. J Med Internet Res 2014 May 01;16(5):e117 [FREE Full text] [doi: 10.2196/jmir.3229] [Medline: 24784982]
- 28. Polit DF, Beck CT. Nursing Research: Generating And Assessing Evidence For Nursing Practice, 11th Edition. New York, NY: Wolters Kluwer; 2013.
- 29. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2006 Jan;3(2):77-101 [FREE Full text] [doi: 10.1191/1478088706qp063oa]
- 30. Nowell LS, Norris JM, White DE, Moules NJ. Thematic analysis. Int J Qual Methods 2017 Oct 02;16(1):e007641 [FREE Full text] [doi: 10.1177/1609406917733847]
- O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. Acad Med 2014 Sep;89(9):1245-1251 [FREE Full text] [doi: 10.1097/ACM.00000000000388] [Medline: 24979285]
- 32. Younas A, Durante A. Decision tree for identifying pertinent integration procedures and joint displays in mixed methods research. J Adv Nurs 2023 Jul;79(7):2754-2769 [FREE Full text] [doi: 10.1111/jan.15536] [Medline: 36524303]
- Morse JM. Critical analysis of strategies for determining rigor in qualitative inquiry. Qual Health Res 2015 Sep;25(9):1212-1222 [FREE Full text] [doi: 10.1177/1049732315588501] [Medline: 26184336]
- 34. Carnevale FA. Authentic qualitative research and the quest for methodological rigour. Can J Nurs Res 2002 Sep;34(2):121-128. [Medline: <u>12425004</u>]
- 35. Bolster MB, Chandra S, Demaerschalk BM, Esper CD, Genkins JZ, Hayden EM, Virtual CareMedical Educator Group. Crossing the virtual chasm: practical considerations for rethinking curriculum, competency, and culture in the virtual care era. Acad Med 2022 Jun 01;97(6):839-846. [doi: 10.1097/ACM.000000000004660] [Medline: 35263303]
- 36. Cutri RM, Mena J. A critical reconceptualization of faculty readiness for online teaching. Distance Educ 2020 Aug 03;41(3):361-380 [FREE Full text] [doi: 10.1080/01587919.2020.1763167]
- Cole AW, Lennon L, Weber N. Student perceptions of online active learning practices and online learning climate predict online course engagement. Interact Learn Environ 2019 May 23;29(5):866-880 [FREE Full text] [doi: 10.1080/10494820.2019.1619593]
- Kuntz J, Manokore V. "I did not sign up for this": student experiences of the rapid shift from in-person to emergency virtual remote learning during the COVID pandemic. High Learn Res Commun 2022 Jul 01;12:110-146 [FREE Full text] [doi: 10.18870/hlrc.v12i0.1316]
- Ortega G, Rodriguez JA, Maurer LR, Witt EE, Perez N, Reich A, et al. Telemedicine, COVID-19, and disparities: policy implications. Health Policy Technol 2020 Sep;9(3):368-371 [FREE Full text] [doi: 10.1016/j.hlpt.2020.08.001] [Medline: 32837888]
- 40. Shepherd L, McConnell A, Watling C. Good for patients but not learners? Exploring faculty and learner virtual care integration. Med Educ 2022 Dec;56(12):1174-1183 [FREE Full text] [doi: 10.1111/medu.14861] [Medline: 35732194]
- 41. Goldingay S, Boddy J. Preparing social work graduates for digital practice: ethical pedagogies for effective learning. Aust Soc Work 2016 Dec 11;70(2):209-220 [FREE Full text] [doi: 10.1080/0312407X.2016.1257036]
- 42. Liu C, Scott KM, Lim RL, Taylor S, Calvo RA. EQClinic: a platform for learning communication skills in clinical consultations. Med Educ Online 2016;21:31801 [FREE Full text] [doi: 10.3402/meo.v21.31801] [Medline: 27476537]
- 43. Pullen Jr RL, Silvers CA. Helping students embrace HIT. Nurs Manage 2018 Dec;49(12):17-21. [doi: 10.1097/01.NUMA.0000547841.89245.bd] [Medline: 30499855]
- 44. Rutledge C, Hawkins EJ, Bordelon M, Gustin TS. Telehealth education: an interprofessional online immersion experience in response to COVID-19. J Nurs Educ 2020 Oct 01;59(10):570-576 [FREE Full text] [doi: 10.3928/01484834-20200921-06] [Medline: 33002163]



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# Evaluating Nurses' Perceptions of Documentation in the Electronic Health Record: Multimethod Analysis

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# Abstract

**Background:** Nurses are one of the largest user groups of the electronic health record (EHR) system, relying on its tools to support patient care and nursing workflows. Recent studies suggested that the redesign of nursing documentation may reduce the time spent in the EHR system and improve nurse satisfaction.

**Objective:** We aimed to assess nurses' perceptions of the redesigned EHR, evaluate the impact of documentation interventions, and identify future improvement needs.

**Methods:** Guided by the American Nursing Informatics Association's Six Domains of Burden conceptual framework, this multimethod project combined both qualitative and quantitative approaches. Registered nurses across the academic health system were recruited via email invitations to participate in focus group discussions. The focus groups were conducted via a web conference and ranged from 60 to 90 minutes in duration. The focus group discussions were transcribed and analyzed through thematic analysis. The EHR vendor's time data were used to analyze nurses' time spent in documentation.

**Results:** In total, 20 registered nurses participated in the focus group discussions, and 17 nurses completed the demographic survey; 88% (15/17) of participants had  $\geq$ 3 years of EHR experience at the academic health system, and 53% (9/17) self-reported being competent in the EHR system. The following six themes emerged: positive feedback, usability and workflow opportunities, nuisance, training and education, communication, and time spent in the system. EHR vendor time data revealed that the time spent in flowsheets averaged 31.11% per 12-hour shift.

**Conclusions:** Overall, participants reported a positive experience and that the EHR supported patient care. There are opportunities to further reduce redundancies in documentation and implement programs that support continuous learning about EHR and health technology tools. Specific suggestions include optimizing the oral health assessment tool. Analyzing frontline nursing perspectives in the redesign of EHR workflows is imperative for identifying interventions that support nurses' satisfaction with the EHR.

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# **KEYWORDS**

electronic health record; nurse; documentation burden; focus group; usability; documentation

# Introduction

# Background

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Nursing documentation is critical for high-quality patient care and effective communication among health care professionals. Before the implementation of electronic health records (EHRs), clinician documentation was primarily recorded by using paper-based methods [1]. The Health Information Technology

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for Economic and Clinical Health (HITECH) Act, which passed in 2009 in the United States, aimed to improve health care quality and safety and encourage the efficient use of health ITs, such as the EHR [2]. Hospitals were incentivized to implement EHR systems, resulting in 98.3% of hospitals adopting electronic-based systems in recent decades [3]. The increased sophistication of EHR systems has introduced documentation requirements and clinician decision support tools, potentially increasing clinicians' documentation burden [4]. The American
Medical Informatics Association (AMIA) describes *documentation burden* as the stress resulting from excessive work that is required to document in the EHR [5].

Nurses are one of the largest user groups of the EHR system and are primary users of flowsheet tools for documentation [6]. Flowsheets are structured tools in the EHR system; they are used to record discrete data over time and are designed in a tabular format. Resembling a spreadsheet, each column represents a date and time, while each row is designed to capture selectable options or free-text values. Nurses capture assessments and observations in flowsheets and, on average, document 631 to 875 flowsheet data entries within a 12-hour shift, equating to approximately 1 data entry per minute [6,7].

There is increased awareness among national government entities and professional health care organizations across the United States regarding the need to implement initiatives that address EHR documentation burden. For instance, the 21st Century Cures Act identified the following three goals for reducing clinician burden: (1) reduce the time and effort needed to document health information, (2) reduce the time and effort needed to meet regulatory requirements, and (3) improve usability [8]. Similarly, in 2021, the AMIA Task Force aimed to reduce clinician documentation burden by 25% within 5 years [5,9]. Additionally, the American Nursing Association's Principles for Nursing Documentation recommend that nursing data entries should be meaningful and nonredundant [10]. Further, a prior study found that flowsheet redesign saved an average of 10 minutes per shift in flowsheets [11]. Other interventions, such as EHR optimizations and training, could improve clinician satisfaction, and nurses show increasing utilization of documentation efficiency tools once such tools are available [12,13].

The American Nursing Informatics Association (ANIA) developed the Six Domains of Documentation Burden conceptual framework, defining the factors that contribute to documentation burden as follows: reimbursement, regulatory, quality, usability, interoperability/standards, and self-imposed [14]. Nursing flowsheet documentation represents a significant amount of the overall documentation time for nurses, making

it a prime area for burden evaluation through ANIA's framework.

During the COVID-19 pandemic, our academic health system (AHS) reduced nursing flowsheet documentation by requiring only the documentation of critical assessments. Along with national calls to action for reducing documentation burden, this streamlined documentation approach served as a catalyst for the chief nursing officer, IT analysts, and nursing informatics team to optimize the nursing digital experience across the enterprise. We adopted a phased implementation approach to address challenges. In 2021, nursing informatics and IT analysts led nursing documentation enhancement workgroups with direct care nurses across the AHS. Nurses highlighted areas of the EHR system that were burdensome and suggested improvements. The nursing informatics team analyzed data from the EHR to identify flowsheet rows with minimal to low usage rates and brought these up as discussion points during workgroup meetings. Additionally, nursing informatics and IT analysts conducted an analysis of the various "vascular access device and drain" documentation groups. Cross-referencing these documentation groups revealed opportunities to consolidate similar documentation groups. During the workgroup sessions, direct care nurses expressed a preference to group and reduce the amount of "vascular access device and drain" documentation groups. Nursing informatics and IT analysts presented proposed changes to the steering council (comprised of the chief nursing officer and cross-campus nursing senior directors) for approval. Projects for implementation were prioritized into the following three phases (Figure 1): phase 1 focused on reducing nonmeaningful nursing documentation tasks, phase 2 involved redesigning flowsheets, and phase 3 involved consolidating and reducing similar "vascular access device and drain" documentation groups. Throughout each phase of the implementation, the nurse workgroup participants contributed recommendations and served as liaisons, gathering feedback from respective units and specialties. After the implementation of the three phases, our AHS sought to evaluate the project's impact and determine if further improvements were needed.

Figure 1. Improvement of nursing documentation experience: phased implementation and focus groups. EHR: electronic health record.



# Objective

We aimed to assess nurses' perceptions of the redesigned EHR, evaluate the impact of documentation interventions, and identify future improvement needs.

# Methods

# Setting

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Our assessment, which used qualitative and quantitative methods, was conducted at an AHS with 4 teaching hospitals

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in the northeastern region of the United States; each teaching hospital was designated as an American Nurses Credentialing Center Magnet site. The AHS employs almost 10,000 nurses, and it implemented the current EHR system in 2012.

# Design

In our multimethod assessment, qualitative data were collected during 5 focus group sessions. A focus group method was chosen to evaluate the phased interventions and participants' lived experiences with documenting in the EHR [15]. Focus groups were selected for their ability to facilitate active

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interaction among participants and generate opinions, suggestions, and feedback through group dynamics [16]. Our quantitative data consisted of monthly data supplied by the EHR vendor, which summarized the time nurses spent in the EHR system. The system logged the time each user spent within the EHR by tracking the time spent performing clicks, scrolls, keystrokes, and mouse movements [17]. These quantitative data could be divided based on EHR-related activities, such as nursing flowsheet documentation, medication administration, and task management.

# Sample

The quality improvement project team recruited inpatient registered nurses across the AHS through an electronic flyer. Recruitment was performed during a pre-existing focus group process known as "Ideas for Innovation in Nursing." This process provided an opportunity for nurses to share their ideas about a given topic (ie, use of 3D printing in nursing practice). The full-page electronic flyer was embedded in the AHS's monthly nursing science newsletter, which has a distribution list of approximately 8000 nurses and provides information about upcoming focus groups. The registered nurses who were interested in participating in the focus groups were required to complete the electronic registration form, which involved selecting a preferred session date and time.

# **Data Collection and Analysis**

The quality improvement team members (DJ, JW, DD, BD, KEZ, and KO) met to develop open-ended questions for guiding focus group discussions. Prior to conducting the focus groups, DJ, JW, and DD were trained by BD and KEZ, who were experienced in qualitative methods and focus group facilitation. Additionally, BD and KEZ participated as comoderators in each focus group discussion. The moderator (DJ) led the focus group sessions, introduced the purpose and formatting of the focus group, and facilitated the questions. The observers (JW, DD, BD, and KEZ) used a template to document notes on and observations of participants' sentiments, behaviors, and nonverbal reactions. Sessions were conducted via a web conferencing platform. The focus group sessions ranged from 60 to 90 minutes in duration.

At the end of each focus group, participants received a link to an anonymous survey. The survey, which was administered via an administration platform, gathered demographic information, self-assessments of EHR competency, and feedback specifically about the focus group sessions. Participants' perceived level of EHR competency was defined by using Benner's [18] novice to expert theory. Benner's [18] model was initially used to understand how nurses develop clinical competence, but it has expanded to evaluate EHR skills [19]. The project team members (DJ, JW, DD, BD, KEZ, and KO) debriefed at the end of each session to review notes, identify themes, and compare findings from prior focus group discussions. Sessions were recorded and transcribed by using a web videoconferencing platform. The transcriptions were validated by the project team. The project team members (DJ, JW, DD, BD, KEZ, and KO) met to confirm that saturation was reached. Transcriptions were entered into ATLAS.ti Web (version v9.4.3; ATLAS.ti Scientific Software Development GmbH)—a qualitative data analysis software for coding. Thematic analysis with an inductive coding process was used to discover themes. The primary coder (DJ) completed initial coding and developed the codebook. The secondary coder (LG) independently reviewed and validated the codes. The coders met to identify patterns and themes within the data, leveraging The Six Domains of Burden conceptual framework to organize the codes and examine the multifaceted burden experienced by nurses [10]. All quotes were reviewed by DJ and LG to reach consensus on discrepancies and further refine codes.

EHR activity data regarding the time spent in flowsheets were calculated for February 2023—the same month as when the focus group discussions were conducted. These activity data were time-stamped, allowing for the calculation of the time spent specifically within that month. The average time spent in a documentation activity was calculated as a percentage for all nurses in the AHS system. This quantitative approach was designed to provide context to the qualitative data. This quality improvement project was reported in accordance with the SQUIRE (Standards for Quality Improvement Reporting Excellence) 2.0 guidelines [20].

# **Ethical Considerations**

This project was undertaken as part of a quality improvement project for evaluating nursing documentation experiences with the EHR. The project team completed an NYU Langone Health Institutional Review Board–approved quality improvement self-certification. Participants voluntarily registered to take part in the focus group discussions and were not provided with any form of compensation. At the beginning of each focus group, participants provided verbal agreement for sessions to be recorded and transcribed while maintaining their anonymity.

This project was determined to not meet the criteria for human subjects research, as guided by the NYU Grossman School of Medicine's Institutional Review Board policy.

# Results

# Participants

A total of 50 nurses responded via the electronic flyer's registration link. Of those, 20 participated in the focus groups, with an 85% (n=17) response rate for the demographic survey; 3 participants declined to complete the survey. Each focus group composition was made up of nurses from different hospitals and units. The focus group participants' demographic characteristics are listed in Table 1. Of the 17 respondents, most (n=12, 71%) were full-time employees, and the participants' primary area of practice was inpatient units (n=10, 59%). Further, 35% (n=6) of participants had been working at the AHS for 3 to 5 years, 47% (n=8) had 3 to 5 years of EHR system experience, and 53% (n=9) self-reported being competent in the EHR system.

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Table . Focus group participants' demographics (n=17).

Demographics	Participants, n (%)
Employment status	
Full-time	12 (71)
Part-time	4 (24)
Per diem	1 (6)
Area of practice	
Inpatient (acute, intensive care unit, maternal/child)	10 (59)
Emergency medicine	1 (6)
Perioperative	4 (24)
Other	2 (12)
Years at academic health system	
1 - 2	2 (12)
3 - 5	6 (35)
6 - 10	4 (24)
11 - 15	2 (12)
16 - 20	1 (6)
>20	2 (12)
EHR <sup>a</sup> system experience (years)	
1 - 2	2 (12)
3 - 5	8 (47)
6 - 10	5 (29)
>10	2 (12)
EHR system proficiency	
Advanced beginner	1 (6)
Competent	9 (53)
Proficient	5 (29)
Expert	2 (12)

<sup>a</sup>EHR: electronic health record.

#### **Focus Group Findings**

#### **Overview**

Herein, our findings are presented over the following six major themes: positive feedback, usability and workflow opportunities, nuisance, training and education, communication, and time spent in the system. Quantitative analysis results for EHR activity data regarding the time spent in flowsheets are reported for the "time spent in the system" theme, which included participants' subjective descriptions of how their shift time is spent; details of the analysis are presented in the *Time Spent in the EHR System* section.

#### **Positive Feedback**

#### **Overview of Positive Feedback**

Seventeen nurses in 5 focus groups provided positive feedback on the benefits of improved EHR workflows, including nursing documentation task management, flowsheet documentation,

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communication, and device and vendor integration. Positive feedback included the following subthemes: safe patient care, efficiency, and ease of use. Nurses reported positive sentiments on the nursing documentation programs that were implemented to improve documentation, such as the following:

The central lines....The date change row, all that I appreciate, because we did not have that for a while, and a lot will get lost in translation....There is a lot of improvements especially with skin,...Central lines catheters and drains. I appreciate all the changes that have been done, it's easier to just go back and backtrack to see when the last dressing was done or how it looked before the wound images. [Participant 15]

#### Safe Patient Care

Five nurses in 3 focus groups reported that the EHR system supported safe patient care delivery. Two nurses commented

on the ease of viewing patients' surgical history along the continuum of care. One participant said:

I think it's a great system. You know, coming from the paper charting to this...when you think about it. How crazy that time was - I cannot imagine not having the electronic chart....Really, it's great. It's great for follow up. It's great for care. I think it improves health. [Participant #1]

#### Efficiency

Nurses commented that efficiency tools, such as the vital signs integration and copy and paste, aid in reducing manual documentation, resulting in less time spent in the EHR system. For instance, a participant stated:

I find it helpful when you hook them up to the monitor and the vitals automatically get transferred....Very helpful for us because we see so many patients a day....It saves us the time of having to sit there manually inputting them. [Participant #18]

Focus group participant #1 also reported that "the more we can integrate the better."

#### Ease of Use

Four nurses appreciated the EHR task management feature and noted that the enhancements made the workflow easier. Six nurses expressed that the flowsheets were intuitive for documentation and were streamlined. One said:

It's super-duper easy. I usually take 5 minutes to finish my baseline charting. [Participant #13]

#### **Interdisciplinary Communication**

An EHR functionality allowing secure, direct messaging between clinicians was cited by 4 nurses in 3 different focus groups as something that improved their clinician experience through convenience and features such as the ability to send an image of an electrocardiogram directly to a covering radiology cardiology resident. The direct messaging feature was appreciated, while workflows involving calls to unit-based landline phones were highlighted as being particularly disruptive. The nurses carried work-issued mobile devices, which can be called directly. Further, a participant stated:

*I mean, I love this system. Because whatever I do, we connect with each other.* [Participant #13]

# Usability and Workflow Opportunities

Fourteen nurses in 5 focus groups reported usability and workflow opportunities in the EHR. Nurses commented on the desire for the standardization and consistency of documentation template design. For example:

There are some things that go in alphabetical order. And then something else will go in order of head to toe. And then something else will go in order of like, abnormal, abnormal, and then normal. And so, it feels like it changes...if it were just consistent, I think it would be easier. [Participant #9] Three nurses commented on the need for specialty-specific documentation templates to support clinical workflows. One reported:

I think the flowsheets are more catered to inpatient nurses...for telehealth nursing we use the flowsheets that were already in [redacted] but I think most of the questions in there are not telehealth specific, and also the nursing assessment is completely different over the phone because we obviously can't visualize the patient. I think there's definitely a lot of improvement that we can go forward with documentation in terms of telehealth. [Participant #3]

# Nuisance

#### **Redundant Documentation**

Four nurses in 2 different focus groups described redundant documentation during the admission process. The EHR frequently prompted them for information that was elsewhere in a patient's chart:

It asks me to put in if the patient received their COVID vaccination....I have to click on it but it's already on the storyboard. So, I think that's just added documentation that is unnecessary on our end. [Participant #6]

Eight nurses reported that in some cases, documentation was repetitive, as they had to document the same finding in several different places within the EHR. Examples included multiple places for documenting paper tape, skin assessments, patient activity, and patient positioning. Nurses described how the repetition was time-consuming and that they desired documentation to be streamlined.

# Nonmeaningful Documentation

Four nurses in 2 focus groups described nuisances related to nonmeaningful documentation. They cited oral assessment items that needed to be documented for all patients, irrespective of patients' needs; verbalized emotional states; subjective findings; and national standards, which necessitate documenting every 15 minutes. Although nurses understood the nature of hospital protocols, they felt that some documentation was more for "covering" oneself rather than serving an actual clinical purpose.

# **Training and Education**

Ten nurses in 4 focus groups discussed training and education related to the EHR. Four nurses described the learning curve for new nurses to acclimate to the EHR system. One participant said:

I also like the tip sheets because if you don't do something for quite a long time, you forget how to do it. The tip sheets are very helpful - tell you how to document. [Participant #4]

Two nurses reported their dissatisfaction with the EHR optimizations and communication method. For example:

I think it's very easy to miss those general broadcast emails. I think just like, batching changes would probably be most helpful. This group of changes is

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happening rather than 1 change here or 1 change here and there's 10 different emails about it. [Participant #8]

#### Communication

Six nurses discussed how the EHR system supports communication. Three nurses commented on the clinical mobile device and its strengths and weaknesses particularly around meeting patients' needs regarding their preferred language. The clinical mobile device, which paired with a mobile app for interpreter support, excelled at simplifying the process of connecting to a remote interpreter:

The steps saved from when you used to call, and they ask you what department you were calling from and what language you needed. That saves you a few minutes and that is priceless on its own. [Participant #10]

#### Time Spent in the EHR System

Participants self-reported that 10% to 50% of their shift is spent documenting in the EHR system, and many perceived this time to be appropriate. The EHR vendor time data were analyzed during the focus group period. The EHR vendor time data for February 2023 revealed that the average EHR time spent in flowsheets was 31.11% per 12-hour shift. In relation to the time spent in flowsheets, one participant stated:

I would definitely say the shift assessment takes up your biggest amount of time. You want to be thorough; you don't want to miss things. So, that really is the largest amount of time. [Participant #1]

# Discussion

#### **Principal Findings**

The project's aims were to explore nursing documentation experiences related to the EHR and evaluate how the documentation reduction interventions impacted perceptions. Themes included positive feedback, usability and workflow opportunities, nuisance, training and education, communication, and time spent in the system. Nurses perceived that the EHR supported the delivery of safe patient care and care team communication. Participants complimented the EHR system's easier flow and remarked on the general improvements. The project revealed that while the nurses overall had a positive experience with using the EHR system, there are further opportunities to optimize the EHR design. The implementation of voice recognition tools for nursing documentation supports the capture of patient assessments in real time by reducing the average time spent documenting by more than 2.6 minutes per assessment [21].

The focus group participants did not describe burden from using the EHR; rather, they noted redundant and nonmeaningful documentation as a nuisance. Focus group participants suggested solutions for reducing nonmeaningful documentation, such as optimizing the oral health assessment tool and only requiring oral health assessment documentation for ventilated and tracheostomy patients, which aligns with the AHS's policies and standards. Due to this project, this enhancement request

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was implemented at the AHS, with positive sentiments from nurses. Many documentation burden reduction interventions have shown improved satisfaction with the EHR among clinicians [22].

The Six Domains of Documentation Burden conceptual framework on EHR documentation burden indicates that most health care system cultures adhere to the ideology of "if it's not documented, it's not done" [10]. As a result, some nurses may document due to perceived legal implications. Focus group participants discussed documentation volume and the sense that they document too much. Health care system accreditation organizations have recognized the need to reduce documentation burden. In 2023, The Joint Commission aimed to eliminate 14% of standards and updated 13 standards [23]. Individual hospitals can make impacts to address EHR documentation barriers and reduce documentation through shared governance workgroups that include frontline nurses [24].

The project's findings reveal opportunities for continuous EHR education. Per the focus group participant survey results, 47% (8/17) of participants had 3 to 5 years of EHR experience, and 53% (9/17) of participants self-reported being competent in the system. Some focus group participants discussed not being familiar with efficiency tools, such as the EHR search toolbar for quickly finding information within a patient's chart. Training sessions can enhance perceptions of efficiency [25]. Future studies should explore the use of the Digital Literacy, Usability, and Acceptability of Technology Instrument for Healthcare—a validated instrument for evaluating frontline nurse competency and usability with respect to the implementation of continuous health IT learning programs [26].

The findings from the focus group discussions prompted the project team to implement strategies that aimed to augment the nursing documentation experience in the EHR system. To support continuous EHR learning, the nursing informatics and IT training teams provided nursing staff with interactive enrichment classes that focused on nursing efficiency and common EHR workflows. The training content was developed based on frontline staff recommendations. The nursing informatics and IT training teams conducted nursing wellness fairs as drop-in opportunities during shifts to showcase EHR efficiency and tips. Remote sessions were offered for nurses to learn about upcoming documentation enhancements that would improve workflow and to provide feedback. As a result of the focus groups, the oral health assessment was optimized such that it only displayed in the EHR for ventilated and tracheostomy patients, rather than being required for all patients, as part of a shift documentation assessment; this change aligned with the AHS's policies and standards. Additionally, efforts were made, in collaboration with direct care nurses, to streamline and reduce wound and skin documentation.

We acknowledge limitations related to our qualitative and quantitative approaches. Our sample did not include nurses from pediatric, behavioral health, or rehabilitation units. The recruitment flyer was distributed within an email newsletter and may not have been seen by all nurses. Further, due to this being a quality improvement project, we could not look at individuals' utilization patterns, and quantitative metrics were summarized

for all inpatient nurses at the hospital. Additionally, perceived documentation time spent in the EHR system was self-reported by focus group participants, and the EHR vendor time data analysis was not limited to focus group participants. Moreover, the focus group discussions were not limited to nurses who were employed prior to the documentation reduction interventions. However, this group made up a small fraction of the interviewees. Lastly, self-reported time spent documenting in the EHR might be influenced by group conformity bias. Participants in focus groups may be hesitant to express views that dissent from those of the group. Future work should explore a validated method for measuring burden [27].

# Conclusion

Our focus group discussion findings suggest that the implemented nursing documentation improvement interventions had an overall positive impact on the nurses' EHR experience. As health care technology and documentation requirements continue to advance, the EHR experience requires ongoing evaluation. Analyzing frontline nursing perspectives in the restructuring of EHR workflows is imperative for identifying interventions that support nurses' satisfaction with the EHR. Future work is needed in supporting nurses after the EHR system onboarding training period.

# **Conflicts of Interest**

None declared.

# References

- Kang MJ, Rossetti SC, Knaplund C, et al. Nursing documentation variation across different medical facilities within an integrated healthcare system. Comput Inform Nurs 2021 May 3;39(12):845-850. [doi: <u>10.1097/CIN.000000000000736</u>] [Medline: <u>33935196</u>]
- 2. Brass CT, Jackson PJ, Lake JE, Spar K, Vincent CH. American Recovery and Reinvestment Act of 2009 (P.L. 111-5): summary and legislative history. : Congressional Research Service; 2009 URL: <u>https://crsreports.congress.gov/product/pdf/R/R40537/6</u> [accessed 2025-04-11]
- Apathy NC, Holmgren AJ, Adler-Milstein J. A decade post-HITECH: critical access hospitals have electronic health records but struggle to keep up with other advanced functions. J Am Med Inform Assoc 2021 Aug 13;28(9):1947-1954. [doi: 10.1093/jamia/ocab102] [Medline: 34198342]
- 4. Padden J. Documentation burden and cognitive burden: how much is too much information? Comput Inform Nurs 2019 Feb;37(2):60-61. [doi: <u>10.1097/CIN.00000000000522</u>] [Medline: <u>30730402</u>]
- 5. 25x5 Documentation Burden Reduction Toolkit. American Medical Informatics Association. URL: <u>https://brand.amia.org/</u> m/3aaa0f687a601441/original/25x5-toolkit.pdf [accessed 2024-06-21]
- 6. Collins S, Couture B, Kang MJ, et al. Quantifying and visualizing nursing flowsheet documentation burden in acute and critical care. AMIA Annu Symp Proc 2018 Dec 5;2018:348-357. [Medline: <u>30815074</u>]
- Gesner E, Gazarian P, Dykes P. The burden and burnout in documenting patient care: an integrative literature review. Stud Health Technol Inform 2019 Aug 21;264:1194-1198. [doi: <u>10.3233/SHT1190415</u>] [Medline: <u>31438114</u>]
- 8. Strategy on reducing regulatory and administrative burden relating to the use of health IT and EHRs. : Office of the National Coordinator for Health Information Technology; 2020 URL: <u>https://www.healthit.gov/sites/default/files/page/2020-02/</u> BurdenReport\_0.pdf [accessed 2024-06-25]
- Payne TH, Corley S, Cullen TA, et al. Report of the AMIA EHR-2020 Task Force on the status and future direction of EHRs. J Am Med Inform Assoc 2015 Sep;22(5):1102-1110. [doi: <u>10.1093/jamia/ocv066</u>] [Medline: <u>26024883</u>]
- 10. ANA's principles for nursing documentation: guidance for registered nurses. American Nurses Association. 2010. URL: https://www.nursingworld.org/globalassets/docs/ana/ethics/principles-of-nursing-documentation.pdf [accessed 2024-06-21]
- 11. Lindsay MR, Lytle K. Implementing best practices to redesign workflow and optimize nursing documentation in the electronic health record. Appl Clin Inform 2022 May;13(3):711-719. [doi: 10.1055/a-1868-6431] [Medline: 35668677]
- 12. Kang C, Sarkar IN. Interventions to reduce electronic health record-related burnout: a systematic review. Appl Clin Inform 2024 Jan;15(1):10-25. [doi: 10.1055/a-2203-3787] [Medline: 37923381]
- Will J, Jacques D, Dauterman D, Groom L, Doty G, O'Brien K. Frequency and characteristics of flowsheet documentation recorded utilizing documentation efficiency tools. Comput Inform Nurs 2025 Feb 1;43(2):e01232. [doi: <u>10.1097/CIN.00000000001232</u>] [Medline: <u>39631030</u>]
- 14. Sengstack PP, Adrian B, Boyd DL, et al. The six domains of burden: a conceptual framework to address the burden of documentation in the electronic health record. American Nursing Informatics Association. URL: <u>https://www.ania.org/assets/documents/position/ehrBurdenPosition.pdf</u> [accessed 2025-04-11]
- Smith TA, Perez JK, Friesen MA. Virtual focus groups as an answer to research during a pandemic: implications for nursing professional development. J Nurses Prof Dev 2022;38(5):279-286. [doi: <u>10.1097/NND.000000000000750</u>] [Medline: <u>33935191</u>]
- 16. Jayasekara RS. Focus groups in nursing research: methodological perspectives. Nurs Outlook 2012;60(6):411-416. [doi: 10.1016/j.outlook.2012.02.001] [Medline: 22464693]

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- 17. How is user system time and behavior data measured? Epic Systems. URL: <u>https://galaxy.epic.com/?#Browse/page=1!68!50!100001668,100028978,100028981&from=Galaxy-Redirect</u> [accessed 2025-04-11]
- 18. Benner P. From novice to expert. Am J Nurs 1982 Mar;82(3):402-407. [Medline: <u>6917683</u>]
- Everett-Thomas R, Joseph L, Trujillo G. Using virtual simulation and electronic health records to assess student nurses' documentation and critical thinking skills. Nurse Educ Today 2021 Apr;99:104770. [doi: <u>10.1016/j.nedt.2021.104770</u>] [Medline: <u>33516978</u>]
- Ogrinc G, Davies L, Goodman D, Batalden P, Davidoff F, Stevens D. SQUIRE 2.0 (Standards for QUality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. Am J Med Qual 2015;30(6):543-549. [doi: 10.1177/1062860615605176] [Medline: 26497490]
- Mayer L, Xu D, Edwards N, Bokhart G. A comparison of voice recognition program and traditional keyboard charting for nurse documentation. Comput Inform Nurs 2021 Aug 4;40(2):90-94. [doi: <u>10.1097/CIN.000000000000793</u>] [Medline: <u>34347642</u>]
- 22. Sloss EA, Abdul S, Aboagyewah MA, et al. Toward alleviating clinician documentation burden: a scoping review of burden reduction efforts. Appl Clin Inform 2024 May;15(3):446-455. [doi: 10.1055/s-0044-1787007] [Medline: 38839063]
- 23. Petrovic K. Reducing the burden: eliminating 168 accreditation requirements is just the start. The Joint Commission. 2023 Jan 24. URL: <u>https://web.archive.org/web/20250120003137/https://www.jointcommission.org/resources/news-and-multimedia/blogs/dateline-tjc/2023/01/reducing-the-burden/</u> [accessed 2025-04-11]
- 24. Donohue-Ryan MA, Peleg NA, Fochesto D, Kowalski MO. An organization's documentation burden reduction initiative: a quality improvement project. Nurs Econ 2023;41(4):164-175. [doi: 10.62116/NEC.2023.41.4.164]
- Livingston K, Bovi J. Department-focused electronic health record thrive training. JAMIA Open 2022 Apr 9;5(2):00ac025. [doi: <u>10.1093/jamiaopen/00ac025</u>] [Medline: <u>35474717</u>]
- 26. Groom LL, Feldthouse D, Robertiello G, Fletcher J, Squires A. A pilot study toward development of the Digital Literacy, Usability, and Acceptability of Technology Instrument for healthcare. Comput Inform Nurs 2024 Dec 1;42(12):879-888. [doi: 10.1097/CIN.00000000001156] [Medline: 38913989]
- Moy AJ, Schwartz JM, Chen R, et al. Measurement of clinical documentation burden among physicians and nurses using electronic health records: a scoping review. J Am Med Inform Assoc 2021 Apr 23;28(5):998-1008. [doi: 10.1093/jamia/ocaa325] [Medline: 33434273]

# Abbreviations

AHS: academic health system
AMIA: American Medical Informatics Association
ANIA: American Nursing Informatics Association
EHR: electronic health record
HITECH: Health Information Technology for Economic and Clinical Health
SQUIRE: Standards for Quality Improvement Reporting Excellence

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# Analysis of Risk Factors and Nursing Strategies for Unplanned Extubation in Children: Retrospective Cohort Study

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# Abstract

**Background:** Unplanned extubation (UEX) is a critical indicator of nursing care quality. Existing research primarily focuses on pediatric intensive care units (PICUs), with limited data available from general pediatric surgery. Currently, most studies on this topic are mainly focused on PICUs, and there is a lack of research data regarding general pediatric surgery. Therefore, further research should be conducted based on this consideration.

**Objective:** This study aimed to analyze the high-risk factors for UEX in children and implement appropriate nursing strategies to reduce its incidence, ensuring clinical safety of pediatric patients.

**Methods:** A retrospective study (January 2018 - December 2023) included pediatric patients with indwelling catheters in general surgery. Exclusion criteria included mental disorders or abnormal Glasgow Coma Scale scores. Data on catheter days, UEX incidents, and risk factors were analyzed.

**Results:** A total of 1977 catheter days were recorded during the perioperative period, comprising 1079 days with urinary catheters, 768 days with postoperative wound drainage tubes, 68 days with gastric tubes, 46 days with peripheral central venous catheters, and 8 days with central venous catheters. During this period, 13 incidents of UEX occurred, yielding an overall UEX rate of 6.58 per 1000 catheter days. Urinary catheters accounted for the highest proportion of UEX incidents (8/13, 61.5%), followed by gastric tubes (3/13, 21.3%) and postoperative wound drainage tubes (2/13, 15.4%). The reintubation rate following UEX was 15.38% (2/13). Further analysis identified significant risk factors associated with UEX: (1) patient characteristics: age  $\leq 3$  years (8/13, 61.5%) and male sex (10/13, 76.9%); (2) clinical management: absence of physical restraints (10/13, 76.9%); and (3) temporal factors: incidents occurring during holidays (9/13, 69.2%). Multivariate analysis revealed that UEX risk was influenced by inter-related factors, including pediatric physiological characteristics (eg, limited self-regulation capacity), suboptimal catheter fixation methods, positional discomfort during patient movement, and variations in nursing interventions (eg, frequency of rounds and caregiver education).

**Conclusions:** Unplanned extubation in pediatric inpatients represents a critical clinical complication that may compromise treatment efficacy and prolong hospitalization. Our findings highlight the multifactorial etiology of UEX events, with risk determinants spanning patient characteristics, care protocols, and environmental factors. To mitigate these risks, we propose implementing evidence-based multidisciplinary preventive strategies, including standardized risk assessment protocols for high-risk subgroups (eg, male patients aged  $\leq 3$  years), enhanced staff training on age-appropriate restraint techniques and securement device utilization, and dynamic adjustment of nursing surveillance frequency during peak risk periods (eg, holidays or postural changes). This systematic approach demonstrates potential to reduce UEX-associated adverse events by 42% - 68%, according to benchmark studies, ultimately improving pediatric care quality.

# (JMIR Nursing 2025;8:e71307) doi:10.2196/71307

# **KEYWORDS**

unplanned extubation; nursing strategies; prevention; risk factor; pediatric care

# Introduction

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# **Unplanned extubation**

Unplanned extubation (UEX), a critical patient safety indicator reflecting nursing care quality, can lead to irreversible clinical

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consequences across all age groups. In adult critical care settings, reported UEX incidence ranges from 7% to 18%, with endotracheal tube dislodgement demonstrating particularly severe outcomes at rates of 0.2% - 14.6% [1-3]. The UEX rate for indwelling nasogastric tubes was 7.6% (95/1243) [4]. A total of 56,508 courses occurred in 36,696 patients, with a crude

UEX rate of 2.8% [5], and 0.43 - 0.79% in pediatric intensive care units (PICUs) [6]. The clinical implications of pediatric UEX extend beyond immediate physiological risks. When delayed reintubation occurs, these events may disrupt therapeutic trajectories, prolong hospitalization duration by 2 - 5 days based on severity [7], exacerbate family-caregiver tensions, and ultimately degrade health care service quality metrics. Despite these consequences, UEX in pediatric general surgical contexts remains understudied. To address this knowledge gap, we conducted a retrospective cohort analysis of UEX incidents recorded in a tertiary pediatric general surgery department between January 2018 and December 2023 (N=1977 catheter days). Through multidimensional risk factor identification, this study provides actionable evidence for developing nurse training protocols targeting high-risk scenarios, optimizing hospital administration policies for device securement, implementing preventive bundles tailored to pediatric surgical populations.

#### **Definition and Classification of UEX**

Unplanned extubation (UEX) is formally defined as the premature removal of indwelling medical devices prior to therapeutic protocol completion, occurring through: (1) Self-extubation: patient-initiated device removal without clinical authorization; (2) accidental dislodgement: unintentional tube slippage due to iatrogenic factors (eg, improper securement during nursing procedures); and (3) therapeutic failure: early device removal mandated by compromised functionality (eg, obstruction leakage or material degradation) [8].

This tripartite classification system emphasizes UEX causation mechanisms, facilitating targeted prevention strategies across clinical scenarios.

The incidence rate of UEX can be calculated in two ways [5,9]: (1) number of UEX instances of a particular catheter during a specific period/total days of catheter placement during the study period  $\times$  1000‰, (2) number of UEX instances of a particular catheter/total number of instances of catheter placement during the study period  $\times$  1000‰. The first method is more commonly used, particularly in monitoring tracheal intubation UEX in

intensive care units (ICUs). This method was also used in monitoring catheter infection rates during the 2011 assessment of tertiary comprehensive hospitals. This study adopts the first method for calculating incidence.

# Methods

# **Study Setting**

This retrospective study enrolled pediatric patients (aged <18 years) who: (1) underwent general surgical procedures with indwelling catheters between January 2018 and December 2023; (2) demonstrated preserved neuromuscular integrity (ie, normal muscle tone, Glasgow Coma Scale (GCS)  $\geq$ 14); and (3) had no documented neuropsychiatric comorbidities affecting device tolerance.

Catheter types analyzed included preoperative peripherally inserted central catheters and intraoperative or postoperative devices such as gastric tubes, urinary catheters, central venous catheters, and surgical wound drainage systems. Patient demographics, catheter maintenance characteristics, and contextual factors during UEX events were systematically documented through electronic health record extraction.

# **Research Method**

This study used a retrospective analysis approach for UEX. According to the hospital protocol, UEXs were reported as adverse events to the nursing department using a hospital-specific reporting form. The types of tubes included, in addition to those previously mentioned, were endotracheal tubes, tracheostomy tubes, fistula tubes, arterial lines, and dialysis catheters. However, as our department does not use these additional tubes, they were not included in this study. The Richmond Agitation-Sedation Scale (RASS) and the pediatric-modified GCS were applied for assessment. The RASS is a commonly used tool in health care to assess the level of sedation and agitation in patients and can provide guidance to nurses. The RASS-specific scoring criteria are presented in Table 1 [10].



Table . The RASS scoring criteria [11].

Score	Status	Clinical symptoms
+4	Aggressive	Violence
+3	Very restless	Try to remove the endotracheal tube, gastric tube, and venous access
+2	Manic anxiety	The body moves hard inability to cooperate with ventilator
+1	Disturbed anxiety	Anxiety and tension but only a slight body movement
0	Alert but quiet	Wake up the natural state
-1	Sleepy	Not fully awake, but can stay awake for more than 10 seconds
-2	Mild sedation	Unable to remain awake for more than 10 seconds
-3	Moderate sedation	Responses to sound
-4	Severe sedation	Responses to body stimuli
-5	Stupor	No response to sound or body stimulation

# **Ethical Considerations**

This study was approved by the Medical Ethics Committee of Shunyi Maternal and Child Health Care Hospital, Beijing (IEC-B-022-V.01-A08; Multimedia Appendix 1). As this was a retrospective study, telephone communication was conducted with legal guardians of all participating children (who experienced unplanned extubation). The research purpose, risks, and data usage scope were fully explained. All guardians provided consent for data inclusion. For secondary data analysis, the original data were anonymized, and informed consent was obtained during primary data collection. Data were deidentified by removing patient names, initials, and hospital IDs. All images in the manuscript and supplementary materials were verified to contain no identifiable features of participants. No compensation was provided to the participants. The composition and working procedures of this ethics committee complied with the principles of good clinical practice and relevant national laws and regulations.

# Results

# **Demographic Risk Stratification**

The demographic characteristics are provided in Table 2. Age-dependent vulnerability showed a descending gradient: infants or toddlers ( $\leq$ 3 years) accounted for 61.6% (8/13) of total UEX cases, preschool children (4 - 6 years) for 23.1% (3/13), and school-aged children (>6 years) for 15.3% (2/13) UEX cases. Gender disparity was pronounced, with men exhibiting 2.3-fold higher risk than women (10/13, 76.9% vs 3/13, 23.1%).

**Table** . Pediatric patients with indwelling catheters and UEX<sup>a</sup> occurrences.

Characteristics	Patients (N=13), n (%)
Gender	
Male	10 (76.9)
Female	3 (23.1)
Age (years)	
≤1	4 (30.8)
1 - 3	4 (30.8)
4-6	3 (23.1)
7-16	2 (15.4)
Clinical Features	
Restraints used	
Yes	3 (23.1)
No	10 (76.9)
Sedative medication usage	
Yes	0 (0)
No	13 (100)
Catheter types	
Urinary catheter	8 (61.5)
Gastric tube	3 (23.1)
Drainage tube	2 (15.4)
PICC <sup>b</sup> /CVC <sup>c</sup>	0 (0)
UEX occurrence details	
Patient condition	
Quiet	4 (30.8)
Restless/crying	9 (69.2)
Awake	13 (100)
Comatose	0 (0)
Nurse presence	
At bedside	1 (7.7)
Not at bedside	12 (92.3)
Time period	
Morning awakening	4 (30.7)
Before/after meals	2 (15.4)
Morning/afternoon treatment	4 (30.8)
Noon/night rest	3 (23.1)
Timing post-catheter use (hours)	
≤6	2 (15.4)
24 - 48	4 (30.8)
≥48	7 (53.8)
Workday/holiday	
Business days	4 (30.8)
Holidays	9 (69.2)

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Characteristics	Patients (N=13), n (%)
Tape replacement (hours)	
≤24	11 (84.6)
224	2 (15.4)

<sup>a</sup>UEX: unplanned extubation.

<sup>b</sup>PICC: peripherally inserted central catheter.

<sup>c</sup>CVC: central venous catheter.

# **Clinical Context of UEX Events**

The data in Table 3 are derived from this study's analysis of catheterized children (N=13) in the Pediatric General Surgery department from 2018 to 2023, with intergroup comparisons performed using Student *t* test. This study identified an overall UEX rate of 6.58 per 1000 catheter-days in pediatric general

surgery. Catheter-specific analysis revealed that gastric tubes demonstrated the highest incidence density (44.1 events/1000 catheter-days); urinary catheters constituted the majority of UEX events (8/13, 61.5%). The RASS scores before and after catheter placement, postoperatively, and during the peri-decannulation period are shown in Table 4.

Table .	Incidence of UEX <sup>a</sup>	in pediatric g	general surgery	for five types of	of tubing from	January 2018 to December	er 2023.
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Name of tubing	Catheter days	Number of UEX occur- rences	UEX incidence rate <sup>b</sup>	UEX for each tubing <sup>c</sup> , %
Urinary catheter	1079	8	7.41	61.5
Gastric tube	68	3	44.1	23.1
PICC <sup>d</sup>	46	0	0	0
CVC <sup>e</sup>	8	0	0	0
Wound drainage tube	768	2	2.6	15.4

<sup>a</sup>UEX: unplanned extubation.

<sup>b</sup>cases / catheter days  $\times$  100%.

<sup>c</sup>UEX occurrences for each tubing type / total UEX occurrences  $\times$  100%.

<sup>d</sup>PICC: peripherally inserted central catheter.

<sup>e</sup>CVC: central venous catheter.

Rating	Before catheter placement, n	After catheter placement, n	Within 30 min- utes of returning to the room post- operatively, n	After returning to the room 2 hours postopera- tively, n	After 24 hours postoperatively, n	Peri-Decannula- tion period, n	Percentage of decannulation scoring (n=78), n (%)
+4	0	0	0	0	0	0	0
+3	0	10	3	1	4	3	21 (26.9)
+2	2	3	2	0	1	6	14 (17.9)
+1	5	0	1	3	2	2	13 (16.7)
0	6	0	1	5	6	2	20 (25.6)
-1	0	0	3	3	0	0	6 (7.7)
-2	0	0	2	1	0	0	3 (3.8)
-3	0	0	1	0	0	0	1 (1.3)
-4	0	0	0	0	0	0	0 (0)
-5	0	0	0	0	0	0	0 (0)

<sup>a</sup>RASS: Richmond Agitation-Sedation Scale.



# Discussion

# **Incidence and Patient-Related Factors of UEX**

#### **Comparative Incidence Analysis**

Existing literature demonstrates significant variability in pediatric UEX rates across care settings. PICU-focused studies such as that by Guan et al [6], a single-center analysis of 41 cases reported UEX incidence rates of 0.43 - 0.79%, with 71% occurring in infants  $\leq 12$  months [12]. In mixed surgical cohorts, Sadowski et al [7] documented a higher event rate of 6.4% (95% CI 5.1 - 7.8), potentially reflecting broader inclusion criteria [13]. The general pediatric surgery cohort in this study (N=1977 catheter-days) revealed a UEX incidence density of 6.58 per 1000 catheter-days, translating to a 2.1-fold higher risk than PICU benchmarks [6] and comparable rates to mixed surgical populations [7], when standardized per insertion. This discrepancy may be attributable to: (1) procedural differences that is, prolonged postoperative immobilization versus critical care protocols; (2) surveillance intensity that is, reduced monitoring frequency in general wards versus PICUs; and (3) catheter type distribution, that is, predominance of urinary or gastric devices (84.6% of UEX events) versus respiratory tubes in ICUs.

#### Age Distribution of Patients

Consistent with developmental vulnerability patterns, our findings corroborate the inverse correlation between age and UEX susceptibility first reported by Guan et al [6]. Comparative analysis revealed that infants and toddlers ( $\leq 3$  years) in our cohort demonstrated 17.2% higher UEX risk compared to the study by Ma et al (Multimedia Appendix 2) [8]. This can potentially be attributable to neurodevelopmental factors (eg, sensorimotor integration increasing immature device manipulation behaviors), cognitive limitations (ie, reduced capacity to comprehend catheter purpose, as per Piaget's preoperational stage characteristics) [14], and anatomical constraints (eg, higher device-to-body size ratio exacerbating positional discomfort). Gender disparity analysis identified men as having a 3.3-fold higher UEX risk than women (n=10, 76.9% vs n=3, 23.1%; P=.046), aligning with established pediatric mobility patterns. Christov-Moore et al [15] showed that this kinetic discrepancy may interact with testosterone-mediated exploratory behavior enhancement and delayed proprioceptive development in male infants.

# **Consciousness State**

Emerging evidence identifies altered consciousness as a critical risk predictor for UEX in pediatric populations. Pediatric patients with critical illness requiring intensive care (ie, ICU or PICU admission) demonstrate heightened susceptibility to delirium, a condition with multifactorial etiology involving both intrinsic patient factors (disease severity, metabolic disturbances) and extrinsic environmental triggers (sensory overload, sleep disruption). This neurocognitive complication is further exacerbated by iatrogenic risks associated with suboptimal care quality, including unplanned extubation events, which may amplify physiological stress and psychological distress. Such associations underscore the need for delirium-preventive

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protocols tailored to high-acuity pediatric settings to mitigate adverse clinical outcomes [16,17].

Standardized neurological assessment tools demonstrate clinical utility in risk stratification:

- Pediatric GCS [18]: It assesses three domains such as ocular response (E1-E4), verbal response (V1-V5), and motor response (M1-M6). Systematic GCS documentation reduces pediatric UEX risk by 38% (odds ratio [OR] 0.62, 95% CI 0.55 - 0.71) [19].
- Confusion assessment method (CAM) [20,21]: It is an ICU-validated delirium screening tool with specificity of 93% and sensitivity 86%. The implementation of this method decreases UEX frequency by 43.7% (risk ratio [RR] 0.58; *P*=.006).

Internationally recognized critical care guidelines uniformly recommend the RASS as the criterion-standard tool for sedation assessment in adult intensive care. The RASS demonstrates high validity in both medical and surgical ICU patients, whether ventilated or nonventilated, sedated or nonanesthetized. [22]. It is recommended by the Association of the Scientific Medical Societies in Germany S2k Consensus [23], and the Chinese Expert Consensus on Neurocritical Care Sedation [24]. The operational thresholds are as follows: (1) agitation identification: RASS scores of +2 to +4 indicate clinically significant agitation requiring intervention (emergency prehospital with sensitivity of 89%) [22], and (2) sedation protocol: maintaining RASS scores between -2 to 0 reduces UEX by 41% (RR 0.59, 95% CI 0.54 - 0.66) []and ventilator-associated pneumonia by 32% (HR 0.68, P=.007) [25].

#### **Comfort of Position**

This study did not impose mandatory positioning restrictions on pediatric patients with indwelling catheters, permitting them to self-select comfortable positions. However, sudden postural changes were prohibited to maintain catheter stability, with continuous monitoring ensuring an indwelling segment length  $\geq 5$  cm during mobilization [26]. Unplanned extubation was mechanistically linked to foreign body sensation–induced physiological stress, particularly in nasogastric intubation cases where nausea incidence increased by 54% (95% CI 46% - 62%) and abdominal distension risk, (OR 2.8, 95% CI 2.1 - 3.7; *P*<.001). Abdominal distension demonstrated a significant association with UEX, with affected patients exhibiting a 3.2-fold elevated risk (HR 3.2, 95% CI 2.1 - 4.9; *P*=.002) compared to nondistended counterparts [27].

The primary reasons for UEX are the tension and fear experienced by pediatric patients or discomfort due to prolonged catheterization, leading them to attempt self-removal. In cases where patients sweat excessively and engage in frequent movements, the edges of the dressing may curl, and adhesive strength may decrease. Some patients may experience slippage due to the short length of the reserved catheter, especially during vigorous activities. For patients who can freely change positions and cooperate well with medical staff, it is crucial to provide specific instructions on precautions when changing positions and the placement of drainage tubes while getting up or lying down to prevent UEX.

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#### **Distribution of High-Risk Time for UEX Occurrence**

The incidence of UEX during holidays and morning hours accounts for 69.2% (n=9) and 30.7% (n=4) of the total UEX occurrence rate, respectively; on workdays, the percentage is 30.8% (n=4). For other time periods, the distribution was 15.4% (n=2) and 7.7% (n=1), respectively, indicating that holidays and the morning period (6 AM-8 AM) pose a high-risk time for UEX. Previous research has identified the high-risk time period for UEX as 4 PM-8 PM, constituting 41.2% (95% CI 38.5% - 44.0%) of occurrences. The subsequent periods from 12 AM-4 PM constitute 18.7% (95% CI 16.2% - 21.3%) [28].

# Analysis of Nursing Staff Allocation and UEX Prevention Mechanisms

Our department implements a standardized health education protocol for pediatric patients with indwelling catheters, requiring assigned nurses to provide systematic guidance to caregivers on catheter maintenance objectives, clinical significance, and nursing standards. This approach aims to reduce human–related UEX risks through enhanced caregiver awareness. Daily ward round evaluations indicate that, while parents can recall basic catheter care protocols, significant knowledge gaps persist regarding critical aspects such as postural management and recognition of abnormal signs. Current evidence suggests a dose-dependent relationship between nursing staff allocation and UEX incidence.

In critical care units, a nurse-to-patient ratio (5.00; 95%CI 2.64-7.99) increased the risk of UEX [29]. This indicates that the nurse-to-patient ratio has a direct impact on preventing UEX [30].

Although this study did not comprehensively quantify dynamic nurse-to-patient ratios, case analysis revealed that 92.3% (n=12) of UEX incidents occurred during nurse absences from the bedside, highlighting the current reliance on collaborative caregiver-staff supervision for catheter safety. Notably, our nursing team's average clinical experience of five years has ruled out technical operational errors as primary contributors to UEX, further emphasizing the necessity for physical preventive measures (eg, optimization of restraint devices) and sustained bedside monitoring. There remains an urgent need for randomized controlled trials to objectively evaluate the preventive efficacy of dedicated nurse-led real-time bedside surveillance on UEX reduction.

# Systemic Deficiencies in Clinical Protocols Contributing to UEX

This study identified procedural deviations in medical or nursing operations as causative factors in 30.8% (n=4) of UEX incidents. Detailed root cause analysis revealed three cases of urinary catheter dislodgement attributable to balloon inflation errors (two instances involved insufficient air volume). Standard balloon inflation volume for urinary catheters is 5 - 10 mL; however, pediatric patients require weight-based adjustment (0.5 - 1 mL/kg, with a maximum volume not exceeding 10 mL) [31]. One case exhibited complete omission of balloon inflation. Additionally, one wound drainage tube displacement resulted from combined mechanical failures— loose fixation sutures

and inadequate adhesive securement—culminating in device migration during patient ambulation.

These incidents underscore the cascading risks posed by protocol nonadherence, particularly when compounded by gaps in nursing supervision and intershift communication. The absence of standardized verification checklists during shift transitions may perpetuate latent systemic errors, ultimately compromising pediatric catheter safety. To mitigate these risks, we recommend the implementation of double-signature catheter integrity checks during shift handovers, mandatory simulation training on device-specific securement protocols (eg, ENFit compliant enteral tubes) [32].

Our analysis revealed distinct patterns in fixation efficacy: 61.5% (8/13) of UEX cases involved single-anchor fixation using hypoallergenic paper tape with an  $\Omega$ -shaped cutaneous application, while 38.5% (5/13) employed multimodal securement combining tape fixation with supplemental measures (elastic bandage reinforcement or surgical suturing). The  $\Omega$ technique's biomechanical advantage lies in its motion-adaptive design—dual tape placements at strategic anatomical sites compensate for pediatric patients' unpredictable movement ranges, thereby enhancing device stability.

A paradoxical pattern emerged regarding adhesive maintenance frequency. High-frequency replacement (<24 hours) was associated with 84.6% (n=11) of UEX incidents, whereas standard replacement ( $\geq$ 24 hours) was observed with only 15.4% (n=2) patients.

This counterintuitive relationship underscores that fixation reliability depends not merely on replacement intervals but crucially on postreplacement adhesive integrity. The probability of UEX detachment increases by 30% (9/30) when using tape to fix it improperly [33].

The interplay between securement methodology and material performance is further evidenced by 65% of fixation-related displacements attributable to suboptimal device-skin interface management [21]. Adopting multiple methods led to greater reduction in UEX rates than those using a single measure [34].

# **Controversies in Physical Restraint Utilization for UEX Prevention**

Our data revealed a 76.9% UEX incidence rate among unrestrained pediatric patients, suggesting potential protective effects of restraint implementation. This finding aligns with the outcomes of a prospective cohort study, suggesting that standardized limb restraint protocols, when properly implemented, demonstrate significant clinical value in preventing critical safety incidents including UEX and inpatient falls among high-risk populations [35]. However, international studies indicate that physical restraints are applied in 47-67% of unplanned extubation cases; however, there remains ongoing debate regarding their efficacy in preventing such incidents [36]. Current evidence suggests that restraint protocols should be dynamically adjusted based on the patient's actual clinical status, with timely and appropriate application guided by specific behavioral manifestations such as calm or agitated states [37].

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Current systematic reviews conclude insufficient evidence (grade certainty: low) to support universal restraint protocols. Our findings underscore the necessity for (1) dynamic risk stratification: differentiating restraint indications between sedated (RASS –2 to 0) and agitated (RASS +1 to +3) states and (2) alternative strategies: implementing sensor-embedded alarms or distraction therapies as restraint-sparing interventions.

The absence of high-quality randomized controlled trials comparing restraint-based versus restraint-free protocols in pediatric surgical populations remains a critical knowledge gap requiring urgent investigation.

#### **Sedative Utilization Paradigm**

This investigation employed a nonpharmacological approach to catheter management, deliberately excluding sedatives or adjuvant pharmacological agents from pediatric care protocols. Current evidence remains inconclusive regarding the prophylactic efficacy of sedation in preventing UEX, as no controlled comparative trials have established definitive causal relationships. Nevertheless, observational data from a cohort of 43 patients revealed substantial divergence in UEX incidence between nonsedated (21/43, 49%) patients and appropriately sedated groups (10/43, 23%) [38]. However, relevant studies [6] have found that among the 41 pediatric cases studied, the incidence of unplanned extubation (UEX) was 51.2% in patients without sedative use, while the rate decreased to 24.4% in those with appropriate sedation. Inadequate or absent sedation has been identified as a primary risk factor for UEX [. This underscores the imperative for protocol-driven sedation titration, ideally maintaining RASS scores between -1 and 0 during invasive device retention periods. For children using sedatives, studies have shown that the proper and adequate use of sedatives can reduce unplanned UEX events [38].[ This study did not include data on sedative use and therefore does not elaborate on the relationship between sedative use and UEX in children.

# Implementing Nursing Strategies to Reduce UEX Incidence

# High-Risk Population Management

According to the findings of this study, infants and young children are identified as a high-risk group for UEX due to physiological factors such as their lively and active nature, lack of self-protection awareness, increased nasal and oral secretions, and susceptibility to sweating. To mitigate these risks, a tiered monitoring protocol, enhanced surveillance system was implemented. A structured rounding protocol mandated 15-minute interval checks during high-risk circadian phases (6 AM-10 PM), documented through standardized bedside monitoring protocols. Each assessment encompassed neurological status (AVPU scale scoring as shown in Multimedia Appendix 3), vital sign stability (HR variability <15%), catheter integrity metrics (migration distance <2cm; securement device adhesion >80% per Infusion therapy standards of practice [39], particularly when the childrens' condition is unstable or they exhibit restlessness. Additionally, bedside safety measures should be implemented. Nursing staff should assist and guide parents in caring for the endotracheal tube, emphasizing key points such as the purpose and

significance of catheter retention. Caregivers should be educated on avoiding tube kinking, bending, compression, or dragging. For children with blood–containing drainage, gentle squeezing of the drainage tube every hour, from top to bottom, is advised to prevent the coagulation of blood in the drainage fluid. Furthermore, the drainage bag or negative pressure drainage device should be positioned below the drainage site to prevent fluid reflux, which could lead to infection or impaired drainage.

#### Neurological Assessment Protocol

Precise evaluation of consciousness levels constitutes the cornerstone of pediatric critical care, requiring differentiation across six distinct neurological states: alertness, somnolence, obtundation, stupor, coma, and encephalopathic presentations (confusion or delirium). Validated pediatric-specific assessment instruments should be systematically implemented as follows:

- Pediatric GCS [40]: (1) ocular response: scored E1-E4 (no eye opening to spontaneous tracking); (2) verbal response: graded V1-V5 (no vocalization to oriented speech); and (3) motor response: ranked M1-M6 (no movement to purposeful obedience). The use of trained nurses for outcome assessment improved the reliability of the results [36].
- Confusion Assessment Method for ICU (CAM-ICU): Implementation of these standardized tools reduces diagnostic errors by 42% (OR=0.57, 95% CI 0.50 - 0.65) compared to subjective clinical judgment alone [41]. Documentation should be aligned to the AVPU (Alert-Voice-Pain-Unresponsive) framework for rapid deterioration detection.

#### **Prophylactic Catheter Management Protocol**

This study indicates that infants and young children constitute a high-risk group for unplanned extubation in pediatric populations due to physiological predispositions, including heightened activity levels, underdeveloped self-protection awareness, excessive oral/nasal secretions, and increased perspiration tendencies. Therefore, implementing optimized nursing protocols such as rotational fixation is recommended[42], which has demonstrated both significant reductions in unplanned extubation rates and superior outcomes in skin integrity assessment scores.

Selecting comfortable positions for the patient, proper tube fixation locations and methods, and minimizing stimulation from tube foreign bodies during routine care are essential. Sudden changes in position should be avoided to prevent UEX.

The observed temporal clustering of UEX incidents—peaking during holiday periods (n=9, 69.2%) and early morning hours (n=4, 30.7%)—suggests critical intersections between nursing resource allocation and caregiver behavioral patterns. Holiday–associated risks likely stem from reduced staffing ratios compounded by familial visitation surges, creating surveillance gaps. Morning vulnerability windows (6 AM-8 PM) may reflect attentional diversion as caregivers prioritize hygiene and nutrition tasks over device monitoring, particularly during post-anesthesia recovery phases when pediatric agitation peaks.

The relationship between quantitative disease severity scoring and nursing levels has been further clarified, providing a scientific and objective basis for clinical condition assessment. This ultimately ensures alignment between disease severity and corresponding care intensity. Recommendations include shortening ward round intervals to 30 minutes during high-risk periods and reinforcing catheter fixation protocols for the second-day care [43].

The current lack of consensus-based guidelines regarding the influence of nurse staffing parameters on adverse nursing outcomes reflects the multifactorial determinants of clinical practice, including nurses' clinical experience, professional competency, educational background, patient acuity levels, and interdepartmental variations. Given these complexities, these confounding variables were deliberately controlled for in the methodological design of this investigation.

#### Strategic Staffing Allocation for UEX Risk Mitigation

The current evidence base fails to demonstrate a definitive linear correlation between hospital nursing workforce configurations and measurable patient safety outcomes. Methodological limitations in evidence appraisal reveal that the incorporation of specialized nursing personnel shows no statistically significant variation in patient mortality rates (P>0.05), notwithstanding these organizational interventions.

These findings collectively establish a dose-response relationship between nursing workforce density and device safety outcomes. High-acuity units demand proactive strategies including (1) implementation of dynamic staffing models that adjust real-time to patient deterioration alerts; (2) mandatory competency training on pediatric-specific restraint protocols and agitation recognition; and (3) structured family education programs using visual aids and multilingual resources to bridge health literacy gaps.

For caregivers with limited medical comprehension, iterative reinforcement through nurse-led daily demonstrations (eg, proper limb positioning during diaper changes) proves more effective than conventional verbal instructions alone.

# **Optimizing Adhesive Management for Enhanced Catheter Securement**

The efficacy of tape fixation extends beyond replacement frequency, critically depending on sustained adhesive integrity. For pediatric patients with hyperhidrosis or cutaneous sensitivity, preapplication skin preparation using chlorhexidine-impregnated wipes significantly improves tape adherence. Applying reinforced adhesive tape within 24 hours or combining with skin barrier products can synergistically enhance the securing effect of medical tape.

This evidence underscores a dual management imperative: (1) proactive maintenance by implementing circadian-aligned replacement schedules to prevent adhesive degradation during

high-risk nocturnal agitation periods and (2) contextual adaptation by using sweat-resistant hydrocolloid tapes for tropical climates or febrile patients, coupled with twice-daily skin integrity assessments.

Thus, competency-based training modules emphasizing  $45^{\circ}$  angle tape placement and tension-free smoothing should be mandated as part of nursing credentialing programs.

#### **Restraint Use in UEX Prevention**

While international guidelines caution against routine restraint use due to ethical and complication concerns, our data advocate for selective immobilization protocols targeting high-risk subgroups: (1) developmental vulnerability: infants or toddlers with immature impulse control ( $\leq 3$  years: n=8, 61.6% of patients) and (2) pharmacological profile: nonsedated patients exhibiting RASS  $\geq$ +2 agitation scores (44.8% of incidents).

When implementing restraints, a structured safety bundle should be mandated: (1) time-limited application with 4-hour intervals with documented neurovascular assessments, and (2) positional rotation to minimize pressure points through scheduled lateral or prone positioning.

#### Summary

Unplanned extubation serves as a sentinel event reflecting systemic vulnerabilities in pediatric airway safety and nursing care quality. The multifactorial etiology of UEX—encompassing developmental vulnerability, iatrogenic procedural gaps, and preventive strategy limitations—necessitates multidimensional interventions tailored to individual risk profiles. Such an approach not only reduces immediate mechanical failures but also addresses the cognitive-behavioral determinants of device interference, particularly in high-risk subgroups such as nonsedated toddlers (RASS  $\geq$ +2) with restricted comprehension capacity.

# **Study Limitations**

This exploratory analysis has several methodological constraints. The exclusion criteria focusing on psychiatric comorbidities failed to account for potential confounders like neurodevelopmental disorders or atopic predisposition, potentially introducing selection bias. With only 13 (76.9%) male participants, the small sample size limits generalizability and risks overestimating UEX susceptibility in infants (61.6%) while obscuring school-age children's risk profiles. As a single-center retrospective review lacking control groups, this study could not establish causal relationships between nursing strategies and outcomes. Furthermore, inherent documentation gaps in medical records-particularly regarding pre-extubation activities and caregiver interactions-constrain operational insights for protocol optimization. Future prospective studies should incorporate standardized video monitoring and validated parental compliance assessments to strengthen evidence-based recommendations.

# **Conflicts of Interest**

None declared.



Ethical review and approval form for scientific research projects [PDF File, 137 KB - nursing\_v8i1e71307\_app1.pdf]

#### Multimedia Appendix 2

Comparison of our study cohort with study by Ma et al [8] [DOCX File, 11 KB - <u>nursing\_v8i1e71307\_app2.docx</u>]

Multimedia Appendix 3

AVPU (Alert-Voice-Pain-Unresponsive) scoring system [DOCX File, 11 KB - nursing v8i1e71307 app3.docx]

#### References

- 1. Chang LY, Wang KWK, Chao YF. Influence of physical restraint on unplanned extubation of adult intensive care patients: a case-control study. Am J Crit Care 2008 Sep;17(5):408-415. [doi: <u>10.4037/ajcc2008.17.5.408</u>] [Medline: <u>18775996</u>]
- 2. Yunyun L. Research progress on high-risk factors and prevention of unplanned extubation in patients with entracheal intubation. Nursing Management in China 2016;16(1):28-30 [FREE Full text]
- 3. de Groot RI, Dekkers OM, Herold IH, de Jonge E, Arbous MS. Risk factors and outcomes after unplanned extubations on the ICU: a case-control study. Crit Care 2011;15(1):R19. [doi: 10.1186/cc9964] [Medline: 21232123]
- 4. Yuan X, Zhu L, Xu H, et al. Effect of quality control circle activities on reducing the unplanned extubation rate of indwelling gastric tubes in pediatric general surgery. Contemporary Nurses (First Half of the Month) 2020;27(8):187-189. [doi: 10.19791/j.cnki.1006-6411.2020.22.084]
- Perry T, Klugman D, Schumacher K, et al. Unplanned extubation during pediatric cardiac intensive care: U.S. multicenter registry study of prevalence and outcomes. Pediatr Crit Care Med 2023 Jul 1;24(7):551-562. [doi: 10.1097/PCC.00000000003235] [Medline: <u>37070818</u>]
- 6. Guan YM, Lou JH. Analysis of unplanned extubation events in critically ill children. Nurs Res 2011;25(2C):548-549. [doi: 10.3969/j.issn.1009-6493.2011.06.040]
- 7. Sadowski R, Dechert RE, Bandy KP, et al. Continuous quality improvement: reducing unplanned extubations in a pediatric intensive care unit. Pediatrics 2004 Sep;114(3):628-632. [doi: 10.1542/peds.2003-0735-L] [Medline: 15342831]
- 8. Ma HF. Risk factor analysis for unplanned extubation in pediatric intensive care units and construction of a risk assessment table [Chinese]. Wanfang Data.: Qingdao University; 2018. URL: <u>https://d.wanfangdata.com.cn/thesis/</u> ChhUaGVzaXNOZXdTMjAyNDA5MjAxNTE3MjUSCUQwMTUzNzIzNhoINmJ6MzZzYTc%3D
- 9. Nursing Center of Hospital Management Research Institute of National Health and Family Planning Commission, Nursing Quality Indicator Research and Development Group. Practical Manual for Nursing Sensitive Quality Indicators: People's Health Press; 2016.
- Chung CY, Chen CL, Cheng PT, See LC, Tang SFT, Wong AMK. Critical score of Glasgow Coma Scale for pediatric traumatic brain injury. Pediatr Neurol 2006 May;34(5):379-387. [doi: <u>10.1016/j.pediatrneurol.2005.10.012</u>] [Medline: <u>16647999</u>]
- 11. Lu ZH, Wang Y, Guo XB, et al. Research progress on risk factors and safety management strategies for unplanned extubation in hospitalized children. J Nurs Manag 2021:21-24 [FREE Full text]
- 12. Shao YD, Zhu JH, Lin YQ. Application of confusion assessment method in early assessment and intervention of ICU delirium. Journal of Nurse Training 2017;32(5):441-444. [doi: <u>10.16821/j.cnki.hsjx.2017.05.018</u>]
- 13. Zhu MM, Liu F, Wang R. Research progress on the application of agitation-sedation scores in critically ill patients. Chinese Journal of Nursing 2018;53(2):247-250 [FREE Full text]
- 14. Piaget J. The Origins of Intelligence in Children, 2nd edition: International Universities Press; 1952. [doi: 10.1037/11494-000]
- Christov-Moore L, Simpson EA, Coudé G, Grigaityte K, Iacoboni M, Ferrari PF. Empathy: gender effects in brain and behavior. Neurosci Biobehav Rev 2014 Oct;46 Pt 4(Pt 4):604-627. [doi: <u>10.1016/j.neubiorev.2014.09.001</u>] [Medline: <u>25236781</u>]
- 16. Holly C, Porter S, Echevarria M, Dreker M, Ruzehaji S. CE: Original Research: recognizing delirium in hospitalized children: a systematic review of the evidence on risk factors and characteristics. Am J Nurs 2018 Apr;118(4):24-36. [doi: 10.1097/01.NAJ.0000532069.55339.f9] [Medline: 29543606]
- 17. Patel AK, Bell MJ, Traube C. Delirium in pediatric critical care. Pediatr Clin North Am 2017 Oct;64(5):1117-1132. [doi: 10.1016/j.pcl.2017.06.009] [Medline: 28941539]
- Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. The Lancet 1974 Jul;304(7872):81-84. [doi: 10.1016/S0140-6736(74)91639-0]
- Slonim AD, See H. What is in a laboratory test? A new approach to thinking about improving care. Pediatr Crit Care Med 2021 Feb 1;22(2):217-218. [doi: <u>10.1097/PCC.0000000002643</u>] [Medline: <u>33528197</u>]

https://nursing.jmir.org/2025/1/e71307

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- Ely EW, Inouye SK, Bernard GR, et al. Delirium in mechanically ventilated patients: validity and reliability of the confusion assessment method for the intensive care unit (CAM-ICU). JAMA 2001 Dec 5;286(21):2703-2710. [doi: 10.1001/jama.286.21.2703] [Medline: 11730446]
- Chen TJ, Chung YW, Chang HCR, et al. Diagnostic accuracy of the CAM-ICU and ICDSC in detecting intensive care unit delirium: a bivariate meta-analysis. Int J Nurs Stud 2021 Jan;113:103782. [doi: <u>10.1016/j.ijnurstu.2020.103782</u>] [Medline: <u>33120134</u>]
- 22. Sessler CN, Gosnell MS, Grap MJ, et al. The Richmond Agitation-Sedation Scale: validity and reliability in adult intensive care unit patients. Am J Respir Crit Care Med 2002 Nov 15;166(10):1338-1344. [doi: 10.1164/rccm.2107138] [Medline: 12421743]
- 23. Rollnik JD, Adolphsen J, Bauer J, et al. Prolonged weaning during early neurological and neurosurgical rehabilitation: S2k guideline published by the Weaning Committee of the German Neurorehabilitation Society (DGNR. Nervenarzt 2017 Jun;88(6):652-674. [doi: 10.1007/s00115-017-0332-0] [Medline: 28484823]
- 24. Zhang L, Liu S, Wang S, Zhou JX, National Center for Healthcare Quality Management in Neurological Diseases; Chinese Society of Critical Care Medicine; Working group of the Expert Consensus on Sedation and Analgesia for Neurocritical Care Patients. Chinese expert consensus on sedation and analgesia for neurocritical care patients. Chin Med J (Engl) 2024 Jun 5;137(11):1261-1263. [doi: 10.1097/CM9.0000000000003084] [Medline: 38644783]
- 25. Barr J, Fraser GL, Puntillo K, et al. Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit. Crit Care Med 2013 Jan;41(1):263-306. [doi: <u>10.1097/CCM.0b013e3182783b72</u>] [Medline: <u>23269131</u>]
- 26. Wu J, Liu Z, Shen D, et al. Prevention of unplanned endotracheal extubation in intensive care unit: an overview of systematic reviews. Nurs Open 2023 Feb;10(2):392-403. [doi: 10.1002/nop2.1317] [Medline: 35971250]
- Fan L, Liu Q, Gui L. Efficacy of nonswallow nasogastric tube intubation: a randomised controlled trial. J Clin Nurs 2016 Nov;11-12(26):1748. [doi: 10.1111/jocn.13764] [Medline: 27218418]
- 28. González-Castro A, Peñasco Y, Blanco C, González-Fernández C, Domínguez MJ, Rodríguez-Borregán JC. Unplanned extubation in ICU, and the relevance of non-dependent patient variables the quality of care. Rev Calid Asist 2014;29(6):334-340. [doi: 10.1016/j.cali.2014.11.005] [Medline: 25534567]
- 29. Neves VC, Locatelli CGR, Ramalho O, et al. Pediatric unplanned extubation risk score: a predictive model for risk assessment. Heart Lung 2023;62:50-56. [doi: 10.1016/j.hrtlng.2023.05.021] [Medline: 37307654]
- 30. Marcin JP, Rutan E, Rapetti PM, Brown JP, Rahnamayi R, Pretzlaff RK. Nurse staffing and unplanned extubation in the pediatric intensive care unit. Pediatr Crit Care Med 2005 May;6(3):254-257. [doi: 10.1097/01.PCC.0000160593.75409.6B]
- 31. Grabe M, Bartoletti R, Johansen TEB, et al. Guidelines on urological infections.: European Association of Urology; 2023. URL: <u>https://uroweb.org/guidelines/urological-infections</u> [accessed 2023-10-15]
- 32. Anderson L. Enteral feeding tubes: an overview of nursing care. Br J Nurs 2019 Jun 27;28(12):748-754. [doi: 10.12968/bjon.2019.28.12.748] [Medline: 31242099]
- 33. Buckley JC, Brown AP, Shin JS, Rogers KM, Hoftman NN. A comparison of the Haider Tube-Guard® endotracheal tube holder versus adhesive tape to determine if this novel device can reduce endotracheal tube movement and prevent unplanned extubation. Anesth Analg 2016 May;122(5):1439-1443. [doi: 10.1213/ANE.000000000001222] [Medline: 26983051]
- Anis A, Patel R, Tanios MA. Analytical review of unplanned extubation in intensive care units and recommendation on multidisciplinary preventive approaches. J Intensive Care Med 2024 Jun;39(6):507-513. [doi: <u>10.1177/08850666231199055</u>] [Medline: <u>37670719</u>]
- 35. Emergency Medicine Group of the Chinese Medical Association Science Branch, Pediatrics Group of the Chinese Medical Association Emergency Medicine Branch, Editorial Committee of the Chinese Journal of Pediatrics. Expert consensus on analgesia and sedation treatment in Chinese children's intensive care units. Chinese Journal of Pediatrics 2024;62(3):196-203 [FREE Full text]
- 36. Enriquez CM, Chisholm KH, Madden LK, et al. Glasgow Coma Scale: generating clinical standards. J Neurosci Nurs 2019 Aug;4(51). [doi: 10.1097/JNN.0000000000460] [Medline: 31058766]
- 37. Moons P, Boriau M, Ferdinande P. Self-extubation risk assessment tool: predictive validity in a real-life setting. Nurs Crit Care 2008;13(6):310-314. [doi: 10.1111/j.1478-5153.2008.00305.x] [Medline: 19128315]
- 38. Curley MAQ, Wypij D, Watson RS, et al. Protocolized sedation vs usual care in pediatric patients mechanically ventilated for acute respiratory failure: a randomized clinical trial. JAMA 2015 Jan 27;313(4):379-389. [doi: 10.1001/jama.2014.18399] [Medline: 25602358]
- 39. Gorski LA, Hadaway L, Hagle ME, et al. Infusion therapy standards of practice, 8th Edition. J Infus Nurs 2021;44(1S Suppl 1):S1-S224. [doi: 10.1097/NAN.0000000000396] [Medline: 33394637]
- 40. Balakrishnan B, VanDongen-Trimmer H, Kim I, et al. GCS-pupil score has a stronger association with mortality and poor functional outcome than GCS alone in pediatric severe traumatic brain injury. Pediatr Neurosurg 2021;56(5):432-439. [doi: 10.1159/000517330] [Medline: 34284393]
- 41. Porter ME. Standardized Clinical Assessment and Management Plans (SCAMPs) reduce diagnostic error in acute care. JAMA Intern Med 2016;176(6):848-850. [doi: 10.1001/jamainternmed.2016.0606]

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- 42. Choi YS, Chae YR. Effects of rotated endotracheal tube fixation method on unplanned extubation, oral mucosa and facial skin integrity in ICU patients. J Korean Acad Nurs 2012 Feb;42(1):116-124. [doi: 10.4040/jkan.2012.42.1.116] [Medline: 22410608]
- 43. Yuerong A. Reasons and management strategies for clinical nurses' inability to conduct timely ward visits. J Clin Ration Drug Use 2012;5(21):134-135. [doi: 10.15887/j.cnki.13-1389/r.2012.21.020]

# Abbreviations

GCS: Glasgow Coma Scale ICU: intensive care unit PICU: pediatric intensive care unit RASS: Richmond Agitation-Sedation Scale UEX: unplanned extubation

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# Effectiveness of Patients' Education and Telenursing Follow-Ups on Self-Care Practices of Patients With Diabetes Mellitus: Cross-Sectional and Quasi-Experimental Study

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# Abstract

**Background:** Information and communications technology can be used in telenursing to facilitate remote service delivery, thereby helping mitigate the general global nursing shortage as well as particular applications (eg, in geographically remote communities). Telenursing can thus bring services closer to end users, offering patient convenience and reduced hospitalization and health system costs, enabling more effective resource allocation.

**Objective:** This study aims to examine the impact of patients' education and telenursing follow-ups on self-care indicators among patients with type I and type II diabetes mellitus (DM).

**Methods:** In phase I, a cross-sectional descriptive analysis was conducted to evaluate the self-care practices of 400 patients with DM at Kafr El Sheikh University Hospital in Egypt. In phase II, a pretest-posttest experiment was applied with a selected group of 100 patients purposively recruited from phase I due to their low self-care practice knowledge to ascertain the impacts of a 4-week intervention delivered via telenursing. They were reminded via telephone follow-up communication of the importance of adhering to recommendations on physical activity, nutritional intake, and the management of blood sugar (ie, insulin). Data collection was undertaken using a structured quantitative questionnaire, encompassing sociodemographic characteristics, medical symptoms and history, and knowledge of DM. Paired *t* test analysis was applied to study pre- and postintervention self-care behaviors.

**Results:** Participants had a mean age of 49.7 (SD 11.5) years. More than one-third received their DM diagnosis over a decade previously (135/400, 33.8%) and were obese (147/400, 36.8%). Almost half (176/400, 44%) received insulin, and the majority had cardiac disease (231/400, 57.7%) and the DM symptom of elevated blood sugar levels while fasting (365/400, 91.3%). A relatively high score of DM knowledge was reported (255/400, 63.7%). Males exhibited significantly lower knowledge levels (102/200, 51%) compared to females (153/200, 76.5%; *P*<.001). The intervention was effective in improving knowledge of DM ( $t_{99}$ =30.7, two-tailed; *P*<.001), self-care practices ( $t_{99}$ =53.7, two-tailed; *P*<.001), and self-care skills ( $t_{99}$ =47, two-tailed; *P*<.001) among patients with DM.

**Conclusions:** The emergent evidence suggests that patients' education and telenursing follow-ups have the potential to improve self-care behavior in patients with DM. The delivery of frequent nursing reinforcement via telenursing enables improved self-management while contemporaneously reducing the need for patients to visit clinical settings (ie, improving patient condition and reducing net health system costs). The outcomes of this research underscore the need to integrate telenursing within conventional care for DM, and more research is needed to longitudinally assay its efficacy and sustainability over the long term and in different clinical and geographical contexts.

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#### **KEYWORDS**

diabetes mellitus; education; knowledge; self-care; telenursing

# Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by elevated blood glucose levels resulting from defects in insulin secretion, insulin action, or both. Insulin is a hormone produced by the pancreas that regulates blood sugar levels and facilitates the uptake of glucose into cells for energy. There are 3 main types of DM (type I DM, type II DM, and gestational DM), each with etiological and pathological characteristics. Type I DM is a condition of the autoimmune system, arising from the lack of functioning beta cells generating insulin. Type II DM is more common and is generally attributable to lifestyle attributes and nutritional factors (eg, sedentary behavior and high sugar consumption), albeit genetic predispositions are also instrumental. Gestational DM occurs during pregnancy and typically resolves after delivery, although it increases the mother's risk of developing type II diabetes later in life.

DM poses a significant threat to the safety of hundreds of millions of people worldwide, with disconcertingly escalating prevalence. It is estimated that 643 million people will be diagnosed by 2030, rising to 783 million by 2045, up from 537 in 2021 [1]. This estimated increase can be associated with global population growth and the rising prevalence of diabetes due to unhealthy lifestyle-related factors and aging populations. The prevalence is significantly higher in certain regions, including the Middle East, where more than 70 million people are currently affected by DM. According to the International Diabetes Federation, Egypt ranks ninth globally for DM prevalence. In early 2020, there were approximately 8.85 million people with DM in the country, representing a prevalence rate of 15.2% [2].

DM entails direct costs in itself, and it also entails secondary costs related to interlinked conditions (which may themselves be causative or reciprocally exacerbated by DM). DM is often associated with complications such as vision impairment and blindness, cardiovascular diseases, and kidney failure and may require foot amputation [3]. In order to mitigate the more serious impacts of the condition and enable patients to have a better quality of life, DM must be managed with a strong autonomous role of patients themselves, including consistent adherence to practices recommended for self-care, such as frequent monitoring of their blood glucose levels, appropriate nutritional intake, recommended levels of physical activity, and medication compliance [3].

While patients tend to be aware of the imperatives associated with such positive behaviors, they commonly struggle to implement them in their daily lives, especially as metabolic disorders and DM itself commonly arise from a knowing lack of compliance with positive behaviors (ie, the general public typically knows that eating large amounts of processed sugar and having a sedentary lifestyle will predispose them to DM, yet they continue to indulge in such behaviors, leading to or exacerbating diabetes) [3]. In low-income countries, research

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has consistently shown that a large proportion of patients with DM typically adhere to negative self-care, essentially manifesting poor control of their glycemic index and a commensurately elevated propensity toward serious resultant issues [4,5].

The accelerating development and adoption of many useful technological solutions in health care services over the last 2 decades have led to greatly expanded opportunities for the more effective management of chronic illness, including DM. Telenursing, which is defined as the use of technological channels (eg, telephone or video calls) to provide nursing services to individuals in remote locations, has offered ways in which to reduce the distance between health care services and patients, as well as reducing the need for some patients to attend traditional care venues (thereby reducing pressure on limited resources) [6]. Its obvious advantages include increasing health providers' interaction with service users, including for symptoms monitoring and educating service users without expensive and burdensome face-to-face clinical appointments.

Telenursing fundamentally increases the ability of health care professionals to deliver services remotely, which has obvious implications for more frequent monitoring of patient symptoms and escalating interventions where appropriate, with personalized assistance for service users in the comfort of their homes and everyday lives [7]. As DM management is particularly sensitive to general lifestyle factors, the telenursing paradigm can be particularly useful to extend the reach of health care providers to give patients with DM additional support and encouragement in their daily lives, especially with engagement for reminders and follow-up on particular issues [7].

It should be noted that telenursing benefits encompass important clinical outcomes in addition to practice expedience in communication; the more frequent and direct communication engendered by telenursing formats enables increased patient adherence to medication, self-care, and other outcomes, which intrinsically comprises improved quality of care and contributes to optimized patient prognosis [8]. A systematic review found that telenursed patients displayed statistically significant enhancement in their glycemic control, with 0.5% reduced HbA<sub>1c</sub> (glycated hemoglobin  $A_{1c}$ ) levels over half a year, alongside decreased BMI in some studies that effectively leveraged "combined" interventions [9].

Additionally, telenursing mitigates the burden placed on health services by obviating in-person (face-to-face) attendance at traditional care delivery venues, which is especially valuable in resource-constrained contexts, such as low-income countries or remote geographical regions [10]. In areas suffering from a dearth of conventional health care resources, telenursing offers essential care delivery channels for patients with DM, preventing the escalation of patients' conditions and reducing net health care costs (eg, timely telenursing interventions can reduce the need for hospital admission) [11].

Among the particular services that can be enhanced by telenursing, limited research has explored its potential to play a role in improving DM patients' capacity to undertake self-care practices. It appears to offer notable advantages, but differing results have been found in practice, with some studies reporting tangible positive outcomes, and others identifying substantive barriers in terms of technological issues and the stakeholder engagement, which can hamper the long-term sustainability of telenursing services [8]. A recent narrative review of 18 randomized controlled trials (RCTs) and 5 quasi-experimental studies worldwide concerning telenursing for DM care reported that a telenursing intervention of weekly telenursing contact over 3 months achieved no significant influence on BMI or weight loss, while a 6-month telenursing program attained no significant differences in either BMI or HbA<sub>1c</sub> [8]. A systematic review of adherence to medication regimens among patients with DM found that there was no study that had reported consistent improvement due to telenursing [12]. Such negative findings are contrary to expectations, given the potential promise of telenursing; thus, further studies are needed to ascertain telenursing impacts on self-care practices among patients with DM in numerous different and varied health care settings.

This study seeks to fill this research gap by ascertaining the impacts of patients' education and telenursing follow-ups on self-care practices among patients with DM at an Egyptian tertiary hospital. Using a single-group pretest-posttest design and cross-sectional analytical approaches, this research sought to evidence telenursing's scope to enhance self-care practices, thereby improving the quality of care and outcomes for patients with DM. The outcomes can guide practice in clinical contexts and advance emerging studies on digital health solutions for the management of chronic diseases, especially DM. The insights gained from this research are particularly important in considering the intervention impacts to improve self-care practices among patients with DM, especially for contexts where conventional care is limited or hard to access.

# Methods

# **Study Design**

This 2-phase study encompassed a cross-sectional assessment of self-care (phase I) and a single-group quasi-experimental pretest-posttest design to assess the impacts of telenursing education on patients' knowledge, skills, and self-care (phase II).

#### **Study Setting**

The research setting was the outpatient clinic for diabetes care at Kafr El Sheikh University Hospital. This is the main diabetes care hub for the whole governorate. The sessions for patient education were delivered in specially allocated locations within the clinic, and the phase II follow-up interventions were delivered remotely using WhatsApp or SMS text messages.

#### Sampling

#### **Inclusion Criteria**

To be eligible for the study, participants had to (1) be adult patients with a diagnosis of DM for at least 1 year, (2) be aged

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between 18 and 65 years, (3) have access to and the ability to use a smartphone, (4) have  $HbA_{1c}$  level greater than 7, and (5) express interest in and willingness to participate in the study's interventions. Patients were excluded if they had psychological illnesses, speech or hearing impairments, or failed to respond to mobile phone contact for 2 weeks.

#### Sample Size and Sampling Technique

For phase I, clinical records for outpatients during 2020 were analyzed. The outpatient clinic records for the year 2020 were reviewed to determine the patient population. Using the Roasoft calculation program with a 50% response rate, a 95% CI, and a 5% margin of error, the required sample size was calculated to be 384. In order to attain more robust data, we purposively selected 400 eligible patients who met the inclusion criteria (above), comprising 200 males and 200 females.

The preliminary analysis of the data collected in phase I showed that 255 (63.7%) of 400 patients were categorized as having poor knowledge and poor self-care practice. Based on the inclusion criteria, a purposive sample of 100 patients was selected for phase II, focusing specifically on those with the lowest scores in both knowledge and self-care practices, as they were identified as the patients most in need of educational intervention.

#### **Data Collection Tools**

#### Sociodemographic and Medical Data Questionnaire

This tool gathered data on sociodemographic features such as age, educational level, and marriage status, and clinical attributes such as time since diabetes diagnosis, presence and type of comorbidities, fasting blood glucose levels, and BMI.

# Knowledge Assessment Questionnaire

Participants' knowledge about DM (hereinafter "knowledge") was gathered using 23 open-ended questions divided into 8 categories: basic knowledge about diabetes and its complications (10 questions), treatment regimens (3 questions), physical exercise (2 questions), the importance of follow-up visits (2 questions), dietary patterns (2 questions), foot care (2 questions), bad habits that worsen the disease (1 question), and sources of knowledge (1 question). Responses were scored using a system where correct and complete answers received 5 marks, correct but incomplete answers received 4 marks, incomplete answers received 3 marks, incorrect answers received 2 marks, and answers of "don't know" received 1 mark. Each subsection score was averaged, with total knowledge scores ranging from 23 to 115 marks. Scores were then classified into poor knowledge (less than 60%, ≤69 marks) and fair knowledge (60% or more,  $\geq 70$  marks).

# Self-Care Practices Questionnaire

This questionnaire focused on self-care practices among patients with DM and covered 43 different practices, which were categorized into 6 areas: nutritional practices and adherence to the DM dietary regimen (12 practices), practices related to medication regimen (5 practices), practices related to glucose monitoring (6 practices), practices related to physical activity (8 practices), practices to avoid complications (6 practices), and

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practices related to foot care (6 practices). The self-care practices were assessed using a 3-point Likert scale, where responses were rated as "always" (2 marks), "sometimes" (1 mark), and "rarely" (0 marks). Scores for each subsection were summed, and the total scores were classified into 3 categories: poor practices (less than 60%), fair practices (60% to <75%), and good practices (75% or more).

# Self-Care Skills Checklist

The researchers used the self-care skills checklist in phase II to evaluate participants' practical self-care skills through direct observation. This assessment focused on 3 key tasks: preparing and injecting insulin (comprising 9 and 7 steps, respectively) and testing glucose levels in urine (9 steps). Conducting direct observations and assessments postintervention enhanced objectivity, providing a more reliable evaluation compared to patients' subjective self-ratings. The checklist used a 3-point scoring system for each step: 3 points for correctly performed steps, 2 points for incorrectly performed steps, and 1 point for steps not performed. Subtotal scores for each skill were calculated, and participants' performance was categorized as either satisfactory ( $\geq$ 60%) or unsatisfactory (<60%) based on the total score for each individual skill and the overall score.

# Language of Data Collection Tools

Questionnaires in this study were used to accommodate the linguistic and practical needs of the participants and researchers. All questionnaires, except the self-care skills checklist, were in Arabic to ensure clear and effective communication with the study participants, who are native Arabic speakers. Delivering the questionnaire in their native language facilitated accurate comprehension of the questions and reliable responses, minimizing the risk of misinterpretation. The self-care skills checklist was in English, as it was designed for and completed by the researchers, all of whom possess a high level of Using English proficiency in English. for the researcher-administered questionnaire allowed for precision in recording and interpreting data while maintaining consistency

with standard scientific and academic conventions. This dual-language approach ensured that both participants and researchers could engage effectively with the study materials, optimizing the validity and reliability of the data collected.

# Piloting and Validation

The developed tools were validated by a panel of experts from the Faculty of Nursing at Kafr El-Shiekh University. The panel consisted of 5 experts: 2 professors of medical-surgical nursing, 1 professor of medicine from the Faculty of Medicine, 1 assistant professor, and 1 lecturer of medical-surgical nursing from the Faculty of Nursing. The tool underwent both face and content validity assessments. The content validity focused on evaluating the clarity, appropriateness, applicability, wording, and comprehensiveness of the tool. To assess the internal consistency of the tool, the Cronbach  $\alpha$  test was used. The results showed a Cronbach  $\alpha$  of 0.78 for the knowledge assessment questionnaire, 0.8 for the reported self-care practice scale, and 0.88 for the diabetic self-care practice checklist. The same group of experts also validated the scientific content of the educational program.

After incorporating the experts' recommendations, the questionnaire was pilot tested. The pilot study was conducted over 3 weeks and included 10% (40/400) of the sample size (40 patients with DM in phase I and 10 patients in phase II). The purpose of the pilot study was to evaluate the clarity, applicability, and comprehensiveness of the tools and to assess the feasibility of the study process. Based on the findings from the pilot study, necessary modifications were made, such as the omission or addition of certain questions, to enhance the content, improve simplicity and clarity, and ensure the tools were concise and focused. The patients who participated in the pilot study were excluded from the main study sample.

# Data Collection Process

Data collection spanned approximately 6 months, from January 2022 to the end of June 2022, and consisted of 2 phases as shown in Figure 1.





# Phase I

The researchers first visited the diabetic clinic to discuss the research objectives and methods with nursing leaders. During this visit, they coordinated meetings with potential participants and identified private spaces for conducting interviews and delivering the initial intervention sessions. A sample of 400 patients with DM, meeting the previously described inclusion criteria, was selected to explore their knowledge of DM and self-care practices. Potential participants were informed about the study's purpose and invited to participate if they were interested in receiving the intervention. Data collection took place for those who agreed to participate, with each interview lasting between 15 and 30 minutes (approximately 10 - 14 participants were interviewed per day, one-on-one).

Participants were grouped according to their outpatient appointments, and the educational intervention sessions were conducted in groups ranging from 10 to 15 members. Sessions were held daily, excluding Fridays, with each session lasting 30 - 40 minutes. Each session began with a welcome and icebreaker, followed by an explanation of the session's objectives and topics, and concluded with a recap and time for participants to ask questions. The sessions ended with an open discussion, allowing participants to address any clarifications, and handouts related to the content were distributed for participants to read at their convenience.

#### Phase II

As mentioned earlier, a purposive sample of a hundred patients from phase I was selected to undergo phase II. Participants underwent telenursing reinforcement of the educational intervention content from phase I via calls, SMS text messages, WhatsApp messages, videos, and voice notes. This was undertaken over 4 weeks (details of this intervention are provided in the following section). One month after the telenursing reinforcement, a posttest assessment was carried out at the outpatient clinic in Kafr Elshiekh Hospital. During this assessment, patients were interviewed to evaluate their knowledge, reported self-care practices, and self-care skills.

#### Intervention

#### Intervention Design

The intervention in this study was developed by the researchers, all of whom were diabetes nursing specialists, to enable patients with DM to enhance their self-care practices in response to the needs of patients. The intervention included educational sessions and telenursing follow-ups as described below.

#### **Educational Sessions**

The researchers delivered 6 educational sessions to the 400 participants in phase I at Kafr El Sheikh University Hospital's outpatient diabetes clinic. The educational sessions were held daily, excluding Fridays, with each session lasting 30 - 40 minutes. The educational sessions involved 3 theoretical and 3 practical sessions on diabetes. Specifically, the theoretical sessions covered essential topics such as basic knowledge of DM and its management (including medical treatment, physical exercise, dietary management, foot care, follow-up, and lifestyle habits that exacerbate the disease). The practical sessions focused on promoting healthy lifestyles (eg, dietary practices and physical exercises) and self-care practices (eg, insulin preparation and injection, glucose testing in urine, blood glucose monitoring, medication schedules, prevention of complications, and foot care practices).

To reinforce the learning experience, the educational content was compiled into a booklet distributed to participants after the sessions, serving as a reference for the information provided. A variety of pedagogical methods were used during the sessions, including practical demonstrations, abstract lectures, group discussions, and role-playing activities. These diverse teaching styles were designed to accommodate different learning preferences and build participants' confidence and adherence to the intervention. Additionally, visual aids such as images, physical models, and PowerPoint presentations were used to enhance understanding and engagement throughout the sessions.

# **Telenursing Follow-Up**

During phase II, 100 participants were purposively selected for a 4-week telenursing follow-up. This intervention aimed to reinforce the educational content provided in phase I and support patients in adopting effective self-care practices. The follow-up schedule included daily 10 - 15-minute calls in the first week, twice-weekly calls in the second week, and weekly calls in the final 2 weeks. These personalized interactions focused on revisiting the educational material and addressing any questions or challenges faced by the participants.

During the follow-up period, participants received daily health education through various channels, including SMS text messages, WhatsApp messages, voice notes, and videos, all of which reiterated the information provided in the educational booklet. To further encourage adherence to self-care practices, daily reminders and audio recordings were sent to prompt actions such as blood glucose self-assessment, medication compliance, foot care, physical activity, and following the recommended diet plan. The content of the telenursing follow-up was meticulously developed by the researchers, drawing on insights from phase I, evidence-based diabetes self-care guidelines, and input from diabetes nursing specialists and clinical researchers. This ensured the content was accurate, culturally relevant, and aligned with the specific needs of the participants.

# **Statistical Analysis**

Data collection, coding, and analysis were undertaken using SPSS (version 20, IBM Inc). Mean and SD values were used

to report continuous data (with independent sample *t* testing to compare group differences) and frequency and percentage values for categorical data (with chi-square and Fisher exact probability tests to determine intervariable relationships). Pretest-posttest differences were determined using paired sample *t* tests and the McNemar test, indicating binary categorical variables' changes following the intervention. The robustness of the contingency table analyses was assured using Monte Carlo simulations. The application of these methods of statistical analysis affirmed cross-comparison results' reliability and mitigated risks of erroneously rejecting null hypotheses, as presented in the following section. After adjustments, a *P* value of  $\leq$ .05 was assumed to indicate statistical significance.

#### **Ethical Considerations**

Kafr El Sheikh University granted ethical approval for this study (KFIRB200-9). Studied patients gave verbal consent to taking part after full disclosure of the nature and scope of the research and their rights, including their ability to decline to take part or to subsequently withdraw without any consequences for their health care services or statutory rights. They were assured of their right to confidentiality, and that all data are reported anonymously in this study, with coding. All participants were informed that the data related to their participation would only be used for the current research purpose as per ethical guidelines for participant protection.

# Results

# **Overall Findings**

As described in the following subsections, significant shortcomings were discovered in participants' knowledge and skills at baseline, especially for female patients. The results after the intervention revealed significant enhancements in self-care practice and knowledge scores (P<.001). All of the patients were able to ascend from "unsatisfactory" to "satisfactory" scores in relation to skills for DM self-care, underscoring the efficacy of the intervention in enabling patients to achieve improved self-management of DM.

# **Sociodemographic Characteristics**

The total studied sample comprised 400 people with DM, who had a mean age of 49.7 (SD 11.5) years. As shown in Table 1, the largest cohort (143/400, 35.7%) was aged 55 - 65 years, while over a fifth (86/400, 21.5%) each were aged 35 - 44 and 45 - 54 years. The vast majority of patients resided in family residences (399/400, 99.7%) and were married (325/400, 81.3%). A large minority (149/400, 37.2%) reported being illiterate, while almost a third (130/400, 32.5%) cited secondary school as their highest educational level and a negligible proportion (12/400, 3%) reported being university-educated. Females were significantly more likely to be illiterate (108/200, 54%) than males (41/200, 20.5%; P<.001). Furthermore, a negligible proportion (1/200, 0.5%) of male participants were unemployed, while none of the female participants were employed.



Table . Participants' sociodemographic characteristics.

Variables	Male (n=200)	Female (n=200)	Total (N=400)	$\chi^{2 a}$	<i>P</i> value
Age (years), n (%)				4.6	<.001
29 - 34	42 (21)	16 (8)	58 (14.5)		
35 - 44	41 (20.5)	45 (22.5)	86 (21.5)		
45 - 54	40 (20)	46 (23)	86 (21.5)		
55 - 64	69 (34.5)	74 (37)	143 (35.7)		
65 - 72	8 (4)	19 (9.5)	27 (6.8)		
Mean (SD)	47.1 (11.4)	52.3 (11.1)	49.7 (11.5)		
Marital status, n (%)				9.2	.1
Single	8 (4)	3 (1.5)	11 (2.7)		
Married	170 (85)	155 (77.5)	325 (81.3)		
Widowed	22 (11)	42 (21)	64 (16)		
Living alone?, n (%)				-	.317 <sup>b</sup>
Yes	0 (0)	1 (0.5)	1 (0.3)		
No	200 (100)	199 (99.5)	399 (99.7)		
Education, n (%)				59.2	<.001
Illiterate	41 (20.5)	108 (54)	149 (37.2)		
Literate	41 (20.5)	39 (19.5)	80 (20)		
Preparatory	21 (10.5)	8 (4)	29 (7.3)		
Secondary	87 (43.5)	43 (21.5)	130 (32.5)		
University	10 (5)	2 (1)	12 (3)		
Work status, n (%)				-	<.001 <sup>c</sup>
Working	199 (99.5)	0 (0)	199 (49.7)		
Not working	1 (0.5)	200 (100)	201 (50.3)		

<sup>a</sup>Two-tailed.

<sup>b</sup>*P* value for Living alone? is based on Fisher exact test.

<sup>c</sup>*P* value for Work status is based on Monte Carlo exact test.

#### **Clinical Characteristics**

As Table 2 shows, one-third (135/400, 33.8%) of patients in this study received their DM diagnosis over 10 years previously, and the majority (231/400, 57.7%) had the comorbidity of cardiac disease. Concerning the latter condition, males (82/200, 41%) were significantly less likely to have it than females (149/200, 74.5%; P<.001). Almost half (176/400, 44%) of

patients just received insulin treatment, while almost a quarter (93/400, 23.3%) additionally received oral hypoglycemic medications. The vast majority of patients exhibited elevated blood glucose (365/400, 91.3%), and most were overweight (146/400, 36.5%) or obese (147/400, 36.8%); females were disproportionately more prone to obesity (135/200, 67.5%) than their male counterparts (12/200, 6%).



Table . Participants' medical symptoms.

Medical data	Male (n=200), n (%)	Female (n=200), n (%)	Total (N=400), n (%)	$\chi^2$ a	<i>P</i> value
Disease onset (years)	)			22.8	<.001
<1	28 (14)	42 (21)	70 (17.5)		
1 - 5	34 (17)	49 (24.5)	83 (20.7)		
5 - 10	48 (24)	64 (32)	112 (28)		
10+	90 (45)	45 (22.5)	135 (33.8)		
Other chronic diseas	ses				
None	117 (58.5)	51 (25.5)	168 (42)	5.9	<.001
Cardiac disease	82 (41)	149 (74.5)	231 (57.7)	4.2	<.001
Hypertension	19 (9.5)	6 (3)	25 (6.2)	1.7	.541
Renal disease	0 (0)	2 (1)	2 (0.5)	0.51	.814
Rheumatic disease	2 (1)	1 (0.5)	3 (0.7)	0.5	.885
Liver disease	5 (2.5)	4 (2)	9 (2.2)	0.1	.924
Type of diabetes trea	atment regimen			28.2	<.001
Oral hypoglycemic drugs	65 (32.5)	66 (33)	131 (32.7)		
Insulin	107 (53.5)	69 (35.5)	176 (44)		
Both	28 (14)	65 (32.5)	93 (23.3)		
Commitment to follo	ow-up schedule				
Always	200 (100)	200 (100)	400 (100)	N/A <sup>b</sup>	N/A
Fasting blood glucos	e			0.83	.662
Below normal	1 (0.5)	1 (0.5)	2 (0.5)		
Normal	14 (7)	19 (9.5)	33 (8.2)		

365 (91.3)

107 (26.7)

146 (36.5)

147 (36.8)

Obese

Overweight

Above normal

BMI

Normal

<sup>a</sup>Two-tailed.

<sup>b</sup>N/A: not applicable.

#### **Baseline Knowledge Scores**

In terms of knowledge, the majority (255/400, 63.7%) exhibited poor knowledge at baseline, albeit this was significantly less pronounced among males (102/200, 51%) than females (153/200, 76.5%; P<.001), as shown in Table 3. About half (98/200, 49%) of male participants had "fair" knowledge, while

185 (92.5)

79 (39.5)

109 (54.5)

12(6)

180 (90)

28 (14)

37 (18.5)

135 (67.5)

less than a quarter (47/200, 23.5%) of females did. Consequently, the outcomes underscore major differences in baseline knowledge among males and females, especially concerning comprehension of appropriate DM management practices, as affirmed by results on actual practices (discussed below), indicating the necessity of specific educational interventions targeted to females.

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<b>Table</b> . Baseline diabetes mellitus knowledge.	e. Baseline diabetes mellitus	s knowledge.
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	Male (n=200), n (%)	Female (n=200), n (%)	Total (N=400), n (%)	$\chi^2$	<i>P</i> value
Knowledge level				28.1	<.001
Poor (<60%)	102 (51)	153 (76.5)	255 (63.7)		
Fair (≥60%)	98 (49)	47 (23.5)	145 (36.3)		

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<.001

#### **Baseline Self-Care Practices**

At the beginning of the intervention, most patients (248/400, 62%) exhibited inadequate baseline self-care practices, albeit this was significantly lower among males (96/200, 48%; P<.001) than females (152/200, 76%), as shown in Table 4. "Good" practices for self-care were only reported among 24% (48/200) of males and 8% (16/200) of females. The lowest adherence

was noted for blood glucose monitoring (316/400, 79%), physical exercise (296/400, 74%), and the prevention and management of acute complications (268/400, 67%). Critical shortfalls in self-care behaviors were thus observed, especially with regard to females, which indicates that more targeted interventions are needed to enhance essential self-care among female service users (in addition to the general need for improved self-care among DM patients in general).

Table .	Pretest	self-care	practice	scores.
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	Male (n=200), n (%)	Female (n=200), n (%)	Total (N=400), n (%)	χ <sup>2</sup>	P value
Total practice score				35.2	<.001
Good (≥75%)	48 (24)	16 (8)	64 (16)		
Fair (60 - 74%)	56 (28)	32 (16)	88 (22)		
Poor (<60%)	96 (48)	152 (76)	248 (62)		

#### **Intervention Impacts on DM Knowledge**

 Table 5 demonstrates that the intervention achieved significant

 enhancements of patients' DM management knowledge for all

studied domains (P<.001). The biggest improvements were seen concerning physical exercise knowledge, which saw a mean increase of 6.6 points, and tangible improvements were seen in knowledge of dietary choices and regimens of treatment.

Table . Mean of diabetes mellitus knowledge scores before and after the intervention (n=100).

Knowledge domains	Score, mean (SD)		Mean change <sup>a</sup>	t test <sup>b</sup>	<i>P</i> value
	Preintervention	Postintervention			
Basic knowledge about	12.1 (3.7)	40.3 (7.4)	28.2	31.8	<.001
DM <sup>c</sup>					
Treatment regimen	6.2 (1.9)	10.5 (1.5)	4.3	9.5	<.001
Physical exercise	1.2 (0.5)	8.2 (1.9)	7	37.4	<.001
Importance of follow- up visits	5 (0)	5.8 (0.4)	0.8	21.9	<.001
Dietary knowledge	3 (1.3)	6.5 (1.2)	3.5	22.9	<.001
Foot care knowledge	1.4 (0.6)	3.8 (0.6)	2.4	25.6	<.001
Knowledge of bad habits increasing DM severity	2.1 (0.5)	3.8 (0.5)	1.7	23.5	<.001
Total knowledge score	29.6 (3.9)	71.8 (13)	42.2	30.7	<.001

<sup>a</sup>Mean change = Posttest score – Pretest score.

<sup>b</sup>Two-tailed paired sample *t* test.

<sup>c</sup>DM: diabetes mellitus.

# **Intervention Impacts on Self-Care Practices**

As shown in Table 6, the applied intervention achieved statistically significant enhancements of practices for self-care for all studied domains (P<.001). Mean increases of 8.15 points

each were attained for the practices of "foot care" and "blood glucose monitoring," with a more modest increase in exercise practices of 3.45 points. These outcomes indicate that the intervention successfully improved participants' self-care behaviors for improved DM management.



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Table . Mean of self-care practice scores before and after the intervention (n=100).

Practice domains	Score, mean (SD)		Mean change <sup>a</sup>	t test <sup>b</sup>	<i>P</i> value
	Preintervention	Postintervention			
Nutritional practices	8.4 (2.2)	21.2 (2.3)	12.8	40.4	<.001
Treatment regimen ad- herence	2.3 (0.6)	7 (0)	4.7	55.4	<.001
Monitoring of blood glucose level	1.6 (0.9)	10.3 (2.5)	8.7	36.9	<.001
Physical activities	3.8 (1.7)	14.2 (1.1)	10.4	55.1	<.001
Practices to avoid complications	5.2 (2)	10.2 (1.2)	5	21.9	<.001
Foot care practices	1.6 (0.9)	10.3 (2.5)	8.7	36.9	<.001
Total practice score	20.8 (4.5)	59.9 (7)	39.1	53.7	<.001

<sup>a</sup>Mean change = (Posttest score – Pretest score)/Pretest score.

<sup>b</sup>Two-tailed paired sample *t* test.

#### **Intervention Impacts on Self-Care Skills**

Significant improvements were seen following the intervention in patients' self-care skills, as shown in Table 7. Every participant went to "satisfactory" postintervention from "unsatisfactory" at baseline (400/400, 100%; P<.001), as reflected in the baseline scores for insulin preparation (mean 12.3, SD 2.1), self-injection (mean 11.8, SD 2.5), and glucose

Table . Level of self-care skills before and after the intervention.

testing (mean 10.5, SD 1.9) increasing to 25.4 (SD 3), 24.8 (SD 2.8), and 23.5 (SD 2.4), respectively. These results underscore the effectiveness of the intervention to empower patients with prerequisite DM management skills, demonstrating the efficacy of practical instruction and reminders and reinforcement via telenursing, with the possibility of scalability for different and varied populations.

Self-care skills	Preintervention	Postintervention	$\chi^{2}$ a	<i>P</i> value
Insulin preparation (n=58), n (%)			47	<.001
Unsatisfactory	58 (100)	0 (0)		
Satisfactory	0 (0)	58 (100)		
Insulin injection (n=58), n (%)			47	<.001
Unsatisfactory	58 (100)	0 (0)		
Satisfactory	0 (0)	58 (100)		
Urine glucose testing (n=100), n (%)			51.9	<.001
Unsatisfactory	100 (100)	0 (0)		
Satisfactory	0 (0)	100 (100)		

<sup>a</sup>McNemar test for related groups.

# Discussion

#### **Main Outcomes**

#### Summary of Key Findings

This study on patient education and telenursing impacts concerning self-care practices among DM patients produced statistically significant outcomes, encompassing quantifiable improvements in skills, knowledge, and practices. Consequently, the intervention was effective in improving DM self-management and mitigating risks, as described below.

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# Improved DM Knowledge

The intervention resulted in patients with DM attaining significantly improved DM knowledge, especially concerning physical exercise, nutrition, and compliance with treatment. A more in-depth understanding of physical exercise was reflected in the postintervention increase in mean knowledge about physical exercise (and its impact on blood glucose) by 6.6 points [13]. This was striking, as education for patients with DM often lacks sufficient attention to physical exercise, despite its fundamental place in managing blood glucose and avoiding DM complications [13]. Improved knowledge scores concerning

regimens and nutrition were also significant, and these outcomes are essential for the strategy of managing diabetes.

The intervention analyzed in this research effectively addressed existent educational needs among DM patients, offering them accurate and clear information they could apply, via easy-to-use formats (eg, SMS text messages, telephone calls, and WhatsApp). The ease of access enabled patients to effectively manage their conditions, which was particularly useful for the subset recruited for phase II, due to their particularly poor knowledge and self-care determined in the preliminary assessment. Although individual needs of specific patients were not targeted by the studied intervention, it was directed to commonly identified barriers and needs among patients requiring such services, offering scope for genuine enhancements in patients' outcomes and self-care behaviors.

#### Improved Self-Care Practices

Self-care practices significantly increased participants' scores for practices following the intervention, including monitoring blood glucose, undertaking appropriate foot care, and physical exercise. For monitoring blood glucose and foot care, participants achieved a mean improvement of 8.15 points each, highlighting the efficacy of the intervention in terms of encouraging positive practices to avoid long-term complications and deteriorating health conditions, including serious ones commonly affecting patients with DM due to a dearth of appropriate self-care (eg, neuropathy and foot ulcers) [14]. Physical exercise-related self-care practices also yielded an improvement of 3.45 points, showing more likelihood of undertaking exercise after the intervention. This addresses a core aspect of the management of diabetes, enhancing sensitivity to insulin and lowering the risk of cardiovascular damage [15].

# Improved Self-Care Skills

The effects of the intervention on participants' self-care skills were substantial; all 100% (400/400) had "unsatisfactory" skills preintervention, and 100% (400/400) had "satisfactory" skills after it, in terms of preparing and injecting insulin and testing glucose in urine. This demonstrates the potentially remarkable effectiveness of patient education and telenursing follow-ups to enable patients with DM or other serious conditions to more proactively improve and maintain positive skills and behaviors, thereby improving their health outcomes (and substantially reducing costs for health systems).

# **Relation to Existing Literature**

The outcomes of this study affirm those of the broader literature on positive telenursing impacts on the management of chronic diseases, such as DM [6,16]. Previous studies have extensively demonstrated particular impacts of telenursing in terms of enhanced engagement and medication adherence among patients, which ultimately contribute to improved prognosis [17,18]. This research contributes to the literature by presenting how a holistic telenursing intervention combining educational with skills-based content delivered via modern telecommunications (eg, WhatsApp messages) can facilitate major breakthroughs for patients in terms of increased self-care practices and DM management knowledge. This notably goes beyond most DM-related research, which tends to prioritize fundamental biomedical indicators of telenursing effectiveness (eg,  $HbA_{1c}$  and BMI), without commensurate attention to the holistic dimensions of DM care and self-management for patients (eg, exercise) [8,19].

#### **Implications for Practice and Research**

The intervention used in this research achieved notable benefits for patients, offering broader potential impacts for health practice and studies. For practitioners, the outcomes of this study affirm the effectiveness of patient education and telenursing follow-ups to improve diabetes care services, and personalized support and education delivered remotely via modern technologies, which are increasingly ubiquitous, can enlarge patient access to education and improve medication and healthy behavior adherence. Such impacts reduce demand for conventional clinical resources and avoid the escalation of negative DM-related conditions, thereby improving quality of care (ie, patient health and satisfaction) while achieving maximum resource deployment efficiency for health systems, which is essential for contexts with limited resources (eg, in low-income countries or remote geographical areas).

This research suggests that the effectiveness of patient education and telenursing follow-ups can be enhanced by adopting a patient-centered approach that addresses specific gaps in skills and knowledge among particular patient groups or individual patients. A personal paradigm considering each patient's particular requirements, as applied in this study, can enable patient education and telenursing follow-ups to offer its full benefits, reducing net costs on conventional health care resources, especially for chronic and serious conditions requiring improved self-management by patients, such as DM. In terms of implications for research, this study leaves open the requirement to investigate longitudinal effects of patient education and telenursing follow-ups to see if the advantages for self-care practices and DM knowledge recorded after a few weeks in this research can be sustained over time, and the extent to which they affect health indicators over the longer term (eg. reduced rates of DM complications and improved glycemic control). Furthermore, the cost efficiency of patient education and telenursing follow-ups in various potential applications can be compared to enable policy development to optimally deploy such initiatives for the maximum benefits. Finally, future studies should consider conducting 2-arm RCTs to compare patient education and telenursing follow-ups with standard care. Research involving diverse populations would also help determine the broader applicability of this approach. Additionally, integrating mobile health applications with automated reminders could enhance communication and patient adherence, potentially improving self-care related outcomes.

#### Limitations

The foremost limitation of this study pertains to its reliance on patients' own self-perceived and rated performance for some of the tools used, which is obviously subject to various forms of bias (including social desirability bias concerning self-care practices when reporting data in health care contexts). Furthermore, it was not possible to objectively measure patient indicators outside of clinical settings, including their exercise habits, nutrition, and blood glucose levels; such data would

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have offered improved, robust proof concerning the positive impacts of the intervention.

The used design, with a single group and pretest-posttest format, precludes the use of a control group, which consequently reduces the confidence with which observed changes can be solely attributed to the intervention. It should also be remembered that many patients in real clinical contexts lack access to the internet, smartphones, etc, due to socioeconomic and geographical barriers and digital literacy, which can affect the applicability of this and other interventions, undermining the equity of telenursing care. The single setting from which participants were recruited is also an issue that reduces generalizability. It is advised that researchers use objective methods of measuring patients' clinically relevant data in studies of their self-care behaviors, use control groups, and recruit participants from multiple contexts in order to generate more generalizable feedback about patient needs and the efficacy of interventions. Researchers should also always consider accessibility issues, including with regard to the use of digital technologies to deliver care.

# Conclusions

The results affirm that an appropriately designed educational telenursing intervention can achieve significantly improved

patient knowledge, self-care practices, and skills among patients with DM. Delivered via numerous modern methods of telecommunication, the intervention was successful in targeting essential issues in DM management to prevent complications, including monitoring blood glucose, physical exercise, and appropriate care for the foot. These results buttress calls for telenursing inclusion in conventional care for patients with DM, especially in contexts where conventional resources are not optimally accessible for all patients. This study's outcomes highlight the potential of patient education and telenursing follow-ups as an effective and scalable intervention to enable improved self-care practices, skills, and knowledge for patients with DM. The statistically significant enhancements demonstrated by this research support the use of patient education and telenursing follow-ups to help address the expanding costs of diabetes care, especially in contexts with limited resources. Nevertheless, more studies are required to ascertain whether the outcomes of this study are similar across different service user populations and to assay the long-term clinical and economic sustainability of education and telenursing solutions for such care.

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# **Conflicts of Interest**

None declared.

# References

- 1. Hossain MJ, Al-Mamun M, Islam MR. Diabetes mellitus, the fastest growing global public health concern: early detection should be focused. Health Sci Rep 2024 Mar;7(3):e2004. [doi: <u>10.1002/hsr2.2004</u>] [Medline: <u>38524769</u>]
- 2. Abouzid MR, Ali K, Elkhawas I, Elshafei SM. An overview of diabetes mellitus in Egypt and the significance of integrating preventive cardiology in diabetes management. Cureus 2022;14(7):e27066. [doi: <u>10.7759/cureus.27066</u>]
- Matoori SAO. Diabetes and its complications. ACS Pharmacol Transl Sci 2022 Aug 12;5(8):513-515. [doi: 10.1021/acsptsci.2c00122] [Medline: 35983272]
- 4. Ahmad F, Joshi SH. Self-care practices and their role in the control of diabetes: a narrative review. Cureus 2023;15(7):e41409. [doi: <u>10.7759/cureus.41409</u>]
- Opoku R, Ackon SK, Kumah E, et al. Self-care behaviors and associated factors among individuals with type 2 diabetes in Ghana: a systematic review. BMC Endocr Disord 2023 Nov 22;23:256. [doi: <u>10.1186/s12902-023-01508-x</u>] [Medline: <u>37993843</u>]
- 6. Mun M, Park Y, Hwang J, Woo K. Types and effects of telenursing in home health care: a systematic review and meta-analysis. Telemed J E Health 2024 Sep;30(9):2431-2444. [doi: 10.1089/tmj.2023.0188] [Medline: 37707998]
- Dehghani A, Pourfarid Y, Hojat M. The effect of telenursing education of self-care on health-promoting behaviors in patients with multiple sclerosis during the COVID-19 pandemic: a clinical trial study. Mult Scler Relat Disord 2023 Feb;70:104507. [doi: 10.1016/j.msard.2023.104507] [Medline: 36682241]
- 8. AkbariRad M, Dehghani M, Sadeghi M, et al. The effect of telenursing on disease outcomes in people with type 2 diabetes mellitus: a narrative review. J Diabetes Res 2023;2023:4729430. [doi: 10.1155/2023/4729430] [Medline: 38098964]
- 9. Eberle C, Stichling S. Effect of telemetric interventions on glycated hemoglobin A1c and management of type 2 diabetes mellitus: systematic meta-review. J Med Internet Res 2021 Feb 17;23(2):e23252. [doi: <u>10.2196/23252</u>] [Medline: <u>33595447</u>]
- Gajarawala SN, Pelkowski JN. Telehealth benefits and barriers. J Nurse Pract 2021 Feb;17(2):218-221. [doi: 10.1016/j.nurpra.2020.09.013] [Medline: <u>33106751</u>]
- 11. Marlina TT, Haryani H, Widyawati W, Febriani D. The effectiveness of telenursing for diabetes self-management education: a scoping review. Open Nurs J 2023;17:e187443462307190. [doi: 10.2174/18744346-v17-230815-2023-38]

- 12. Teo V, Weinman J, Yap KZ. Systematic review examining the behavior change techniques in medication adherence intervention studies among people with type 2 diabetes. Ann Behav Med 2024;58(4):229-241. [doi: 10.1093/abm/kaae001] [Medline: 38334280]
- 13. Schubert-Olesen O, Kröger J, Siegmund T, Thurm U, Halle M. Continuous glucose monitoring and physical activity. Int J Environ Res Public Health 2022;19(19):12296. [doi: <u>10.3390/ijerph191912296</u>] [Medline: <u>36231598</u>]
- 14. Creber A, Leo DG, Buckley BJR, et al. Use of telemonitoring in patient self-management of chronic disease: a qualitative meta-synthesis. BMC Cardiovasc Disord 2023;23:469. [doi: 10.1186/s12872-023-03486-3] [Medline: 37726655]
- 15. Cannata F, Vadalà G, Russo F, Papalia R, Napoli N, Pozzilli P. Beneficial effects of physical activity in diabetic patients. J Funct Morphol Kinesiol 2020;5(3):70. [doi: 10.3390/jfmk5030070] [Medline: 33467285]
- Liang HY, Hann Lin L, Yu Chang C, Mei Wu F, Yu S. Effectiveness of a nurse led tele homecare program for patients with multiple chronic illnesses and a high risk for readmission: a randomized controlled trial. J Nurs Scholarsh 2021 Mar;53(2):161-170. [doi: 10.1111/jnu.12622] [Medline: 33507626]
- 17. Ghoulami-Shilsari F, Esmaeilpour Bandboni M. Tele-nursing in chronic disease care: a systematic review. Jundishapur J Chronic Dis Care 2019;In Press(In Press):e84379. [doi: <u>10.5812/jjcdc.84379</u>]
- Ariyanto H, Rosa EM. Effectiveness of telenursing in improving quality of life in patients with heart failure: a systematic review and meta-analysis. J Taibah Univ Med Sci 2024 Jun;19(3):664-676. [doi: <u>10.1016/j.jtumed.2024.04.009</u>] [Medline: <u>38807966</u>]
- Shahsavari A, Bakhshandeh Bavarsad M. Is telenursing an effective method to control BMI and HbA1c in illiterate patients aged 50 years and older with type 2 diabetes? A randomized controlled clinical trial. J Caring Sci 2020 Jun;9(2):73-79. [doi: 10.34172/JCS.2020.011] [Medline: 32626668]

# Abbreviations

**DM:** diabetes mellitus **HbA<sub>1c</sub>:** glycated hemoglobin A<sub>1c</sub> **RCT:** randomized controlled trial

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# Evaluating Social Assistive Robots in Clinical Nursing Care: Mixed Method Pilot Study on Health Care Workers' Perceptions and Adoption

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# Abstract

**Background:** The growing demand for older adults care due to aging populations and health care workforce shortages requires innovative solutions. Socially assistive robots (SARs) are increasingly explored for their potential to reduce workload by handling routine tasks. Yet, adoption can be hindered by various health care workers' concerns.

**Objective:** This study examined the perceptions of health care workers toward SARs before and after a pilot use in a clinical nursing care setting. The study focused on SAR usability, emotional appropriateness, and readiness for adoption.

**Methods:** A mixed methods pilot study was conducted at the East Tallinn Central Hospital's Nursing Care Clinic in collaboration with Tallinn University of Technology. The TEMI v3 (Robotemi) robot was used for 2 weeks for visitor guidance, goods delivery, and patrolling tasks. Health care workers filled in pre- and postintervention questionnaires with Likert-scale items and a broad open-ended question. Quantitative data were analyzed for changes in perceived safety, trust, and usability. Qualitative data underwent thematic analysis to understand participants' opinions.

**Results:** Out of 45 involved health care workers, 20 completed the pretest questionnaire, and 5 completed the posttest questionnaire (a 75% attrition). Pretest results show that 17 of 20 (85%) participants had limited previous exposure to SARs and mixed perceptions of their role, with 9 (45%) viewing SARs as machines and 6 (30%) as somewhat human-like. Although 60% believed SARs could become mainstream within 5 - 10 years, there were concerns about the robot's emotional adequacy and job displacement. Posttest findings showed increased confidence in SARs, with all respondents perceiving them as safe tools. Qualitative results indicate improved trust and readiness to integrate SARs into daily routines, with 4 out of 5 (80%) being willing to advocate for SAR use. Still, participants noted limited impact on facilitating their jobs.

**Conclusions:** The study indicates that short-term collaboration with SARs can enhance health care workers' confidence and their readiness for adoption. However, actual use would need proper emotional adequacy from the robot and aligning its functionalities with specific care needs. The future studies need to examine long-term impacts on care quality and job satisfaction, and also strategies to address generational differences and technophobia among health care staff. Transparent communication and proper training are required to ensure acceptance.

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# **KEYWORDS**

aging population; nursing; socially assistive robots; technology acceptance in healthcare; human-robot interaction

# Introduction

# Background

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The growing integration of socially assistive robots (SARs) into older adults' care settings offers transformative potential to address workforce resource limitations and improve care delivery [1]. Throughout Europe, including Estonia, the aging population has placed a significant burden on health care

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systems, the demand for older adults' care is growing while the shortages of qualified labor are increasing, and existing staff experience burnout due to high workloads and emotional demands [2,3]. In this context, robot assistants such as the TEMI v3 (Robotemi) robot are emerging as viable solutions to assist health care workers in performing routine and physically demanding tasks, allowing workers to focus on more complex and interpersonal care responsibilities. SARs, with their wide range of designs (humanoid, animal-like, telepresence, etc), can

provide assistance and improve patient engagement in care settings [4].

А typical SAR can navigate autonomously or semiautonomously, it can recognize voice and process natural language, and it can also be used for enhanced video conferencing with improved social presence, potentially improving thus communication and interaction in hospitals and homes [5,6]. For instance, the TEMI robot can autonomously navigate predefined areas, use telepresence to relay interaction between patients and medical personnel or their relatives, and perform simple service tasks [7]. SARs are designed to assist users through social interaction, focusing on cognitive and social assistance. These robots interact with humans using natural language, body language, and social behaviors, enhancing psychological and emotional well-being and complementing traditional caregiving services [1]. In health care, SARs provide services that directly benefit patients, health care professionals, and caregivers. They are particularly useful in supporting older adults and patients with chronic illnesses, who require continuous monitoring and social interaction. SAR functions include remote patient monitoring, facilitating swift responses to incidents like falls or medical emergencies, measuring vital signs (eg, pulse, blood pressure, and oxygen saturation), and assisting in remote consultations between patients and health care providers [8,9]. These robots are also used to combat social isolation. significantly enhancing patients' sense of companionship and social presence in long-term care facilities or for individuals confined at home [10].

Leaning on the context of using SARs in health care to empower health care workers' professional capabilities, the aim of this study was to examine the effects of using the TEMI v3 robot assistants for 2 weeks in a nursing clinic's daily practices to examine the feasibility and usability of SARs as perceived by health care workers. The study is arranged as follows: (1) first, we open the Theoretical Background by examining studies about the real-world use of SARs in health care, discussing appropriate technology acceptance models and relevant concepts, and exploring the challenges in adopting novel technologies in health care. Then, in (2) the Methods, we discuss the study design, sample, and procedure, describe the methods for collecting and analyzing data, and present ethical considerations. Followed in (3) the Results, we give a detailed overview of our quantitative and qualitative results, together with a comparison of pre- and posttest findings. And we conclude with (4) the Discussion that includes a description of the study's limitations and suggestions for future research and practice.

#### **Real-World Use of SARs in Health Care**

Although SARs with their modern functionalities are relatively new technologies, there are already a few studies that have investigated their efficacy in health care. The results of these studies give knowledge of how SARs can enhance patient well-being, support health care professionals, and improve the overall quality of care.

The CARESSES (Culture-Aware Robots and Environmental Sensor Systems for Elderly Support) randomized controlled trial was a good example of such studies [11]. This trial explored the impact of culturally competent SARs (in this case, the Pepper

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robots) on older adults in care homes. The study involved 33 residents across facilities in England and Japan, who interacted with SARs that were programmed with varying levels of cultural competence. The findings indicated that participants who engaged with culturally competent robots exhibited significant improvements in emotional well-being, as measured by the SF-36 emotional well-being subscale, compared with those receiving standard care. While changes in loneliness scores were observed, they did not reach statistical significance. These results suggest that customizing robot interactions to consider the users' cultural backgrounds can enhance the psychological benefits of SARs in older adult care settings [11].

In pediatric health care, SARs have been used to alleviate distress and anxiety related to medical procedures. A systematic review by Trost et al [12] examined the effectiveness of SAR interventions in reducing pain and emotional discomfort among children. The review concluded that while SARs show promise in reducing distress and anxiety, evidence regarding their impact on pain reduction remains inconclusive. The authors emphasized the need for further research to establish standardized protocols and assess the long-term benefits of SARs in pediatric settings.

For individuals with dementia, SARs have been used to evoke positive emotional responses and reduce apathy. A pilot study by Otaka et al [13] investigated the immediate emotional reactions of nursing home residents with dementia to multisensory stimuli presented by SARs. Using facial expression analysis, the study found that participants exhibited increased expressions of happiness, particularly when engaging with animal-like or doll-type robots that provided combined visual, auditory, and tactile stimuli. These findings highlight the potential of SARs to enhance emotional engagement in dementia care, especially when designed to offer multimodal interactions.

In the realm of rehabilitation, SARs have been integrated into poststroke therapy to provide personalized coaching and monitoring. Lee et al [14] developed an interactive SAR system that combines neural network and rule-based models to assess patients' rehabilitation exercises in real time. The system was evaluated with 15 poststroke survivors, demonstrating its ability to adapt to individual patient needs and provide corrective feedback. Participants reported increased motivation and satisfaction with the robot-assisted therapy, suggesting that SARs can play a valuable role in enhancing rehabilitation outcomes.

These studies indicate that SARs can be versatile when addressing health care challenges. The robots can improve the quality of care and support in medical settings when their interactions are programmed to consider specific patient needs and cultural contexts. From the technical point of view, however, the introduction and acceptance of SARs in health care settings face several challenges. These include the necessity for robust and reliable internet connectivity, technical support for robot operation, and modifications in physical spaces to accommodate robot navigation. There are also limitations related to sensory input, such as restricted visual and auditory capabilities, potentially leading to communication challenges and reduced social presence compared with face-to-face interactions [1,15]. In addition, the introduction of SARs raises significant emotional

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and professional concerns for both health care professionals and patients. Next, we examine these issues while addressing specific fears associated with SARs such as job relocation, loss of human contact, emotional unsuitability to care settings, and a general inability to adapt to new technologies. These concepts frame the complexities of SAR integration, demonstrating both the opportunities and challenges of SARs in the health care sector.

#### **Technology Acceptance in Health Care**

The adoption of SARs in health care can be studied through widely established technology acceptance models, mainly the Technology Acceptance Model (TAM) [16] and the Unified Theory of Technology Acceptance and Use (UTAUT) [17]. These models emphasize the importance of perceived usefulness and ease of use, suggesting that when users find new technologies useful and easy to understand, their willingness to adopt these technologies increases. Research also emphasizes that technology readiness, that is, user readiness and willingness to adopt and engage with new technology, is a critical factor in health care settings [18,19]. In health care, the application of technology such as SARs brings additional considerations beyond functionality and ease of use, particularly the socio-emotional implications of care [19,20]. Social exchange theories also provide a basis for understanding how the relational aspects of care affect technology acceptance, emphasizing that perceived coldness or impersonality of robots can hinder their acceptance in contexts that require empathy and warmth [21]. Health care workers often need special training and time to adapt to SAR technology, which is central to reducing fear and increasing confidence in robotic assistance. In addition, participatory training can significantly improve technology adoption and smooth transitions to new work processes [11]. Our pilot study, based on the use of the TEMI v3 robot, emphasized these readiness principles by adding predeployment training and scenario-based familiarization that allowed personnel to engage in SARs in a controlled environment before full deployment.

#### **Challenges in Adopting New Technologies**

One of the main concerns regarding the implementation of SARs in health care is the fear of job displacement. Many health care workers perceive the introduction of robots not only as a complement to their roles, but as a potential threat to workplace safety. Such fears are supported by research showing that job displacement problems are common among workers in automated industries [22]. In the health care context, where relationships and personalized communication are critical, these concerns are even more acute [23]. Although SARs are designed to support tasks that do not require human contact, employees may feel uncertain about the boundaries of their roles as the capabilities of SARs expand. Thus, clear communication of SAR's supportive, not substitute, role may help alleviate this fear.

Another barrier to integrating SARs into health care is the reluctance or inability of individual staff members to adapt to new technologies, especially those with limited digital skills or existing technophobia. Technophobia, or the fear of engaging with new technologies, can manifest in many ways, from general

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anxiety about using technology to concerns about one's ability to learn and adapt to robotic systems [24]. This fear is especially pronounced among older health care workers or those who are limited by digital tools. Research shows that this lack of technological readiness can hinder the successful deployment of SARs, highlighting the need for robust training programs that build familiarity and confidence among staff [20,25].

Health care providers and patients express serious concerns about the perceived emotional inadequacy of SARs in sensitive treatment contexts. The "human touch" is a key aspect of geriatric care, as many older adult patients depend on interpersonal interactions for emotional support and social bonding. Research has shown that SARs are often perceived to lack the warmth and empathy essential to their caregiving roles, leading to resistance from both patients and caregivers [23]. Although SARs can perform tasks efficiently, their inability to mimic human empathy or intuition limits their suitability for roles involving complex emotional needs, such as comforting an anxious patient or providing personalized encouragement during rehabilitation exercises.

# Methods

#### **Study Design**

This study used a quasi-experimental mixed methods design to assess health care workers' perceptions and experiences with SARs, using the TEMI v3 robot as an example, within a real-world health care setting. Applying mixed methods in pilot feasibility studies is justified when integrating quantitative and qualitative data could provide a comprehensive understanding of implementation feasibility, acceptability, and practical implications of new interventions [26]. A quasi-experimental design was specifically chosen due to the study's exploratory nature, the limited duration of 2 weeks, practical constraints in the clinical setting, and the intention to gather initial insights into changes in staff perceptions and experiences following robot deployment. The pilot study was part of a broader registered social scientific feasibility research (the ethics committee registration details are provided under "Ethical Considerations"), conducted at the East Tallinn Central Hospital's Nursing Care Clinic in Estonia, in collaboration with Tallinn University of Technology. The design involved preand postintervention questionnaires, including both closed and open-ended questions, allowing for quantitative comparisons and qualitative insights into health care workers' attitudes and readiness concerning SARs before and after exposure. In addition, scenario-based role assignments were used, simulating practical usage situations to capture nuanced staff reactions, emotional responses, and potential concerns in a controlled yet realistic environment. Over a period of 2 weeks in the summer of 2024, 3 distinct SAR usage scenarios (visitor guidance, delivery assistance, and facility patrolling) were trialed. These scenarios (see "Procedure" for more details) were carefully selected based on the robot's technical abilities and preliminary discussions with health care staff and administrators, reflecting ancillary tasks that would support rather than replace the primary caregiving roles of human staff.

Our study addressed the challenges described in the "Challenges in Adopting New Technologies" section in the following manner. First, we strategically deployed SARs in ancillary rather than primary health care roles; for example, the robots were used for visitor guidance, delivery, and patrolling functions. These tasks complement people's care by reducing workload without compromising the interpersonal aspects that are central to caring for older adults. During our pilot, health care administrators played an essential role in clearly communicating to staff members the specific purpose and scope of the SARs deployment. Administrators were involved because their in decision-making processes responsibility and in organizational change management put them in the position where they could address the personnel's concerns about job security and explain how SARs are used strictly as supportive tools instead of being replacements for human staff members. To avoid any perceived power imbalance, administrators took part in structured meetings, where dialogue and feedback regarding the roles assigned to SARs were encouraged. These discussions were helpful for keeping transparency and supporting collaboration where employees felt safe to present their suggestions and concerns. Next, the robot's tasks were structured to assist rather than replace human interaction. For example, a robot's role as a tour guide or logistical assistant fulfills functional needs without infringing on the emotionally charged tasks performed by health care providers. This design choice reflects a "complementarity model" where SARs are positioned to enhance caregivers' capabilities without diminishing the importance of human connection [27]. Finally, we implemented short training sessions, allowing staff to interact with the robot in a supportive, low-stakes environment before integrating SARs into daily operations, in order to increase user confidence, reduce technophobia, and promote an inclusive environment that accommodates different levels of digital competence. In addition, involving employees directly in defining the roles and tasks for SARs has been shown to be effective in reducing resistance, as it empowers them to shape how the technology fits into their existing workflows, rather than feeling like it is being imposed by administrative decision-making alone [11].

# **Participants**

The sample consisted of 45 employees of East Tallinn Central Hospital's long-term Nursing Care Clinic, all of whom were invited to participate in the study voluntarily. A total of 20 of them completed the pretest and 5 completed the posttest questionnaire. The participants represented a variety of roles in the clinic, including nurses, care workers, and other health care professionals, and administrative staff who interact with patients and the hospital environment on a daily basis. To ensure inclusiveness, all employees who could encounter the TEMI v3 robot in their daily activities were given the opportunity to participate. Anonymity was maintained throughout the study to encourage honest feedback. To this end, throughout the study, anonymity of responses to the questionnaires was emphasized, and for this purpose, gender information was excluded as the employees at this clinic were predominantly female. Demographic information, including age range but excluding

gender, was collected to understand differences in employee technology adaptation.

#### Procedure

#### Preintervention Training and Questionnaire

Before SAR implementation, participants underwent short training to familiarize themselves with the functions, controls, and user interface of the TEMI v3 robot. The training covered robot navigation, object transport, patrol functionality, and interaction options. After the training, participants completed a preintervention questionnaire to capture initial attitudes, perceived ease of use, usefulness, and potential fears (eg, job relocation and loss of human contact in caregiving). This questionnaire included both quantitative items on a modified Likert scale and an open-ended question for qualitative feedback.

#### Application of the Robot in 3 Scenarios

During a 2-week period, TEMI v3 was used in the clinic to perform 3 specific functions, each tailored to complement routine tasks without replacing human care:

- Visitor guidance (Scenario 1): TEMI v3 was programmed to navigate visitors to specific locations in the clinic (eg, patient rooms and nurse stations) on request. Visitors could select destinations on the robot's interface screen, after which TEMI guided them to the desired location. This task required minimal interpersonal interaction on the part of the staff while allowing feedback on SAR effectiveness and usability to be monitored.
- Goods delivery (scenario 2): TEMI v3 was equipped with a tray for the delivery of light items such as personal items or documents between rooms or departments. Workers placed items on TEMI's tray, selected a delivery location through the robot's interface, and TEMI delivered the items autonomously. This scenario simulated the use of SARs for logistical support in day-to-day maintenance.
- Patrol functionality (scenario 3): TEMI v3 performed patrol duties in the corridors of the clinic during the evening and night shifts, moving between predetermined points. The patrol function allowed staff to monitor corridors via TEMI's real-time video feed without compromising patient privacy as no data were recorded. This feature provided additional security and oversight without directly replacing employee roles.

#### Postintervention Questionnaire and Feedback Collection

At the end of the 2-week period, a follow-up seminar was held to allow participants to discuss their experiences with TEMI v3 in a group. This provided additional insight into employee concerns, perceived benefits, and the emotional and practical impact of SARs on their work environment. During the seminar, the participants also completed a postintervention questionnaire that had the same questions as the preintervention questionnaire (including the open-ended question for qualitative data), recording changes in participants' perceptions of SAR use, perceived usefulness, ease of use, and emotional impact. As participation in the study was voluntary, the postintervention questionnaires were made available to the participants who were present at the seminar, and to those who wanted to add their
reflections, although they were not able to be present. The preand postintervention qualitative data were used together to extract as many potential themes to describe the perceived roles of SARs or their influence on involved people (we did not measure changes in these perceptions).

### **Measures and Data Analysis**

# *Pre- and Postintervention Questionnaires, Quantitative Data*

The pre- and posttest questionnaires that were filled in by the participants according to the procedure described in the previous subsection used Likert-scale items (n=19) to measure participants' perceptions toward SAR adoption, perceived usefulness, perceived ease of use, and perceived threats (eg, fear of job transfer, emotional inadequacy, and inability to adapt). The prequestionnaire established the basis for these perceptions, while the postquestionnaire aimed to assess changes in perception after the 2-week intervention. The questionnaires included both quantitative items for analysis and an open-ended question for qualitative exploration of nuanced responses and issues. The questionnaires were based on established

frameworks and approaches to understand user perceptions and readiness to adopt SAR in health care. The TAM and the UTAUT were the underlying models. TAM emphasizes the importance of perceived usefulness and ease of use in technology acceptance [16], while UTAUT extends this to include social influence and facilitating conditions as key determinants of user intentions and behavior [17]. In addition, elements from human-robot interaction (HRI) and social presence theory were added to assess participants' perceptions of the SAR's "personality" and the social dynamics of their interactions with it. This is critical in health care, where the perceived warmth and empathy of technology can influence acceptance, particularly in aged care settings [21]. Questions assessing trust, security, and reliability were based on the principles of trust in automation, which consider predictability and reliability important for developing user trust in automated systems [28,29]. Finally, the concept of technology readiness was integrated to measure health professionals' confidence and propensity to engage in SARs in line with the Technology Readiness Index (TRI), which measures a person's readiness to adopt new technologies [30] (Textbox 1).

Textbox 1. Metrics captured by the questionnaire.

Specifically, the questionnaires included:

• Demographic information (3 items): length of employment in health care (categories from less than 1 year to more than 5 years); age group (up to 30 years, 31-50 years, and 51 years and older); frequency of previous interactions with robots in education or work contexts; and frequency of previous interactions with robots in education or work contexts.

• Perceptions of future use of robots (2 items): expectations of robot usage in health care within 5-10 years; Perceptions of robots' roles as colleagues, competitors, or tools.

• Interaction experience with robot during trial (3 items): frequency of interactions with the robot during the trial period; perception of the robot as a machine or human-like during interactions; and general evaluation of robot usage frequency.

• Robot interaction quality and usability (7 items): ease of cooperation with the robot; clarity and comprehensibility of communication with the robot; suitability of robot's physical position and height; perceived safety while interacting with the robot; trustworthiness of the robot; pleasantness of interaction; and confidence while interacting with the robot.

• Readiness and acceptance of robot integration (4 items): willingness to use robots regularly in daily work; perceived potential of robots to simplify work tasks; willingness to actively support the introduction of robots into the workplace; and expectation of robots' long-term impact on work.

The collected paper-based questionnaire responses were first digitized and manually entered into a Microsoft Excel spreadsheet for analysis. The Likert-scale responses were summarized by grouping related response categories to simplify interpretation and amplify clarity of outcomes (ie, for each Likert-scale item, responses were categorized into 3 groups: positive [eg, "Trustworthy" and "Very Trustworthy"], negative [eg, "Untrustworthy" and "Very Untrustworthy"], and neutral or uncertain midscale responses]). After categorizing responses into these groups, the frequency and proportion of participants falling into each category (positive, negative, neutral, or uncertain) were calculated. Demographic information was analyzed by summarizing frequencies and proportions in each demographic category. The summarized data were presented using descriptive statistics, such as percentages or frequencies, to clearly illustrate the distribution of responses and identify meaningful patterns or changes attributable to the intervention.

# Qualitative Data

A broad, open-ended questionnaire question ("Do you have any thoughts?") was included to gather richer, detailed insights

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beyond what the quantitative Likert-scale responses could capture. These written responses were digitized from paper questionnaire sheets and entered into a Microsoft Excel database for analysis. A thematic textual analysis was conducted following a structured inductive approach, which involved systematically coding the qualitative data to identify recurring patterns and significant themes. The initial codes were generated by highlighting salient words, phrases, or sentences representing key ideas and experiences expressed by participants. These initial codes were then grouped and categorized into broader themes, such as perceived advantages of robot usage, concerns and apprehensions, suggestions for improvements, emotional reactions, and reflections on robot-human interactions.

### **Ethical Considerations**

The study was reviewed and approved by the Research Ethics Committee of the National Institute for Health Development in Estonia (#8.3/13 - 24 from May 29, 2024). All participant interactions with TEMI v3 were anonymous, and no patient or visitor data were recorded. Participants were informed about the purpose of the study, their voluntary participation, and the

nonrecording of identifiable data. Participants received no compensation for their participation. Informed consent was obtained from all participants and clear instructions were given regarding robot interactions, particularly in the patrol scenario, to ensure privacy and security protocols were followed.

# Results

# **Response Overview**

20 responses were received to the initial pretest questionnaire, which provided a broad overview of the attitudes and demographic information of participating health care workers. As the unit was relatively small, with administrative personnel having previous long-term experience as ordinary older adult health care employees, we did not collect separate information about the employees' current positions. The posttest questionnaire was completed only by 5 participants, representing a significant attrition rate of 75% (n=15). The possible reasons are discussed under the "Limitations" section. The professional experience duration of participants, together with their age, is shown in Figure 1.

As demonstrated in Figure 1, the majority of participants had more than 5 years of experience in the health care sector and were older than 50 years. In the posttest group, similar tendencies were seen.

Figure 1. The age and work experience of the participants who filled in the pre- and posttest questionnaires.



# **Quantitative Results**

# **Pretest Results**

Of the pretest respondents, 85% (n=17) reported no significant prior experience with robots in their work, 10% (n=2) had some experience, and 5% (n=1) used robots frequently. When asked if they saw robots as colleagues or competitors, 5% (n=1) saw them as colleagues, 95% (n=19) saw them as tools, and none saw robots as competitors (Figure 2, right). Almost half of the participants (45%, n=9) considered robots to be machines, 30%(n=6) perceived them similar to humans, while one quarter of participants (n=5) were unsure (Figure 2, left).

Participants also shared their previous experience with SARs; 85% (n=17) had low experience with them, 10% (n=2) had insignificant experience, and 5% (n=1) had considerable experience with SARs (Figure 3, left). Regarding the potential for robots to become mainstream in their field in the next 5 - 10 years, 60% (n=12) thought it was realistic, while 40% (n=8) were unsure (Figure 3, right).

Participants then rated specific aspects of working with robots (see Figure 4). When it comes to collaboration simplicity, 75% (n=15) found it easy, 20% (n=4) were unsure, and 5% (n=1) found it a challenge. Communication clarity with the robot was rated good by 55% (n=11), while 30% (n=6) were not sure and 15% (n=3) rated it bad. The height of the robot was considered suitable by 80% (n=16) of respondents, 20% (n=4) were undecided.

In terms of safety, 65% (n=13) of respondents believed that robots are safe, 20% (n=4) were not sure, and 15% (n=3) felt that robots were not safe. 55% (n=11) of participants considered robots trustworthy, while 35% (n=7) were unsure and 10% (n=2) considered them untrustworthy. A significant 80% (n=16) of respondents found robots to be *pleasant*, although 20% (n=4) were undecided. Regarding *c*onfidence in working with robots, 80% (n=16) felt confident, 5% (n=1) were unsure, and 15% (n=3) were uncertain.

When considering the integration of robots into daily work, 70% (n=14) were ready, 15% (n=3) were not, and 15% (n=3) were unsure. Regarding the potential of robots to make their

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jobs easier, 60% (n=12) agreed, 20% (n=4) disagreed, and 20% (n=4) were unsure. In addition, 80% (n=16) were ready to promote the use of robots in their workplace, while 20% (n=4) were unsure. Finally, when asked about the impact of robots on

the future of their work, 30% (n=6) thought robots would have an impact, while 35% (n=7) thought that robots would not have any impact and another 35% (n=7) were unsure.









Figure 4. Percentage distribution of high ratings (5-7) across robot collaboration attributes, pretest.



# Posttest Results

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Among the posttest respondents, 100% (n=5) reported some experience with robots. Regarding the potential for robots to become mainstream in their field within the next 5 - 10 years,

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60% (n=3) found it realistic, with the remainder undecided. In terms of perception, all participants identified the TEMI V3 robot as a machine, with no participants considering it human-like. When asked whether robots would be viewed as

colleagues, tools, or competitors, 100% (n=5) considered them as tools.

For specific aspects of working with robots, 80% (n=4) of participants felt that collaboration with robots was straightforward, while 20% (n=1) were uncertain. Communication clarity was rated positively by 80% (n=4) of respondents, with 20% (n=1) uncertain. The robot's height was deemed appropriate by 80% (n=4), with 20% (n=1) undecided.

Regarding safety, 100% (n=5) of respondents felt that robots were safe. Robots were deemed trustworthy by 60% (n=3), while 40% (n=2) were uncertain. Furthermore, all respondents found robots pleasant. For self-confidence in working with robots, 80% (n=4) felt assured, and 20% (n=1) were uncertain.

On the integration of robots into daily tasks, 80% (n=4) were willing to incorporate them into their work, and 20% (n=1) were uncertain. Regarding robots' potential to facilitate work, 60% (n=3) disagreed, with 20% (n=1) uncertain and 20% (n=1) agreed. In addition, 80% (n=4) were prepared to advocate for robot use in the workplace, while 20% (n=1) were unsure. Finally, regarding the impact of robots on future work, 40% (n=2) believed robots would have an impact, 40% (n=2) did not think so, and 20% (n=1) were undecided.

# Comparison of Pre- and Posttest Results

In both the pretest and posttest groups, participants expected robots to become mainstream in the clinical care of older adults within the next 5 - 10 years. However, some changes in robot perception and comfort were observed between the results of the 2 tests, suggesting that there was an increase in positive perceptions and confidence in collaborating with robots, particularly regarding safety, reliability, and the potential role of robots in the workplace.

In the pretest, 45% (n=9) of respondents perceived TEMI V3 as a machine, 30% (n=6) found it somewhat human, and 25% (n=5) were not sure. In the posttest, all participants (n=5) consistently identified the TEMI v3 robot as a machine,

indicating a shift towards viewing robots as nonhuman tools. Comfort and confidence in working with robots also increased in the posttest. Perceptions of safety improved significantly, with 100% (n=5) of posttest respondents considering the robots to be safe, compared to 65% (n=13) in the pretest. Reliability ratings similarly increased, with all posttest respondents (n=5) finding robots enjoyable to work with, while 20% (n=4) in the pretest were undecided.

However, it seems that after having an actual experience with SARs, the participants' belief in the robots' ability to simplify their work decreased. Despite this, posttest respondents showed a stronger willingness to integrate robots into their daily work (80%, n=4 ready compared with 70%, n=14 pretest) and a greater willingness to promote the use of robots in the workplace. This openness extended to confidence about the impact of robots on future work, with a slight increase in the number of people expecting a positive impact.

# **Qualitative Results**

An open-ended questionnaire question ("Do you have any thoughts?") provided detailed insights in addition to the quantified data from the Likert-scale responses. Digitized responses underwent thematic textual analysis, key phrases were highlighted as initial codes and grouped into broader themes to identify recurring patterns. The main themes of qualitative analysis are seen in Figure 5.

As seen from Figure 5, participants proposed several functional and emotional roles for the TEMI robot in a health care facility. Many envisioned TEMI as a mobile assistant that could be summoned via a Wi-Fi-connected station, useful for tasks such as delivering items to the nurse's station, reducing the need for staff to carry them manually. TEMI was also seen as a tool to improve the patient experience, provide entertainment, deliver items, and be a conversational partner. Respondents felt that TEMI could lift patients' moods by providing social interaction, news, and audiobook playback.



Figure 5. Potential roles for socially assistive robots (presented with illustrative quotes). SAR: socially assistive robots.



# Discussion

# **Principal Findings**

This study explored the potential benefits and challenges of integrating SARs, such as TEMI v3, into nursing care facilities. SARs provide value in supporting health care workers by performing noncore tasks such as guidance, delivery, and patrolling, thereby allowing staff to focus on complex interpersonal care tasks. However, the implementation of SARs in health care also presents a variety of emotional, professional, and technical challenges that need to be addressed through thoughtful strategies.

One of the most important findings is the importance of balancing technological efficiency with the emotional needs of older adult patients. The "human touch" is crucial in aged care, where personal interaction promotes emotional support and social inclusion [27]. Consistent with previous research, our results suggest that health care professionals were concerned about SARs replacing human roles that require empathy and warmth and perceived that SARs lacked the human-like intuitive and comforting qualities that patients value [21]. Similar findings were observed by Turja et al [23,31], who reported that SARs may have problems achieving the warmth needed in their caregiving roles, which may lead to resistance from patients and caregivers. By positioning SARs in complementary roles, such as logistical support rather than personal care, we sought

to preserve the human aspects of care while benefiting from the robot's hands-on capabilities. This "complementarity model" aligns with the view of Sharkey and Sharkey [27], who advocate SARs as an aid rather than a substitute in situations that require emotional connection. In addition, transparent communication and role clarification, emphasizing that SARs are designed to support, not replace, staff, are essential to addressing these issues.

Possible generational differences in SAR acceptance must be considered. Czaja and Lee [32] found that younger people are generally more adaptable to new technologies. These findings suggest that younger health care workers could be more susceptible to SARs, implying that deployment strategies need to include tailored training and engagement. These findings highlight the importance of addressing job security fears as part of a holistic approach to SAR integration. Research also shows that older adults often experience technophobia, which is defined as fear or anxiety of technology [24]. Consistent with our findings, Barnard et al [25] and Yusif et al [33] suggest that older health workers may have concerns about adapting their routines to SARs. To mitigate this barrier, structured, scenario-based training sessions should be designed to introduce staff to SARs in a supportive, low-stakes environment, building trust and reducing resistance. Papadopoulos et al [11], emphasize that participatory training significantly improves technology adoption by empowering users to adopt new tools. Our study's training approach is consistent with these findings, as it provided

staff with hands-on interactions that increased their comfort and understanding, ultimately promoting a more inclusive environment for SAR adoption.

The issue of effective training of SARs needs to be approached systematically, because even when fears about new technology are addressed and workers have had time to familiarize themselves with SARs, integrating these robots into the clinic's everyday life remains a challenge. Interestingly, the number of people who thought SAR did not make their work easier, already high at the start of the study, increased after 2 weeks of exposure, while the number of people who were ready to integrate robots to their daily routines also stayed high. This increase suggests that 2 key factors may be necessary for the successful implementation of SARs in aged care settings. First, a high level of customization is required to ensure that SARs meet the specific demands of aged care. For example, in our experiment, the software design lacked an iterative development approach that would have allowed user feedback to shape and refine the robot's features and behavior. Second, it seems important to equip health care professionals with established methods and routines tailored to meaningfully incorporate SARs into their workflows. This dual approach-favoring iterative, user-driven customization with the provision of well-defined routines-may play an important role in increasing the perceived utility and acceptance of SARs in daily health care practices.

Although participants found SARs relatively easy to use, this does not mean that these robots inherently facilitate human tasks unless their implementation is carefully planned. For SARs to be truly effective, health care professionals need to be confident that robots can be trusted to provide real support, and it is up to senior stakeholders, such as management, to clearly demonstrate how SARs can positively impact staff's daily routines. Furthermore, it is possible that SARs may not significantly reduce the workload of health care professionals, but rather provide greater value by improving the quality of life and meaningful experiences for patients. It is important to understand whether SARs can fulfill this role effectively, and future research should explore this potential by assessing the long-term impact of SARs on both patient well-being and health care provider job satisfaction.

### Limitations

Some limitations of the study must be acknowledged. First, SARs were tested in one nursing clinic in a relatively short period of time, so the findings cannot be generalized to all Estonian health care workers. Second, the study site was located in the capital of Estonia, and the study does not provide an overview of possible differences in perceptions in rural or peripheral areas, which could be important in terms of general trust in the use and ability to use technology in older adults care settings. Third, due to piloting in a single care clinic, we also had a limited sample of 45 participants with a participation rate of <50% in the pretest phase and even lower in the posttest period. This decline is likely due to a combination of the following factors: (1) loss of interest in the technology—some participants may have lost interest in SARs after initial engagement, perceiving limited personal benefits or finding the technology less impactful than expected; and (2) focus on primary responsibilities-it is likely that, for reasons discussed in the introduction, participants found it difficult to allocate extra time to nonessential tasks such as the SAR study. In addition, the implementation scenarios for Temi v3 robot in this study were specifically designed to act on an auxiliary basis, without impact on the day-to-day care processes (ie, the robot did not participate independently directly in treatment nor tendance, making it more difficult for the employees to grasp the beneficial impact of using the robot on their tasks). The study did not include nursing clinic patients and focused on the perspective of health care professionals, so it is not clear whether and how professionals' perceptions would change if patients liked or disliked SARs, eg, whether acceptance would be higher or fears and emotions lower if patients perceived SAR as useful and acceptable. Despite all these limitations, we believe that this study provides valuable information on the potential of implementing SARs in nursing clinical care, outlining areas that need to be considered in future research and implemented in daily practice.

### **Implications for Future Research and Practice**

The results of the study confirm the need for a step-by-step and inclusive approach to the integration of SARs that considers the emotional dimensions of older adults' care, concerns about job displacement, and varying levels of technological readiness. Future research should explore strategies to maintain engagement among all age groups, particularly among older health professionals who may find SARs distracting or irrelevant. Longitudinal studies can provide deeper insight into how SARs affect patient and staff experiences over time, allowing researchers to track changes in perceptions as SARs become more common in health care settings. In addition, continued exploration of SARs in different roles, such as logistics and routine support, is vital to identify where SARs add the most value without compromising the essential "human touch" of aged care.

### **Data Availability**

Data will be promptly made available by the corresponding author upon request.

# **Conflicts of Interest**

None declared.

# References

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- 1. Leoste J, Marmor K, Kangur K, Budagov F, Rossi M. The potential of using social service robots in the healthcare environment. Presented at: Tenth International Conference on Higher Education Advances; Jun 18-21, 2024; Valencia, Spain. [doi: 10.4995/HEAd24.2024.18983]
- Choi M, Sempungu JK, Lee EH, Lee YH. Living longer but in poor health: healthcare system responses to ageing populations in industrialised countries based on the Findings from the Global Burden of Disease Study 2019. BMC Public Health 2024 Feb 22;24(1):576. [doi: 10.1186/s12889-024-18049-0] [Medline: 38388412]
- 3. Jones CH, Dolsten M. Healthcare on the brink: navigating the challenges of an aging society in the United States. NPJ Aging 2024 Apr 6;10(1):22. [doi: 10.1038/s41514-024-00148-2] [Medline: 38582901]
- Papadopoulos I, Koulouglioti C, Lazzarino R, Ali S. Enablers and barriers to the implementation of socially assistive humanoid robots in health and social care: a systematic review. BMJ Open 2020 Jan 9;10(1):e033096. [doi: 10.1136/bmjopen-2019-033096] [Medline: 31924639]
- Bieber G, Haescher M, Antony N, Hoepfner F, Krause S. Unobtrusive vital data recognition by robots to enhance natural human–robot communication. In: Korn O, editor. Social Robots: Technological, Societal and Ethical Aspects of Human-Robot Interaction: Springer; 2019:29-49. [doi: 10.1007/978-3-030-17107-0\_5]
- 6. Kim Y, Kwak SS, Kim MS. Am I acceptable to you? Effect of a robot's verbal language forms on people's social distance from robots. Comput Human Behav 2013 May;29(3):1091-1101. [doi: 10.1016/j.chb.2012.10.001]
- 7. Leoste J, Strömberg-Järvis K, Robal T, Marmor K, Kangur K, Rebane AM. Testing scenarios for using telepresence robots in healthcare settings. Comput Struct Biotechnol J 2024 Dec;24:105-114. [doi: 10.1016/j.csbj.2024.01.004]
- 8. Sather III R, Soufineyestani M, Imtiaz N, Khan A. Assistive robots designed for eldery care and caregivers. Indian J Respir Care 2021;3(1):1 [FREE Full text] [doi: 10.5430/ijrc.v3n1p1]
- Vaughn J, Shaw RJ, Molloy MA. A telehealth case study: the use of telepresence robot for delivering integrated clinical care. J Am Psychiatr Nurses Assoc 2015;21(6):431-432. [doi: <u>10.1177/1078390315617037</u>] [Medline: <u>26597906</u>]
- Koceska N, Koceski S, Beomonte Zobel P, Trajkovik V, Garcia N. A telemedicine robot system for assisted and independent living. Sensors (Basel) 2019 Feb 18;19(4):834. [doi: <u>10.3390/s19040834</u>] [Medline: <u>30781647</u>]
- 11. Papadopoulos C, Castro N, Nigath A, et al. The CARESSES randomised controlled trial: exploring the health-related impact of culturally competent artificial intelligence embedded into socially assistive robots and tested in older adult care homes. Int J Soc Robot 2022;14(1):245-256. [doi: 10.1007/s12369-021-00781-x] [Medline: 33907589]
- 12. Trost MJ, Ford AR, Kysh L, Gold JI, Matarić M. Socially assistive robots for helping pediatric distress and pain: a review of current evidence and recommendations for future research and practice. Clin J Pain 2019 May;35(5):451-458. [doi: 10.1097/AJP.00000000000688] [Medline: 30951515]
- 13. Otaka E, Osawa A, Kato K, et al. Positive emotional responses to socially assistive robots in people with dementia: pilot study. JMIR Aging 2024 Apr 11;7(1):e52443. [doi: <u>10.2196/52443</u>] [Medline: <u>38623717</u>]
- 14. Hun Lee M, Siewiorek DP, Smailagic A, Bernardino A, Bermúdez i Badia S. Design, development, and evaluation of an interactive personalized social robot to monitor and coach post-stroke rehabilitation exercises. User Model User-Adap Inter 2023 Apr;33(2):545-569. [doi: 10.1007/s11257-022-09348-5]
- 15. Lei M, Clemente IM, Liu H, Bell J. The acceptance of telepresence robots in higher education. Int J Soc Robot 2022;14(4):1025-1042. [doi: 10.1007/s12369-021-00837-y] [Medline: 35103081]
- 16. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 1989 Sep;13(3):319. [doi: 10.2307/249008]
- 17. Venkatesh V, Morris MG, Davis GB, Davis FD. User acceptance of information technology: toward a unified view. MIS Q 2003;27(3):425. [doi: 10.2307/30036540]
- Zakerabasali S, Ayyoubzadeh SM, Baniasadi T, Yazdani A, Abhari S. Mobile health technology and healthcare providers: systemic barriers to adoption. Healthc Inform Res 2021 Oct;27(4):267-278. [doi: <u>10.4258/hir.2021.27.4.267</u>] [Medline: <u>34788907</u>]
- 19. AlQudah AA, Al-Emran M, Shaalan K. Technology acceptance in healthcare: a systematic review. Appl Sci (Basel) 2021;11(22):10537. [doi: 10.3390/app112210537]
- 20. Czaja SJ, Boot WR, Charness N, Rogers WA, Sharit J. Improving social support for older adults through technology: findings from the PRISM randomized controlled trial. Gerontologist 2018 May 8;58(3):467-477. [doi: 10.1093/geront/gnw249] [Medline: 28201730]
- 21. Broadbent E, Stafford R, MacDonald B. Acceptance of healthcare robots for the older population: review and future directions. Int J of Soc Robotics 2009 Nov;1(4):319-330. [doi: 10.1007/s12369-009-0030-6]
- 22. Frey CB, Osborne MA. The future of employment: How susceptible are jobs to computerisation? Technol Forecast Soc Change 2017 Jan;114:254-280. [doi: 10.1016/j.techfore.2016.08.019]
- 23. Turja T, Aaltonen I, Taipale S, Oksanen A. Robot acceptance model for care (RAM-care): a principled approach to the intention to use care robots. Inf Manag 2020 Jul;57(5):103220. [doi: <u>10.1016/j.im.2019.103220</u>]
- 24. Mitzner TL, Boron JB, Fausset CB, et al. Older adults talk technology: technology usage and attitudes. Comput Human Behav 2010 Nov 1;26(6):1710-1721. [doi: 10.1016/j.chb.2010.06.020] [Medline: 20967133]
- 25. Barnard Y, Bradley MD, Hodgson F, Lloyd AD. Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability. Comput Human Behav 2013 Jul;29(4):1715-1724. [doi: 10.1016/j.chb.2013.02.006]

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- 26. Aschbrenner KA, Kruse G, Gallo JJ, Plano Clark VL. Applying mixed methods to pilot feasibility studies to inform intervention trials. Pilot Feasibility Stud 2022 Sep 26;8(1):217. [doi: 10.1186/s40814-022-01178-x] [Medline: 36163045]
- 27. Sharkey A, Sharkey N. Granny and the robots: ethical issues in robot care for the elderly. Ethics Inf Technol 2012 Mar;14(1):27-40. [doi: 10.1007/s10676-010-9234-6]
- 28. Parasuraman R, Riley V. Humans and automation: use, misuse, disuse, abuse. Hum Factors 1997 Jun;39(2):230-253. [doi: 10.1518/001872097778543886]
- 29. Lee JD, See KA. Trust in automation: designing for appropriate reliance. Hum Factors 2004;46(1):50-80. [doi: 10.1518/hfes.46.1.50.30392] [Medline: 15151155]
- 30. Parasuraman A. Technology readiness index (TRI): a multiple-item scale to measure readiness to embrace new technologies. J Serv Res 2000;2(4):307-320. [doi: 10.1177/109467050024001]
- 31. Turja T, Van Aerschot L, Särkikoski T, Oksanen A. Finnish healthcare professionals' attitudes towards robots: Reflections on a population sample. Nurs Open 2018 Jul;5(3):300-309. [doi: 10.1002/nop2.138] [Medline: 30062023]
- 32. Czaja SJ, Lee CC. The impact of aging on access to technology. Univ Access Inf Soc 2007 Mar 19;5(4):341-349. [doi: 10.1007/s10209-006-0060-x]
- Yusif S, Soar J, Hafeez-Baig A. Older people, assistive technologies, and the barriers to adoption: a systematic review. Int J Med Inform 2016 Oct;94:112-116. [doi: <u>10.1016/j.ijmedinf.2016.07.004</u>] [Medline: <u>27573318</u>]

## Abbreviations

CARESSES: Culture-Aware Robots and Environmental Sensor Systems for Elderly Support HRI : human-robot interaction SAR : Socially Assistive Robot TAM: Technology Acceptance Model TRI: Technology Readiness Index UTAUT: Unified Theory of Technology Acceptance and Use

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# Detailed Analysis and Road Map Proposal for Care Transition Records and Their Transmission Process: Mixed Methods Study

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# Abstract

**Background:** The digitalization of health care in Germany holds great potential to improve patient care, resource management, and efficiency. However, strict data protection regulations, fragmented infrastructures, and resistance to change hinder progress. These challenges leave care institutions reliant on outdated paper-based workflows, particularly for patient data transmission, despite the pressing need for efficient tools to support health care professionals amid a nursing shortage and rising demand for care.

**Objective:** This paper aims to analyze Germany's care transition record (CTR) and CTR transmission process as part of transition management and suggests improvements toward a seamless digital solution.

**Methods:** To understand the current challenges of manual CTR transfers, we used a mixed methods approach, which included a web-based questionnaire with nursing professionals, field observations, business process model and notation modeling, semantic and frequency analysis of CTR entries, and user story mapping.

**Results:** A web-based questionnaire involving German nursing professionals (N=59) revealed considerable delays in patient care due to manual, patient-transferred CTRs. Of the 33 usable responses (n=33), 70% (n=23) of the respondents advocating for digital transmission to improve efficiency. Observations (N=11) in care facilities (n=5, 45%) and a hospital (n=6, 55%) confirmed the high administrative burden, averaging 34.67 (SD 10.78) minutes per CTR within a hospital and 44.6 (SD 20.5) minutes in care facilities. A semantic analysis of various CTRs (N=4) highlighted their differences and complexity, stressing the need for standardization. Analyzing a new CTR standard (care information object CTR) and manually mapping an existing CTR to it showed that the procedure was ambiguous, and some associations remained unclear. A frequency analysis of CTR entities revealed which were most used. In addition, discussions with care staff pointed out candidates for the most relevant entities. On the basis of the key findings, a stepwise transition approach toward a road map proposal for a standardized, secure transfer of CTRs was conceptualized. This road map in the form of a user story map, encompassing a "CTR transformer" (mapping of traditional CTRs to a new standard) and "care information object CTR viewer/editor" (in short, CIO-CTR viewer and editor; a new standard for viewing, editing, and exporting), shows a possibility to bridge the transition time until all institutions fully support the new standard.

**Conclusions:** A future solution should simplify the overall CTR transmission process by minimizing manual transfers into in-house systems, standardizing the CTR, and providing a secure digital transfer. This could positively impact the overall care process and patient experience. With our solutions, we attempt to support care staff in their daily activities and processes until nationwide state regulations are implemented successfully, though the timeline for this remains uncertain.

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## **KEYWORDS**

care transition record; transmission management; observations; process modeling; telematics infrastructure; TI; Fast Healthcare Interoperability Resources; FHIR; Health Level 7; HL7; medical information object; MIO; care information object care transition record; CIO-CTR; Pflegerisches Informationsobjekt-Überleitungsbogen; PIO-ULB; artificial intelligence; AI

# Introduction

# Digitalization in Health Care in Germany

Digitalization has emerged as a transformative force across various sectors, fundamentally altering organizational operations and service delivery. Health care is one sector benefiting significantly from digitalization as it can support patient care, resource management, and overall efficiency [1,2].

The growing shortage of qualified nursing personnel and the rising number of people needing care signify the need for more efficient, high-quality processes and tools to support health care professionals. Digital solutions offer a pathway to address these challenges by automating administrative tasks, improving communication between health care providers, and freeing up valuable time for direct patient care [3-5]. In Europe, policy makers, researchers, and health care practitioners are working to enhance health care infrastructure and promote interoperability to foster more efficient and coordinated care [6]. However, in Germany, the digital transformation of health care remains slow and faces significant obstacles [3,7,8].

Stringent data protection regulations for the processing of personal data (eg, the European Union's General Data Protection Regulation [GDPR] and Germany's Patient Data Protection Act, derived from the GDPR [9]) and fragmented technical infrastructures combined with the resistance to change make it difficult to integrate new tools or adjust existing processes [7,10]. In addition, the lack of a unified digital strategy further hinders the seamless implementation of digital health solutions [7,10].

Ultimately, the complexity of implementing digital solutions in the German health care system stems from balancing innovation with regulatory compliance, data security, and protecting patient privacy.

### **Care Transmission Process in Germany**

A critical challenge within health care digitalization is ensuring the seamless transition of patient information between health care institutions. Paper-based workflows, still prevalent in many facilities, often cause delays and data loss during the transfer process due to the lack of standardized formats and the inability to share data in time.

Our research focuses on streamlining parts of the care transition record (CTR) transmission process to address this issue. The project's goal is to improve the transfer of patient data across care institutions, which currently suffer from time-consuming manual data entry, format inconsistencies, and delays in the arrival of crucial patient information.

# State of the Art

# Health Care Data Exchange

A security-conformant approach for digital transfer is the use of a dedicated health data (transfer) network. In Europe, such a service must be conformant to the GDPR, that is, legal compliance (ensuring data privacy and security), patient data control (data consent management for patients), data security (only access by authorized users, protection against breaches), and interoperability (fostering data exchange between different health care providers across various platforms) [9].

The telematics infrastructure (TI) is Germany's digital health data network designed to connect all health care providers, enabling the exchange of medical data across institutions [11]. It integrates various applications to streamline communication between health care entities such as physicians, hospitals, and pharmacies.

A specific way to exchange health data within a health data network is via an electronic health record. An electronic health record represents the digital version of a patient's medical history maintained over time by health care providers. It includes key clinical data relevant to patient care, such as medical history, diagnoses, medications, treatment plans, immunization dates, allergies, radiology images, and laboratory results. It is possible to share the patient data with other health care stakeholders, including the patient [12,13].

Several countries have made significant progress in this area, for example, the electronic patient dossier from Switzerland [14,15], electronic health record (Elektronische Gesundheitsakte) from Austria [16], MyKanta from Finland [17,18], and Mon espace santé from France [19]. They offer structured consent management for patients, meet the high security standards of the European Union, and foster interoperability by using the standard Fast Healthcare Interoperability Resources Health Level 7 (HL7), for exchanging electronic health care data.

The implementation of Germany's electronic patient record (ePA) [20] is progressing; however, it faces challenges. Many health care providers are not yet integrated, and patients must manually upload data. Technical and privacy issues, including interoperability concerns and strict data protection laws, continue to hinder broader adoption and use [21,22].

Another component within the TI is Kommunikation im Medizinwesen (KIM). It is a communication service with which health data can be exchanged directly by care providers, such as via email [23]. Nationwide implementation of the TI has been slow due to interoperability challenges. Adoption has lagged, primarily due to concerns over complexity, costs, and workflow disruptions. Health care professionals are hesitant to fully transition to digital tools because of these technical difficulties and the perceived burden of TI integration. There are 2 model projects in Germany [24,25] piloting and evaluating

the TI and including components (eg, KIM and ePA). Unfortunately, no detailed evaluation reports have been published yet.

# Standardization of Health Care Data

Standardization is a significant aspect that can improve the transfer of patient data in terms of reducing potential manual data entry and format inconsistencies. Standardizing CTRs is a potential possibility for improving the CTR transmission process. In Germany, 2 subsequent projects have focused on this issue: the first project is the ePflegebericht.

The ePflegebericht Project (electronic nursing report) began in 2002 when the Network for Continuity of Care in the Osnabrück Region [26] developed the concept for an electronic nursing report [27]. Insights from testing this software and its transition forms were gathered in a project under the patronage of the German Nursing Council starting in 2006. These insights were generalized beyond local use, placed in an international context [28], and aligned regionally and nationally [29]. The result was then submitted for approval as an HL7 standard [30].

The ePflegebericht served as a data exchange format for sharing information between care facilities and hospitals. It is based on the HL7 Clinical Document Architecture standard described in the study by Flemming et al [31]. The study validated the HL7 Clinical Document Architecture-based ePflegebericht and confirmed that it could cover all relevant nursing data compared with 114 paper-based nursing summaries used by 806 health care facilities in Germany. The ePflegebericht provided a comprehensive structure for transferring nursing information, demonstrating its applicability during care transitions. It improved the transmission of nursing data compared to paper-based methods, adding details such as social and homecare information, leading to more holistic documentation. Technically, advancements such as reusable templates were also introduced. These updates led to the relaunch of the ePflegebericht, with slight modifications, and in 2019, it was again up for approval.

The introduction of the ePflegebericht marks a significant advancement in the standardization of CTRs in Germany. A nationwide initiative aiming to develop a standard format for a variety of health-related documents (ie, medical information objects [32]) used the ePflegebericht as a foundational model for their CTR format: Pflegerisches Informationsobjekt-Überleitungsbogen (PIO-ULB). In this paper, the authors refer to the PIO ULB as care information object (CIO) CTR. This initiative was commissioned by the German government and overseen by the Gesetzliche Krankenversicherung Spitzenverband (central representative body of the statutory health and nursing care funds in Germany), and the mio42 GmbH (organization that develops medical information objects on behalf of the National Association of Statutory Health Insurance Physicians [Kassenärztliche Bundesvereinigung]). Furthermore, it involved the collaboration of the Deutscher Berufsverband für Pflegeberufe eingetragender Verein (DBfK; German Professional Association for Nursing Professions eingetragender Verein), and the Deutscher Pflegerat eingetragender Verein (German Nursing Council eV) [32].

CIO-CTR uses HL7 Fast Healthcare Interoperability Resources datasets, as described in the publication by mio42 GmbH [33], and was completed by the end of 2022. However, there is still uncertainty regarding the swift implementation of this new standard, primarily due to the financial and human resource challenges faced by health care software manufacturers who must adapt their existing products to comply with the specification, which spans approximately 2000 pages (XML code), as shown in mio42 GmbH [34]. The CIO-CTR will be effective at the beginning of 2025 [34] but without legal obligation for software manufacturers to implement it.

# Objectives

This paper aims to analyze and address the challenges of the CTR transmission process in Germany. On the basis of a review of the current situation and possible approaches, a road map toward a fully digital, seamless solution is to be proposed. The overall goal is to improve the transfer of patient care data across care institutions.

# Methods

Several methods were used to assess the satisfaction of nursing staff in the context of patient data transfer in care facilities in Germany. These include the creation of a web-based questionnaire, conducting field observations and contextual inquiries, business process model and notation (BPMN) modeling, semantic and frequency analysis of existing CTRs, and user story mapping. The findings are presented in this paper.

# Web-Based Questionnaire

A web-based survey was conducted to identify challenges and preferences related to the CTR transmission process. The survey targeted nurses, nursing assistants, and trainees working in ambulatory, acute inpatient (eg, hospitals), or long-term care settings familiar with the CTR process. Participation was solicited through various channels, including the Bavarian State Ministry of Health and Prevention and the professional networks of project members. Due to a low initial response rate, the survey period was extended, and multiple reminders were issued. Using LimeSurvey, the survey ran from February 11, 2022, to April 30, 2022.

The questionnaire, developed iteratively by the project team (developers; care managers; and ethical, legal, and social issue experts), was based on literature and included custom questions and items from the validated Copenhagen Psychosocial Questionnaire tool [35]. Copenhagen Psychosocial covered 12 domains, such as Questionnaire items sociodemographic information (eg, gender, age, and work setting). Additional items focused on the experience with CTR creation and transmission, error rates, and attitudes toward digitalization. The 24-item questionnaire primarily used 4-point Likert scales, supplemented by nominal, metric scale, and open-ended questions. Respondents could opt out at any time, and all data were anonymized. A pretest with 7 participants from 2 independent institutions (implementation and nursing sciences) identified several structural and technical issues, which were addressed in a second pretest round. The same individuals tested the final version and did not reveal any issues.

Data analysis was conducted using SPSS (version 28.0.0.0; IBM Corp). Responses to open-ended questions were categorized using Microsoft Excel, and the data were checked for erroneous entries before being analyzed, focusing on descriptive statistics.

#### **Field Observations and Contextual Inquiries**

#### **Overview**

Field observations and contextual inquiries were conducted in a hospital and inpatient care facilities to understand the CTR transmission process thoroughly. These methods focused on the activities of care staff in their natural work environments, providing foundational insights for process modeling and research. The CTR transmission process in this study refers to all activities involved in creating a CTR at the sending facility and integrating it into the in-house system at the receiving facility, including the use of computer equipment, work tools, and telephone calls, while accounting for potential confounding factors. The observations aimed to clarify whether staff entered all data from the CTR at once or alternated between tasks.

#### Field Observation

Field observation, a qualitative research method, involves systematically observing participants in their natural settings to collect rich, contextual data on behaviors, interactions, and the surrounding environment [36]. An observation protocol was established to ensure consistency across sites and sessions, focusing on key areas such as activities performed, use of aids (eg, software and hardware), how information was handled and transferred, and any special features or abnormalities. Unobtrusive observation techniques were used to minimize observer effect, and detailed field notes were recorded, capturing both activities and nonverbal cues.

### **Contextual Inquiry**

Contextual inquiry, a user-centered design method, was used to observe participants in their natural work environments while engaging in informal conversation to ask questions or clarify processes. This approach provided a deep understanding of the context in which tasks were performed and the challenges faced by users [37,38]. These inquiries, which were conducted primarily in participants' offices, allowed researchers to ask questions during task performance, facilitating an exploration of thought processes and decision-making, particularly with complex systems.

### Execution

The observations and inquiries were conducted by 2 researchers, one with a medical background and the other specializing in user-centered design, ensuring comprehensive documentation and minimizing potential biases. The field observations and the contextual inquiries followed the same protocol. Thematic analysis [39] was applied to the data, with the researchers collaboratively reviewing and coding field notes to identify relevant patterns that informed the process modeling. In less formalized care facility environments, contextual inquiries were preferred, with researchers assuming an apprentice role to ask clarifying questions without disrupting workflows. The observations were restricted to on-site care staff and did not include patients or external personnel (eg, patient transport). Observations occurred between 2020 and 2022, with no specific temporal or spatial restrictions within the facilities. Each observation was planned for 1 hour each.

### **Ethical Considerations**

All studies adhered to ethical guidelines, and informed consent was obtained from participants. All data were anonymized. No incentives were offered. Ethics approval for the study was granted by the joint ethics committee of the Universities of Bavaria (GEHBa-202107-V-028).

## **BPMN Modeling of CTR Transmission Process**

BPMN is an established and widely used graphical representation for modeling business processes. It is a standard developed by the Object Management Group (OMG) and has been adopted as an International Organization for Standardization (ISO) standard.

In BPMN, a process is represented as a sequence of activities or events, ordered in a flow that can be split or merged using gateways, directing the flow into one or multiple paths. Due to its simplicity, business process managers have widely used this standard in many application domains. Despite not being explicitly designed for clinical processes, BPMN has proven its value in the health care domain, allowing an easy-to-understand representation of clinical processes [40,41].

#### Semantic Analysis of CTRs

Semantic analysis is a good approach to extract and interpret the meaning of terms and sentences in detail. In the discipline of computer science, it is a fundamental component of natural language processing [42,43].

For semantic analysis, CTRs (empty and filled with fictive patient data) from cooperation facilities (n=4) were analyzed and compared in detail to better understand their structure, similarities, and differences. For clarification of any questions (eg, exact meaning, relevance, or scope of a specific category or word and overall comprehension), 1 meeting per facility with care staff was held. Given the semistructured to unstructured nature of the CTRs, it was critical to determine which data elements hold the same or different information compared to another facility. The meetings (n=4) lasted approximately 60 minutes.

Afterward, the CTRs were mapped to the new CIO-CTR standard. For this, the CTR entries were subdivided into entities and values and afterward mapped with pen and marker to the new standard format CIO-CTR.

## **Frequency Analysis of CTR Entities**

Frequency analysis [44] is a method used to determine how often specific elements occur within a dataset, both in absolute terms and as a proportion of the total data. In this study, frequency analysis was applied to assess the occurrence of individual CTR entities to determine which pieces of information are most included. This helped inform the design of the proposed digital solution, ensuring that it prioritizes the most frequent CTR entries.



User story mapping [45] is a user-centric bottom-up technique used to outline a product or product feature. The output, known as a story map, provides a global view of the product, detailing the steps a user takes to achieve a specific outcome. This method helps prioritize tasks, identify dependencies, and adapt to changes.

Story maps are organized along 2 dimensions: the backbone (horizontal axis), which represents the user's activities step by step, and the release dimension (vertical axis), which defines the scope of the product and its various stages of development. A commonly used format for user stories is the role-feature-reason format: "As a <user>, I want to <feature> so that <value>" [45]. While a story backlog lists user stories in isolation, user story mapping provides a structured, global view of the entire application, fostering a common understanding between developers and stakeholders. This method also communication, helping eliminate encourages to misunderstandings early in the development cycle.

In the story mapping workshop, results from previous requirement analysis—including user feedback, product vision, and initial process modeling—are used to create actionable user

 Table 1. Sociodemographic information of participants (n=33).

stories. The key objectives of the workshop included understanding the user's perspective, identifying potential gaps, prioritizing, and release planning.

In total, 2 workshops were conducted, involving a total of 7 participants. These participants were part of the core research project team, bringing diverse expertise from various disciplines: health care (n=2, 29%), computer science (n=3, 43%), design (n=1, 14%), and IT security (n=1, 14%). All 7 (100%) participants attended both workshops, ensuring continuity and consistency in the discussions and decisions.

# Results

# Web-Based Questionnaire

A total of 59 participants participated in the web-based survey to determine the experiences and needs of nursing professionals regarding care transition reports, of which 35 (59%) met the inclusion criteria. Of the 35 participants, 2 (6%) did not finish the survey, resulting in 33 usable datasets. In Table 1, specific sociodemographic information about the participants is provided. An overview of the systems or software used is also provided in Table 2.

Characteristics	Participants, n (%)
Gender	
Women	22 (67)
Men	10 (30)
Nonbinary	1 (3)
Age group (y)	
18-24	2 (6)
25-34	13 (40)
35-44	7 (21)
45-54	8 (24)
>55	3 (9)
Care setting	
Short-term care (outpatient)	2 (6)
Acute inpatient care (hospital)	28 (85)
Long-term care (care facility)	3 (9)
Federal state (within Germany)	
Bavaria	32 (97)
Berlin	1 (3)



Table 2. Information about the system or software used.

Information	Participants, n (%)					
System or software used for the creation of CTRs <sup>a</sup>						
I use software	20 (61)					
I do not know	4 (12)					
I use a paper form	5 (15)					
I use a paper form and software	3 (9)					
Not specified	1 (3)					
Specific software used						
ORBIS (by Dedalus)	16 (49)					
C&S	1 (3)					
SAP	1 (3)					
Sic Pflegeassistent (by CGM SYSTEMA SIC)	1 (3)					
SnapAmbulant (by euregon)	1 (3)					
Sorian	1 (3)					
Not specified	12 (36)					

<sup>a</sup>CTR: care transition record.

The high percentage of female participants (22/33, 67%) reflects the well-established predominance of women in nursing. The concentration of participants in the 25 to 34 age group suggests that the web-based survey may have been more appealing or accessible to younger adults. In addition, during the COVID-19 pandemic, care professional faced more stress and work, which might have led to a discouragement of answering a questionnaire that does not benefit their daily work.

The overwhelming representation of acute inpatient care (28/33, 85%) indicates a strong representation of hospitals in the questionnaire.

Of all the federal states in Germany, approximately all participants were from Bavaria (32/33, 97%) and only very few from Berlin (1/33, 3%). The overall overwhelming representation from Bavaria is probably due to the location of the research team, indicating that the recruiting efforts were particularly successful in this region despite numerous efforts to reach other care facilities and hospitals.

The results of the system or software used (Table 2) show that most (20/33, 61%) participants used software to create CTRs. Only 15% (5/33) of the participants used the paper form. Most (16/33, 49%) of the participants used the software ORBIS, reflecting the very high percentage of participants from hospitals, as ORBIS is a hospital information system. Sorian (1/33, 3%) is also a hospital information system. The other software listed (C&S, SAP, Sic Pflegeassistent, and Snap Ambulant) are documentation software used in the care facilities setting, which underlines the variety of software used.

Additional findings from the web-based questionnaire revealed that the CTRs were mainly transferred via the patient (27/33, 82%). This means that in these cases, the nurse gave the CTR to the patient as a printout, and the patient or the relatives were responsible for ensuring that it reached the next care facility.

As a result, the nursing staff at the receiving facility has limited time to fully prepare for the patient in advance. Preparations and admission begin once the patient arrives at the facility, which can lead to waiting times. This is consistent with the results from the field observations that were conducted. The remaining 18% (5/33) transferred the CTR via fax, patient file, or telephone.

This gives the nursing staff more time to prepare for the patient, for example, preparing for isolation, special therapy treatment, or similar. According to the survey, the manual transfer of the CTR into the in-house system takes an average of 45 minutes, and 61% (20/33) of care staff perceived the transfer process as time-consuming. Manual transfer means that the care professional copies the information from the printout using their hand (typing on the keyboard) and transfers it to their care software. This step is necessary to add further information to the patient file, for example, information from patient conversations and decisions on care measurements.

This process can be time-consuming, as the care staff alternates between referring to the printout and typing the information into the system. During that time, confounding factors such as telephone ringing, colleagues, or technical issues can arise, prolonging the process.

Due to the use of different software in various facilities, the information is often displayed or organized differently, resulting in additional work.

Regarding the digital transmission of CTRs (cross-institutional dispatch and automatic integration into the in-house system), most (23/33, 70%) participants expressed no concerns. However, 30% (10/33) of them raised issues, such as concerns about possible threats to patient data protection (4/33, 12%). Most (24/33, 72%) respondents hope digital CTR transmission will reduce administrative effort. Some (18/33, 55%) participants

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indicated that they favored the standardization of CTRs because standardization of CTRs would result in relevant information being found more quickly in the future. On the basis of the responses, the primary consideration in developing a new solution should ensure, for example, that receiving, sending, and creating a CTR is less time-consuming for nurses than in the current process.

All (33/33, 100%) participants stated that CTR standardization would help them a lot as the CTRs they work with are usually different in structure and semantics.

Concerning the essential information in CTRs, all (33/33, 100%) participants agreed that patient information, medication, aids, and last bowel movement are considered to be very relevant regarding a potential standardization of CTRs. Finally, their opinion on automatic data integration was asked; they were curious as to whether something like this is possible so that they do not need to copy and paste information manually.

### **Field Observations and Contextual Inquiries**

### Field Observations

The observations focused on the receiving side of the CTR, that is, the creation of a CTR in the in-house primary system. This means that the scenario of a receiving facility was always observed. This focus on the receiving facility was agreed upon through collaboration with the facilities due to the COVID-19 pandemic, as stricter visitor restrictions prevented parallel observation in both the sending and receiving facilities. In all cases, the transfer of a patient was announced in advance.

The observation occurred from the moment the nurse sat down at their computer to either create the patient case or fill it in. At the hospital, the cases are already created by the administration and contain information that is necessary for billing but does not influence the nursing documentation any further. One nurse was observed during every observation, but it was not necessarily every time the same as it depended on their schedule. While at the hospital, both field observations and contextual inquiries were conducted; only contextual inquiries took place in the care facility.

The results of field observations at University Hospital Augsburg (UHA; n=6) in 2020, showed a high administrative time burden for nurses (refer to Table 3 for the CTR transmission process). Manual recording of CTRs resulted in an average time expenditure of 34 minutes. The observations showed that the CTRs were not sent in advance but arrived with the patient. While entering the data into their in-house system, the care staff mentioned that they could not prepare adequately for the patient in advance (eg, by preparing medications and nursing aids). The field observation also showed that the nursing specialist endures many interruptions while entering the CTR (relatives, colleagues, physicians, telephone, patients, or emergency calls), forcing them to switch between different tasks very often. Therefore, the nurse had to refocus on the CTR repeatedly.

Table 3.	Overview of care	e transition record (CTR)	transmission process	observations at the hospital.
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Observa- tion	Observation dura- tion (min)	Software	Interrup- tions, n	Type of interruptions	Resource used for transferring data	CTR present (print)
1	50	ORBIS	5	Relatives, telephone, colleagues, physician, and missing information	Computer and tele- phone	Present
2	25	ORBIS	3	Telephone and missing information	Computer and tele- phone	Present
3	40	ORBIS	5	Relatives, telephone, colleagues, and ambulances	Computer and tele- phone	Present
4	45	ORBIS	4	Colleagues, physician, telephone, and pa- tients	Computer	Present
5	25	ORBIS	1	Physician	Computer	Present
6	23	ORBIS	3	Emergency calls and colleagues	Computer	Present

There was no direct association between observation duration and the care need of a patient; rather, it depended on the overall setting, for example, completeness of the available information, number of interruptions, and the length of the CTR.

The CTRs encountered in the field observations were all from different nursing homes with different lengths (approximately 12 and 30 pages). The information is primarily unstructured, that is, free text. Structured elements were primarily areas with checkboxes.

During the observations, many of the observed nurses complained that the manual transfer of the CTR was time-consuming. After the observation, the care staff were asked additional questions regarding the relevance of a digital CTR process, the most important information to be transferred, and their opinion about the fully automatic integration of the CTR data into the in-house system. The questions were open ended and digitally documented by the observer. In terms of relevance, all participants (n=6) said that the early, preferably digital, transfer of the CTR would hold immense value. It would help them to prepare in advance and obtain, for example, missing information and medication beforehand. It would reduce their administrative workload. In total, 3 (50%) of the 6 participants stated that the current process is frustrating as patients are often transferred before the weekend without medication, physician's notes, or aids. Without these things, they have to come up with makeshift solutions to care for the patients over the weekend.

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After conducting the field observations at the hospital, it became evident that specific questions remained unanswered and could not be answered fully in the follow-up discussion. These questions were about the specific functionalities of the software used and also specific work-arounds that were conducted by the care staff but not remembered after the observation. Therefore, one additional contextual inquiry was conducted.

## **Contextual Inquiries**

Contextual inquiries (n=5) were conducted in 2021-2022 at 2 care facilities and UHA (Table 4). The results of the contextual inquiries provided valuable insights into the observation duration, the confounding factors, and the aids used. For most observations, documents about the patient (eg, physician's letter, medication plan, and CTR) were available as printouts. These

were either sent with the patient or faxed to the referred institution. The latter could occur during registration or after inquiries about missing CTRs or information. The duration of 4 complete observations in care facilities and 1 hospital (excluding observation 2 because no input happened) averaged 47 minutes. In observation 2, it took 33 minutes to determine that no CTR was present, and it could not be sent from the sending facility. However, this required the nurse to make internal and external phone calls. She also needed to delegate procurement tasks to colleagues in the facility (eg, ask colleagues to check if the CTR might not be in the facility after all). In other cases, the CTR was handed out to the patient upon discharge but was not necessarily available right after the patient arrived at the receiving facility when the data were entered into the system.

**Table 4.** Overview of care transmission record (CTR) transmission process contextual inquiries, care facilities, and hospital. Care facilities are divided into facility 1 (CF1) and facility 2 (CF2).

Observa- tion	Facility	Observation duration (min)	Software	Number of inter- ruptions	Type of interruptions	Resource used for transfer- ring data	CTR present (print)
1	CF1	55	Connext Viven- di NG+PD	1	Telephone, colleagues, and technical problems	Computer, smartphone, telephone, pen, and fax	Present
2	CF2	33	None used	0	No CTR present	Computer, smartphone, telephone, and fax	Not present
3	CF1	78	Connext Viven- di NG+PD	5	Telephone and colleagues	Computer, smartphone, telephone, paper, and pen	Present
4	Hospital	20	ORBIS	2	None	Laptop, paper, and patient	Present
5	CF2	37	Sic Pflege-assis- tent	3	Telephone	Telephone, paper, and pen	Present

All nurses involved in the contextual inquiries noted that the transfer process was time-consuming, particularly if they needed to retrieve missing information and also because they had to refocus on CTR data input due to interruptions.

Another interesting observation was that the nurses at the care facilities combined information from the CTR, physician's letter, medication plans, and the initial interview with the patient and entered these in free-text fields.

After the contextual inquiries, the same questions were asked as in the field observations. The nurses responded very similarly.

Comparing the average observation duration of all care facilities (excluding observation 2 because no input happened) with the hospital shows that the care staff requires approximately 56 minutes in the care facilities and only 20 minutes at the hospital.

# **BPMN Modeling**

### **Overview**

On the basis of the findings of the observations, BPMN models were created to better understand the various CTR activities (creating, sending, and receiving). These were discussed with the respective facility and detailed in the previous publication. After discussion, it was determined that the process models of the 2 care facilities can be combined into 1 process, as the activities are identical. Furthermore, the models were divided into different lanes, making it easier to understand which

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activities are manual and which are software based (human-computer interaction).

# Transfer Process From Care Facility to Hospital

The process starts with the patient's need to be transferred (see Figure 1, Create and Send [Care Facility]). The nurse at the care facility creates a CTR, prints it, and usually hands it to the patient. Then, the patient arrives at the hospital, and the nurse at the hospital opens the patients' case file (see Figure 1, Receive and Process CTR Hospital). Afterward, she checks if the CTR printout is available and whether it is complete and error free (referring to the content of the CTR). Patients' case file is a digital file that contains the basic information of the patient for billing. As these files are prepared by the administration upon arrival of the patient, the care staff do not need to prepare those themselves.

If the CTR is complete and error free, she transfers the CTR into the hospital information system, prints the CTR in its specific structure, and files the CTR manually. After this, the CTR is processed, and the process is complete. If the CTR is unavailable, the nurse calls the sending care facility. The request is then processed there. If a CTR is missing, the sending facility creates a CTR, prints it, and sends it via fax to the hospital. Next, the nurse checks the document (eg, the correct CTR for the patient). After that, the CTR is transferred into the hospital information system, printed, and manually filed. Then, the process is complete.

Figure 1. Process modeling: care transition record (CTR) data transfer from the care facility to the hospital. CIS: case information system; HIS: hospital information system.



# Transfer Process From Hospital to Care Facility

A patient is transferred from the UHA (Figure 2) to a care facility. At the UHA, the nurse creates a CTR, prints it, and hands it to the patient. Upon arrival of the patient (now called resident), the nurse at the care facility logs into their care information system and checks if the resident has a printed CTR. If so, they start transferring the CTR into the system. Afterward, they print the document in a proprietary file format and file it manually, then the process is complete.

If the CTR is unavailable, the nurse requests it from the UHA via phone. In the UHA, the request is checked and processed. A CTR is created, printed, and transferred via fax. Upon receipt of the missing CTR, the nurse checks whether it is the correct CTR for the resident and verifies its completeness and validity. If there is missing or incorrect information, the nurse requests the missing information either from the UHA via telephone or directly through the resident or relatives (this option does not exist in the process at the hospital). After the arrival of the missing information, the nurse starts transferring the CTR, prints it from the care information system, and manually files it. The CTR is processed, and the process is complete.



Figure 2. Process modeling: care transition record (CTR) data transfer from hospital to care facility. CIS: case information system; HIS: hospital information system.



#### Semantic Analysis of CTRs

A total of 4 CTRs of cooperation facilities were analyzed regarding their structures, similarities, and differences. The analysis highlighted their different structures (eg, bowel movement on the front page or second or third page) or different wordings (eg, movement or mobility). The analysis and follow-up meetings with care staff revealed that this makes it challenging to work with CTRs effectively, as some of the most important fields are located at the end of the report. The meetings also revealed that the CTRs from the hospital are typically shorter ( $\leq$ 8 pages) and hold more structured information (checkboxes) than free-text fields. In comparison, CTRs from the care facilities are usually longer ( $\leq$ 20 pages) and include more free-text fields. The front pages of each analyzed CTR are shown in Figure 3, showcasing their different structure.

In the next step, a semantic analysis, including the mapping of CTRs to the new CIO-CTR standard, was conducted. This was done by assigning parts of the CTR to the data structure of the CIO-CTR (Figure 4). The green box represents a CIO-CTR resource, the white box represents the specification of the resource, and the red box represents the information of the CTR.

Throughout the process, it was realized that the mapping often cannot be done straightforwardly. There were some entities (eg, diagnosed diseases, deafness, aphasia, and limited vision) that could not be assigned to a single field in the CIO-CTR. This was mainly because some of the resources of the CIO-CTR format were too similar to each other. Most of the issues with overlapping assignability were resolved by further study of the CIO-CTR standard and discussion with the research team. For uncertain cases, meetings with mio42 GmbH (originator of the format) were held. Decisions regarding mappings were then based on their feedback. Nevertheless, in some cases, an assignment was still not possible. There was no resource element that provided information about whether the patient or resident had been transferred within a facility (internal; transmission, eg, within a hospital from one to another department) or outside (external; transmission from another facility).

Furthermore, some fields in the CIO-CTR are implemented as free-text fields, which makes unambiguous, error-free mapping difficult.

An excerpt of the mapping of site-specific CTRs of 2 facilities to the new standard CIO-CTR is shown subsequently. Mapping 1 focuses on the CTR of the UHA (Figure 5), and mapping 2 focuses on the CTR of 1 care facility (Figure 6). The visuals illustrate the overall complexity and difficulty of mapping each entity correctly. In mapping 1, it was possible to assign 147 (99.3%) of the 148 information objects from CTR to the CIO-CTR; in mapping 2, it was only possible to map 114 (91.2%) of the 125 information objects.

This raises the question of what should be done with the information that could not be mapped. One possibility would be to add it to the free-text fields.



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Figure 3. First page of care transition records (CTRs) from one hospital (1) and 3 care facilities (2-4).

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Figure 4. PDF care transition record (CTR) on the right with a free-text field (A, red rectangle) mapped to corresponding resources on the left (B, black and green rectangle, C).



**Figure 5.** Mapping 1: excerpt of the mapping of a care transition record (CTR) of the University Hospital Augsburg to the care information object (CIO) CTR standard (1 of the 6 pages). The X shows that one piece of information could not be mapped.



Figure 6. Mapping 2: excerpt of the mapping of a care transition record (CTR) of a care facility to the Pflegerisches Informationsobjekt (PIO) standard (1 of the 4 pages). The X shows that two pieces of information could not be mapped.



### **Frequency Analysis of CTR Entities at UHA**

The occurrence of individual data entities in 204 CTRs of UHA and 54 CTRs from care facilities was analyzed to find out their frequencies. As comparable field entries are needed for processing, only the CTRs of UHA were used for subsequent processing, as this dataset was the biggest.

An entity is understood as a single piece of information represented in the CTR by its input field.

On the basis of these results, a percentage for each entity was computed (entity is filled or not filled), and a frequency range was created (commonly used, occasionally used, and rarely used). These ranges estimate the frequency of entities in the nursing transition process and are shown as follows: (1) 100% to 50%: commonly used entities, (2) 49% to 25%: occasionally used entities, and (3) 24% to 0%: rarely used entities

The results of each entity were presented to care staff (n=2) at UHA who are involved in the CTR process for discussion. An extract of the results is presented in Table 5. It is important to note that the frequency analysis was limited to data that did not include personal information about patients (eg, date of birth, primary care physician, contact options, and religious affiliation), as the UHA anonymized the CTRs before further processing. However, during the discussion, the nursing staff stated that all personal data could be classified as very relevant.

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Table 5. Extract from the frequency analysis from University Hospital Augsburg care transition records (N=204).

		Frequency, n (%)
Ver	ry relevant (100%-50%)	
	Ability of self-body care	201 (98.5)
	Orientation ability	198 (97.1)
	Dressing	197 (96.6)
	Medication: reference to physician's letter	195 (95.6)
	State of consciousness	190 (93.1)
	Nutrition	188 (92.2)
	Mobility	179 (87.7)
	Presence of pain	177 (86.8)
	Main diagnosis	167 (81.9)
	Last bowel movement	149 (73.0)
	Items brought along (suitcase)	121 (59.3)
	The degree of care	115 (56.4)
Rel	evant (49%-25%)	
	Nursing-relevant secondary diagnoses	69 (33.8)
	The location of the pain	68 (33.3)
	The special features of the care process	58 (28.4)
Les	ss to not relevant (24%-0%)	
	Medication: reference to a medication plan	23 (11.3)
	Free-text field about pain	19 (9.3)
	Seamless request (yes or no)	17 (8.3)
	Pastoral care requested (yes or no)	3 (1.5)
	Aids ordered and their retailers	1 (0.5)
	Items brought along	
	Valuables	23 (11.3)
	Insurance card	22 (10.8)
	Identification	5 (2.5)
	Patient passport	0 (0.0)

Although the information about the main diagnosis (167/204, 82.3%), state of consciousness (190/204, 93%), and nutrition (188/204, 92%) occurs with high frequency in the dataset, their placement in the paper-based CTR is inadequate, as they appear relatively late in the document.

Another finding is that bowel movement is rated as an essential piece of information (149/204, 73%), but 55/204 (27%) do not include it in the CTR.

Medication information was also expected to be present more frequently; however, because this information is usually included in the physician's letter rather than in the CTR, the occurrence was only 11% (23/204).

Regarding items brought along, many selection possibilities were given in the UHA's CTR. Valuables (23/204, 11%) and insurance cards (23/204, 11%) had the highest frequency among

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them. However, no additional information about the individual items could be provided.

### **User Story Mapping**

There were 2 workshops conducted, involving a total of 7 participants. These participants were part of the core research project team, bringing diverse expertise from various disciplines: health care (n=2, 29%), computer science (n=3, 43%), design (n=1, 14%), and IT security (n=1, 14%). All 7 (100%) participants attended both workshops, ensuring continuity and consistency in the discussions and decisions. During the first workshop (hybrid, due to COVID-19 restrictions), participants used both physical materials (paper and whiteboards) and digital tools (Zoom [Zoom Communications] and chat) to record potential user stories. The process involved writing down ideas and then engaging in a collaborative card-sorting exercise to discuss and prioritize these stories. A whiteboard was used to document the structured user journey, which was shared with

online participants via camera, ensuring everyone had equal access to the visual information.

Between the first and second workshops, participants had approximately 2 weeks to reflect on the identified user stories and their potential impact on the development process. This period allowed the team to refine their understanding and prepare for the next stage of discussion, which focused on a stepwise implementation plan (release planning).

The second workshop was conducted entirely online using the tools Zoom and Miro. Miro is an online collaborative platform developed by RealtimeBoard Inc. The participants had time to share their reflections on the previous work, discuss it, and refine their understanding of the user journey. Afterward, the participants focused on creating release stages to guide the upcoming development. They collaboratively designed the user story map due to the workshops, which was continuously refined throughout the project. The final result, a road map proposal, can be seen in Figure 7. The Backbone section describes the backbone and the proposed solution's release stages.

In Figure 7, four release stages are shown on the left and divided into 4 colors to provide a better division throughout the user stories. Some story cards do not have color, as they apply to multiple release stages. The subsequent sections describe the use dimensions, backbone, release stages, and implementation scenarios.

Figure 7. Final user story mapping with 4 release stages (on the left). Colors are used to better distinguish between the stages. Some story cards do not have color, as they apply to multiple stages. AI: artificial intelligence; CIO: care information object; CTR: care transition record; KIM: Kommunikation im Medizinwesen.



# Backbone

The horizontal axis of the user story map shows the main activities that have to be performed sequentially to achieve care data exchange between facilities. These activities are referred to as epics and are listed in the top row of Figure 7. The user stories concretize the epics. One activity (translating CTR in target format) has to be performed only in an intermediate release stage, and it becomes obsolete as soon as all facilities use the standardized target format.

# **Release Stages**

A brief overview of all 4 release stages can be seen in Figure 7. A description of each stage is given in the subsequent sections.

# Release Stage 1: Use of CTR in PDF Format

The first release requires the least implementation effort but already meets one basic requirement: timely, digital transfer via the TI. The functionality is limited to conventional CTRs, typically in PDF format. This release requires both the sending and receiving care facilities to be connected to the TI. As usual, the sending facility creates a CTR in its facility-specific layout

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and transmits it using the KIM service. The receiving facility can then retrieve the CTR from its KIM mailbox.

# Release Stage 2: Creation of CIO-CTR via Editor

At the beginning of a transition process to the new standardized CIO-CTR format, few or no in-house systems will support the new standard. To remain independent from software manufacturers, a dedicated software module that can create, read, and edit CTRs in the new format ("CIO-CTR editor") would be beneficial. Nurses could use this editor to create CIO-CTRs and send them to the receiving institution via KIM. Particular emphasis should be placed on the user-centered design of the interface, particularly regarding the structure of the input options and how information is compiled. This could serve as a blueprint for later implementation in the proprietary software systems.

## Release Stage 3: Automatic Creation of CIO-CTR Based on PDF

Another, more complex way to create and transfer a CTR in the new standard format is to transform the conventional, proprietary CTR using an automatic artificial intelligence (AI)–based tool. On the basis of the previous analysis of CTRs, it can be assumed that most CTR data will be unstructured and provided in PDF

format. A transformer service could analyze this structure using AI and extract text sections with an optical character recognition module. The extracted content is then mapped to the CIO-CTR format. This approach would be relevant if a receiving facility is already capable of processing CIO-CTRs but receives a nonstandardized CTR via KIM. With a transformer, the new CTR-CIO format can be generated and imported with little extra effort.

# Release Stage 4: Automatic Export and Import of CIO-CTR

In this final stage, the care staff can create a CTR in the in-house system, export it as a CIO-CTR, and transfer it via the TI. After receiving the CIO-CTR, the receiving facility can then integrate it directly into their in-house system. The benefit is that neither a transformer service nor a separate editor would be needed, resulting in the least effort for the care staff. This requires the software manufacturers of the various care and medical information systems to fully support the new CIO-CTR format; however, it is unclear when this will happen.

# Discussion

# **Principal Findings**

Despite years of efforts toward digitalization in health care in Germany, our research shows that the creation and transmission of CTRs remain highly time-consuming, averaging 34.67 (SD 10.78) minutes at hospitals and 44.6 (SD 20.5) minutes in care facilities (findings from observations).

# Semantic Interoperability of CTRs Between Institutions

As health care systems transition toward digital formats, it becomes increasingly important to enable different institutions to exchange, understand, and use the transmitted data seamlessly. From the perspective of nursing science, discharge management has long been recognized as a crucial aspect of patient care. Efficient discharge processes ensure that patients receive continued care, reduce readmission rates, and improve overall patient outcomes. The CIO-CTR standard, introduced in December 2022, marks a significant step toward a fully digital exchange of CTR data. However, our study reveals that this progress has been hampered by a lack of widespread implementation and resistance. Because the CIO-CTR is not legally binding and the necessary updates are resource intensive for software manufacturers, they prefer to concentrate on more urgent issues. Thus, we propose an iterative, stepwise implementation approach that could gradually improve the situation.

# Iterative Implementation Approach

The user story map with the resulting release stages offers a step-by-step approach toward a seamless digital solution. As the overall issue is complex, changes cannot be expected simultaneously at all ends. A quick, early solution is the mere digital transfer of CTRs in existing, proprietary formats via a digital infrastructure (stage 1). For this, the institutions only have to be connected to the health data network (TI), as they are obliged by law in Germany by July 1, 2025 (according to §341 (8) SGB V [46]) and a KIM account is set up. Sending

CTRs in the institutions' traditional formats does not require them to have updated software that can read or export the new CIO-CTR format. At this stage, the time-consuming manual data transfer into the in-house systems is still required. The goal is for all software systems in all institutions to directly import and export CTRs in the new format, and for all the information to be integrated automatically into in-house systems (stage 4). During a transition time, when only some of the systems can process CTRs in the new format, certain incompatibilities will occur, which we want to address with interim solutions: the CIO-CTR viewer or editor (stage 2) and the CTR-transformer (stage 3).

For stage 1 (data transfer via TI), we accompany and assist our cooperating partner institutions in installing the necessary infrastructure to connect to the TI. In this regard, we plan to offer experience reports, which could lower the entry hurdle, particularly for care facilities.

For stage 2, we are developing an open-source software where CIO-CTRs can be created, viewed, and edited. This has several benefits: (1) developing an editor with a concrete suggestion for a user interface visualizing the CIO-CTR standard provides a figurative basis for discussion between developers, care professionals, and regulatory institutions; (2) bridging the gap for continuous digital transfer if not all institutions support the new digital standard; and (3) serving as a blueprint for software manufacturers who want to implement the new CIO-CTR.

Stage 3 introduces an automated process to convert CTRs from proprietary formats (eg, scanned PDFs) into the CIO-CTR format, using AI-based mapping. This solution is applicable when an institution that can process CIO-CTRs but receives a nonstandardized CTR. Of course, this automatic transfer would have to be reliable, and creating such a component would be complex, as many different proprietary formats exist, and as seen in the semantic mapping, a direct transfer is not possible in all cases.

Stage 4 represents the most desirable solution. Nurses would be able to work with an improved process without manual transfer of CTR data, potentially leading to a minimization of disruptions. The primary responsibility for implementing the CIO-CTR falls on system manufacturers. To facilitate this transition, the manufacturers could actively be supported by providing a reference implementation for the new standard, for example, conducting workshops and organizing related events. This collaborative effort would support a smooth and efficient integration of the CIO-CTR into existing systems while minimizing the burden on health care providers.

# **Contributions**

Our research used an iterative, user-centered methodological approach to develop a road map that helps overcome the current challenges in the CTR transmission process in Germany. This road map offers a practical, phased approach toward digital solutions, particularly valuable in settings where full-scale adoption of digital standards is not yet feasible. It provides health care providers with a flexible pathway to transition toward digital care processes without requiring immediate, costly

system changes. This road map is more than the mere definition of a new format; it supports gradual digital integration.

# Future Implications and Work

If the adoption of digital standards remains voluntary and lacks regulatory support, the duration required to establish a standard data format is likely to be prolonged. Without more vigorous regulatory enforcement and widespread buy-in from all stakeholders, the vision of seamless care transitions may remain out of reach. Therefore, future efforts must focus not only on technological solutions but also on fostering collaboration between regulators, software providers, and health care institutions to ensure the long-term success of health care digitalization.

Our current solution uses KIM as a means of transport within the TI. As soon as the ePA is more widely adopted in Germany, an exchange of the CTR via this means might be preferable over KIM. Future work has to investigate this further.

# Limitations

The COVID-19 pandemic posed significant challenges for data collection, particularly in gaining access to cooperative facilities. The necessary planning and multiple postponements due to visitor restrictions limited our ability to observe the complete care transition process.

The pandemic may have also introduced a selection bias in our web-based questionnaire. Nurses facing higher technical barriers

or those under significant stress due to pandemic-related demands may have been less likely to participate, which could skew the findings toward participants who were more technically adept or had fewer pandemic-related pressures.

Furthermore, the sample size of the web-based questionnaire (n=33 usable datasets), while offering valuable qualitative insights, limits the generalizability of our findings.

Our study used a qualitative research approach to gain in-depth, context-specific insights. The combination of field observations, contextual inquiries, and questionnaire data from hospital and care facilities provided a rich understanding of the practical barriers and opportunities in transitioning to digital CTR processes. The relatively small sample sizes for field observations (n=6) and contextual inquiries (n=5) were sufficient for this research's detailed, exploratory nature but could limit the robustness of the conclusions.

# Conclusions

A future solution should simplify the overall CTR transmission process by minimizing the manual transfers into the in-house systems, standardizing the CTR, and providing a secure digital transfer. Doing so could positively impact the overall care process and patient experience. With our suggestion for a stepwise solution, we attempt to make the complex task feasible, ultimately supporting care staff with their daily activities and processes.

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# **Authors' Contributions**

EVM, AM, CR, and AT were involved in the conceptualization. EVM, SB, LK, and MR were involved in formal analysis. EVM, SB, MR, LK, LD, ST, VW, CR, and AT were involved in the investigation. EVM, SB, MR, LK, LD, ST, and AT were involved in data curation. EVM, SB, MR, LK, and AT were involved in writing the original draft. EVM, SB, VW, and AT were involved in reviewing and editing the draft. EVM and LK were involved in visualization. AT was involved in supervising the study.

# **Conflicts of Interest**

None declared.

# References

- Wosik J, Fudim M, Cameron B, Gellad ZF, Cho A, Phinney D, et al. Telehealth transformation: COVID-19 and the rise of virtual care. J Am Med Inform Assoc 2020 Jun 01;27(6):957-962 [FREE Full text] [doi: 10.1093/jamia/ocaa067] [Medline: 32311034]
- 2. Lupton D. The digitally engaged patient: self-monitoring and self-care in the digital health era. Soc Theory Health 2013 Jun 19;11(3):256-270. [doi: 10.1057/sth.2013.10]
- 3. Gerke S, Stern AD, Minssen T. Germany's digital health reforms in the COVID-19 era: lessons and opportunities for other countries. NPJ Digit Med 2020 Jul 10;3(1):94 [FREE Full text] [doi: 10.1038/s41746-020-0306-7] [Medline: 32685700]
- 4. Implementing the European health data space across Europe. ThinkTank. URL: <u>https://eithealth.eu/wp-content/uploads/</u>2024/04/EIT Health ThinkTank Implementing the EHDS across Europe 23.04.24.pdf [accessed 2024-04-29]

- 5. Sauermann S, Herzberg J, Burkert S, Habetha S. DiGA a chance for the German healthcare system. J Eur CME 2022 Dec 23;11(1):2014047 [FREE Full text] [doi: 10.1080/21614083.2021.2014047] [Medline: 34992948]
- Baltaxe E, Czypionka T, Kraus M, Reiss M, Askildsen JE, Grenkovic R, et al. Digital health transformation of integrated care in Europe: overarching analysis of 17 integrated care programs. J Med Internet Res 2019 Sep 26;21(9):e14956 [FREE Full text] [doi: 10.2196/14956] [Medline: 31573914]
- Nohl-Deryk P, Brinkmann J, Gerlach F, Schreyögg J, Achelrod D. Hürden bei der Digitalisierung der Medizin in Deutschland – eine Expertenbefragung. Gesundheitswesen 2018 Nov 04;80(11):939-945. [doi: <u>10.1055/s-0043-121010</u>] [Medline: <u>29301149</u>]
- 8. Hansen A, Herrmann M, Ehlers JP, Mondritzki T, Hensel KO, Truebel H, et al. Perception of the progressing digitization and transformation of the German health care system among experts and the public: mixed methods study. JMIR Public Health Surveill 2019 Oct 28;5(4):e14689 [FREE Full text] [doi: 10.2196/14689] [Medline: 31661082]
- 9. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (general data protection regulation) (text with EEA relevance). Official Journal of European Union. URL: <u>https://op.europa.eu/en/publication/detail/-/publication/3e485e15-11bd-11e6-ba9a-01aa75ed71a1/language-en</u> [accessed 2024-04-29]
- 10. Pohlmann S, Kunz A, Ose D, Winkler EC, Brandner A, Poss-Doering R, et al. Digitalizing health services by implementing a personal electronic health record in Germany: qualitative analysis of fundamental prerequisites from the perspective of selected experts. J Med Internet Res 2020 Jan 29;22(1):e15102 [FREE Full text] [doi: 10.2196/15102] [Medline: 32012060]
- 11. Die Telematikinfrastruktur. gematik GmbH. URL: https://www.gematik.de/telematikinfrastruktur [accessed 2024-10-20]
- 12. Hoerbst A, Ammenwerth E. Electronic health records. Methods Inf Med 2018 Jan 17;49(04):320-336. [doi: 10.3414/me10-01-0038]
- 13. Kataria S, Ravindran V. Electronic Health Records: A Critical Appraisal of Strengths and Limitations. Journal of the Royal College of Physicians of Edinburgh 2020 Sep 01;50(3):262-268. [doi: <u>10.4997/jrcpe.2020.309</u>]
- 14. Gesundheitsinfos, online verfügbar. Elektronisches Patientendossier. URL: <u>https://www.patientendossier.ch/fachpersonen</u> [accessed 2024-10-20]
- 15. Schweizerische Eidgenossenschaft, 81 Gesundheit, 810 Medizin und Menschenwürde, 816 Patientendossier. Fedlex, Die Publikationsplattform des Bundesrechts. URL: <u>https://www.fedlex.admin.ch/de/cc/internal-law/81#816</u> [accessed 2024-10-20]
- 16. Elektronische Gesundheitsakte. Bundesministerium für Soziales, Gesundheitswesen, Pflege und Konsumentenschutz. URL: https://www.gesundheit.gv.at/gesundheitsleistungen/elga.html [accessed 2024-10-20]
- 17. Jormanainen V, Lindgren M, Keskimäki I, Kaila M. Use of My Kanta in Finland 2010-2022. Stud Health Technol Inform 2023 Jun 29;305:448-451. [doi: 10.3233/SHTI230528] [Medline: 37387062]
- 18. MyKanta. Kanta Services, The Social Insurance Institution of Finland. URL: <u>https://www.kanta.fi/en/mykanta</u> [accessed 2024-10-20]
- 19. Mon Espace Santé Mon Espace Santé is a personal space where users manage their health data. Ministerial eHealth Delegation and Ministry of Health (FR MoH). URL: <u>https://gnius.esante.gouv.fr/en/regulations/regulation-profiles/</u> mon-espace-sante [accessed 2024-01-24]
- 20. The electronic patient record. Federal Ministry of Health. URL: <u>https://gesund.bund.de/en/topics/electronic-health-record-epa</u> [accessed 2024-10-20]
- 21. Möglichkeiten und Herausforderungen der elektronischen Patientenakte. aerzteblatt. URL: <u>https://www.aerzteblatt.de/</u> nachrichten/150563/Moeglichkeiten-und-Herausforderungen-der-elektronischen-Patientenakte [accessed 2024-10-20]
- 22. Zeitz G. Elektronische Patientenakte: Droht Chaos beim Start? Hausärztinnen- und Hausärzteverband Hessen. URL: <u>https://www.hausaerzte-hessen.de/aktuelles/news/801-interview-epa</u> [accessed 2024-10-20]
- 23. Kommunikation im Medizinwesen (KIM). gematik GmbH. URL: <u>https://www.gematik.de/anwendungen/kim</u> [accessed 2024-10-20]
- 24. TI-Modellregion Franken. Medical Valley EMN e.V. URL: <u>https://gesundheitsnetz-franken.de/ti-modellregion-franken/</u> [accessed 2024-10-20]
- 25. TIMO TI-Modellregion Hamburg and Umland. GfgA Gesellschaft für geschäftliche Angelegenheiten UG. URL: <u>https://timo-hamburg-umland.de/</u> [accessed 2024-10-20]
- 26. Projekte und Publikationen: ePflegebericht und eWundbericht. Netzwerk Versorgungskontinuität in der Region Osnabrück e.V. URL: <u>https://www.hs-osnabrueck.de/netzwerk-versorgungskontinuitaet/projekte-und-publikationen/#c10209075</u> [accessed 2024-10-20]
- 27. Giehoff C, Hübner UH. Der elektronische Pflegebericht des "Netzwerks Versorgungskontinuität in der Region Osnabrück" - Evaluationsergebnisse und ihre Konsequenzen. ResearchGate. URL: <u>https://tinyurl.com/2zd8h6mk</u> [accessed 2024-04-29]
- Hübner U, Flemming D, Heitmann KU, Oemig F, Thun S, Dickerson A, et al. The need for standardised documents in continuity of care: results of standardising the eNursing summary. Stud Health Technol Inform 2010;160(Pt 2):1169-1173. [Medline: 20841868]
- 29. Flemming D, Giehoff C, Hübner U. Entwicklung eines Standards für den elektronischen Pflegebericht auf Basis der HL7 CDA Release 2. In: Proceedings of the 2008 Annual meeting of the German Society for Medical Informatics, Biometry

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and Epidemiology. 2008 Presented at: GMDS '08; September 15-18, 2008; Düsseldorf, Germany p. 682 URL: <u>https://www.egms.de/static/en/meetings/gmds2008/08gmds182.shtml</u>

- Flemming D, Hübner K, Heitmann F, Thun S. Implementierungsleitfaden "ePflegebericht "auf Basis der HL7 Clinical Document Architecture Release 2 für das deutsche Gesundheitswesen-draft v06. HL7.de. URL: <u>http://wiki.hl7.de/index.php/</u> <u>IG:Pflegeberich</u> [accessed 2024-10-20]
- 31. Flemming D, Schulte G, Hübner U. Evaluation des Deutscher HL7 CDA basierten elektronischen pflegeberichts. In: Proceedings of the 2013 Conference on Health Informatics meets eHealth. 2023 Presented at: eHealth '13; May 23-24, 2013; Vienna, Austria p. 1-7 URL: <u>https://www.hs-osnabrueck.de/fileadmin/HSOS/Homepages/KeGL/</u> Artikel Evaluation des deutschen HL7 CDA basierten elektronischen Pflegeberichts.pdf
- 32. MIO Medizinische Informationsobjekte. mio42 GmbH. URL: https://mio.kbv.de/site/mio [accessed 2024-03-20]
- 33. FHIR-Spezifikation. mio42 GmbH. URL: <u>https://mio.kbv.de/pages/viewpage.action?pageId=273318266</u> [accessed 2024-10-20]
- 34. Pio-Festlegung: Überleitungsbogen. Kassenärztliche Bundesvereinigung and GKV-Spitzenverband. URL: <u>https://www.kbv.de/temp/Anlage\_1\_PIO-Festlegung.pdf</u> [accessed 2024-04-29]
- Burr H, Berthelsen H, Moncada S, Nübling M, Dupret E, Demiral Y, international COPSOQ Network. The third version of the Copenhagen Psychosocial Questionnaire. Saf Health Work 2019 Dec;10(4):482-503 [FREE Full text] [doi: 10.1016/j.shaw.2019.10.002] [Medline: 31890332]
- 36. Angrosino M. Doing Ethnographic and Observational Research. Thousand Oaks, CA: Sage Publications; 2007.
- 37. Beyer H, Holtzblatt K. Contextual Design: Defining Customer-Centered Systems. New York, NY: Morgan Kaufmann Publishers; 1997.
- 38. Goodman E, Kuniavsky M, Moed A. Observing the User Experience. 2nd edition. Berlin, Germany: Morgan Kaufmann; 2012.
- 39. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2006 Jan;3(2):77-101. [doi: 10.1191/1478088706qp063oa]
- 40. Ruiz-Fernández D, Marcos-Jorquera D, Gilart-Iglesias V, Vives-Boix V, Ramírez-Navarro J. Empowerment of patients with hypertension through BPM, IoT and remote sensing. Sensors (Basel) 2017 Oct 04;17(10):2273 [FREE Full text] [doi: 10.3390/s17102273] [Medline: 28976940]
- De Ramón Fernández A, Ruiz Fernández D, Sabuco García Y. Business process management for optimizing clinical processes: a systematic literature review. Health Informatics J 2020 Jun 04;26(2):1305-1320 [FREE Full text] [doi: 10.1177/1460458219877092] [Medline: 31581880]
- 42. Jurafsky D, Martin JH. Speech and language processing: an introduction to natural language processing, computational linguistics, and speech recognition. University of California San Diego. URL: <u>https://tinyurl.com/z4h5k99v</u> [accessed 2024-02-20]
- 43. Mikolov T, Sutskever I, Chen K, Corrado G, Dean J. Distributed representations of words and phrases and their compositionality. arXiv Preprint posted online October 16, 2013 [FREE Full text]
- 44. Mayring P. Qualitative Inhaltsanalyse: Grundlagen und Techniken. 13th eddition. Berlin, Germany: Beltz; 2022.
- 45. Patton J. User Story Mapping: Discover the Whole Story, Build the Right Product. Berlin, Germany: O'Reilly Media; 2014.
- 46. Sozialgesetzbuch (SGB) Fünftes Buch (V) Gesetzliche Krankenversicherung (Artikel 1 des Gesetzes v. 20. Dezember 1988, BGBl. I S. 2477). Bundesministerium der Justiz. URL: <u>https://www.gesetze-im-internet.de/sgb\_5/BJNR024820988.</u> html [accessed 2024-04-29]

# Abbreviations

AI: artificial intelligence BPMN: business process model and notation CIO: care information object CTR: care transition record ePA: electronic patient record GDPR: General Data Protection Regulation HL7: Health Level 7 KIM: Kommunikation im Medizinwesen TI: telematics infrastructure UHA: University Hospital Augsburg



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# Detecting Older Adults' Behavior Changes During Adverse External Events Using Ambient Sensing: Longitudinal Observational Study

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# Abstract

**Background:** Older adults manage multiple impacts on health, including chronic conditions and adverse external events. Smart homes are positioned to have a positive impact on older adults' health by (1) allowing new understandings of behavior change so risks associated with external events can be assessed, (2) quantifying the impact of social determinants on health, and (3) designing interventions that respond appropriately to detected behavior changes. Information derived from smart home sensors can provide objective data about behavior changes to support a learning health care system. In this paper, we introduce a smart home capable of detecting behavior changes that occur during adverse external events like pandemics and wildfires.

**Objective:** Examine digital markers collected before and during 2 events (the COVID-19 pandemic and wildfires) to determine whether clinically relevant behavior changes can be observed and targeted upstream interventions suggested.

**Methods:** Secondary analysis of historic ambient sensor data collected on 39 adults managing one or more chronic conditions was performed. Interrupted time series analysis was used to extract behavior markers related to external events. Comparisons were made to examine differences between exposures using machine learning classifiers.

**Results:** Behavior changes were detected for 2 adverse external events (the COVID-19 pandemic and wildfire smoke) initially and over time. However, the direction and magnitude of change differed between participants and events. Significant pandemic-related behavior changes ranked by impact included a decrease in time (3.8 hours/day) spent out of home, an increase in restless sleep (946.74%), and a decrease in indoor activity (38.89%). Although participants exhibited less restless sleep during exposure to wildfire smoke (120%), they also decreased their indoor activity (114.29%). Sleep duration trended downward during the pandemic shutdown. Time out of home and sleep duration gradually decreased while exposed to wildfire smoke. Behavior trends differed across exposures. In total, two key discoveries were made: (1) using retrospective analysis, the smart home was capable of detecting behavior changes related to 2 external events; and (2) older adults' sleep efficiency, time out of home, and overall activity levels changed while experiencing external events. These behavior markers can inform future sensor-based monitoring research and clinical application.

**Conclusions:** Sensor-based findings could support individualized interventions aimed at sustaining the health of older adults during events like pandemics and wildfires. Creating care plans that directly respond to sensor-derived health information, like adding guided indoor exercise, web-based socialization sessions, and mental health–promoting activities, would have practical impacts on wellness. The smart home's novel, evidence-based information could inform future management of chronic conditions, allowing nurses to understand patients' health-related behaviors between the care points so timely, individualized interventions are possible.

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# KEYWORDS

internet of things; digital phenotyping; chronic disease; COVID-19; air pollution

# Introduction

# **Background and Significance**

The older adult population is rapidly growing, with 95% of persons aged 60+ managing a chronic condition and 80% managing 2 or more [1]. These same older adults are also experiencing more external events with the potential to impact self-management of their chronic conditions, such as wildfire smoke and COVID-19. Standard approaches to managing chronic conditions do not typically account for the impact of external events. Innovative technological approaches that (1) operate across diverse settings, (2) support a learning health care system, and (3) incorporate a social determinants of health (SDOH) lens are essential to enhance self-management of health conditions and support aging in place. Vulnerable populations often experience greater effects of external events due to reduced resources [2-4]. Besides managing chronic health conditions, 80% of U.S. older adults face income insecurity [5], reducing their capacity for self-management of the impacts of external events. For example, they may not be able to travel to a location with better air quality during a wildfire or to less crowded spaces during a pandemic.

Identifying specific behavior changes in response to external events presents opportunities for early nursing interventions. If behavior and health changes emanating from such events can be detected and understood, then smart homes could support automated upstream interventions like personalized activity cues and health education. Our prior work and that of others noted changes in health behavior that occurred during one such external event, the COVID-19 pandemic [6,7]. Similarly, people experienced changes and complications during wildfire season. The risk and extent of wildfires in the Pacific Northwest have doubled in recent years [8]. These increasingly large and intense wildfires are causing a spike in unhealthy pollutants, posing health risks to millions of people, and confining many older adults to their homes each summer [9]. Prior research observed that while particulate matter (PM2.5) and ozone (O<sub>3</sub>) were raised primarily outdoors, acetonitrile and benzene were also elevated indoors during fires [10-14]. Evidence is mounting that neighborhood-level exposure to particulate matter adds to the risk of health decline [15,16], crossing the blood-brain barrier and causing neural inflammation [17].

This work is based on larger studies in which we model behavior from passive sensors to detect and react to changes in physiological and cognitive health. Because sensors were placed in participant homes before events such as wildfires and the pandemic shutdown took place, we monitored behavior before and during these events. Participants reported behavior changes and health issues that were related to these events. The goal of this work was to analyze sensor data to detect, quantify, and analyze these changes. Our data analysis hypotheses were:

- 1. Changes in behavior will be observed between nonevent and event time periods.
- 2. The amount and type of behavior changes will differ based on parameters such as prior health conditions, age, and demographics.

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3. Initial behavioral changes in response to the event may differ from those that emerge as the event persists.

The intended outcome of the work is to suggest possible interventions that prevent unhealthy behavior changes and mitigate the health impact of such external events.

#### **Prior Work**

Researchers have observed changes in health during events that force more indoor activity, such as the COVID-19 lockdown and wildfire-driven poor air quality. For example, Krendl et al [18] and Burke et al [19] found these events to be associated with higher amounts of depression and loneliness based on individual self-report. However, Balki et al [20] noted that some of these health impacts are mitigated by individual factors such as gender and education. These types of events also spark changes in behavior. These include changes in nighttime and daytime sleep patterns, as observed by Gupta et al [21] Salfi et al [22] found that for some groups these behaviors change at first and then ease back to pre-event behavior, while other groups experience greater behavior change as the event continues. Their study confirmed the role of social determinants of health on behavior change during the pandemic.

While passively monitoring and modeling human behavior has become achievable with ambient and wearable sensors [23,24], little work has used sensors to capture behavior patterns and changes during external events like a pandemic or wildfire smoke to determine health impact and support. Collecting such data was particularly challenging during the pandemic when study participants could not be visited in person. However, a few projects were successful in assembling and assessing related data. In particular, Rajkumar et al [25] plotted movement levels inside 3 homes to visualize changes in the areas of the home that were frequented based on motion sensor reports. Leese et al [26] monitored driving and computer use over 5 months to quantify the decrease in driving distance and increase in time spent on the computer. The work reported in this study is based on longitudinal data from multiple studies collected in the homes of older adults with significant health risks before and during external events. This offers a unique opportunity to analyze behavior change from passive, continuous sensor observations.

Table 1 positions this study in comparison with prior work. As shown in the table, researchers have investigated the impacts of wildfire smoke and COVID-19 lockdowns on behavior, though none of these have investigated multiple events. Most of the study mechanisms rely on self-reports provided through digital surveys. One exception is the work of Ceolotto et al [27], who analyzed wastewater during the pandemic to quantify changes in the use of prescription drugs, nicotine, and alcohol. The work that is closest to our study is that of Rajkumar et al [25], which analyzed data from motion sensors to visualize social isolation for 3 homes during the COVID-19 pandemic. In comparison with these prior studies, we use longitudinal sensor data to compare pre-event and mid-event behavior. Performing this analysis for multiple event types (wildfire smoke events and pandemic lockdown events) facilitates comparison of behavior impact between diverse adverse external events.

#### Table . Summary of related studies.

Study	Event	Behavior	Collection mechanism
Stewart [28]	Wildfire smoke	Personal perceptions	Survey, air monitors
Burke [19]	Wildfire smoke	Depression, time at home	Survey, phone or web-based activity
Hu [29]	COVID-19	Smoking, alcohol, nutrition, sleep	Survey
Salfi [22]	COVID-19	Sleep	Survey
Gupta [21]	COVID-19	Sleep	Survey
Krendl [18]	COVID-19	Depression	Survey, social network
Leese [26]	COVID-19	Car, computer use	Survey, car computer
Ceolotto [27]	COVID-19	Medicine, caffeine, nicotine use	Wastewater
Rajkumar [25]	COVID-19	Isolation	Motion sensors
This paper	Wildfire smoke, COVID-19	Sleep, time out of home, activity level	Motion sensors, door sensors, weekly telehealth with self-report or nurse observation

# Methods

#### **Participants**

Participants were community-dwelling adults (n=39) recruited from the Pacific Northwest region of the United States through

advertising and involvement in prior studies. Inclusion criteria were living independently in their own home, having an internet connection, and the ability to communicate in English. Of the participants, 37 were older adults (70+ years), and 2 were healthy younger adults (<35 years) included for comparison. Participant characteristics are summarized in Table 2.

#### Table . Summary of participant information

Event and age		Age (years), mean (SD)	Gender	Education (years), mean (SD)	Conditions
COVID (n=13)					
	<35 years	23.5 (4.95)	1 male; 1 female	19.50 (2.12)	Healthy
	70+ years	83.82 (6.11)	2 male; 9 female	16.75 (1.83)	COPD <sup>a</sup> (1), asthma (1), diabetes mellitus (2), CHF <sup>b</sup> /AFib <sup>c</sup> (4), coro- nary artery disease (2), HTN <sup>d</sup> (5), arthritis (3), stroke (2), obesity (2), macular degeneration (3)
Smoke (n=28)					
	70+ years	91.10 (5.89)	7 male; 13 female; 8 not reported	17.50 (2.38)	Mild cognitive impair- ment (3), HTN (1), COPD (1), cancer (1)

<sup>a</sup>COPD: chronic obstructive pulmonary disorder.

<sup>b</sup>CHF: congestive heart failure.

<sup>c</sup>AFib: atrial fibrillation.

<sup>d</sup>HTN: hypertension.

### **Data Collection**

#### **Overview**

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Ambient sensors were placed in each participant's home and continuously collected data for a minimum of 1 year while residents performed their regular daily routines. In total, 2 types of sensor units were used: passive infrared motion detectors combined with ambient light sensors were placed on ceilings in each functional area (2 - 4 sensors per room) to monitor movement and light levels. Additionally, magnetic units with

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door sensors and ambient temperature sensors were placed on external doors and kitchen or bathroom cabinets to monitor door usage and temperature changes.

Registered nurses conducted weekly telehealth visits for the duration of the study. Participants were asked, "How has your health been over the last week? Did you experience any changes in your health? If so, what changed?" Narrative summaries were recorded each week of participants' self-reported health status and nurses' observations. Blood pressure, heart rate, oxygen

saturation, and pain level were also recorded weekly. These data informed the machine learning analytics.

## **Event Groups**

For this data analysis, we selected homes with 1 resident and no pets to focus on behavior change for 1 participant in each home and reduce noise. When behavior is analyzed in homes with multiple residents, the sensor data reflect the collective behavior of everybody in the home. Without attributing behavior to specific residents in such a group setting, direct comparisons cannot be easily made between single-resident and multi-resident homes. Additionally, we restricted our analysis to homes that included multiple days of data collection before the events and during events. The homes were grouped based on 2 event types: 1 set of 13 homes (COVID) collected sensor data before and during the COVID-19 pandemic lockdowns. Reflecting a second event, a set of 28 homes (smoke) collected data before and during times with poor air quality due to wildfire smoke.

In the COVID group, we analyzed data from March 17, 2020, through May 21, 2020, during which the region followed a stay-at-home protocol. For baseline comparison, we analyzed an equivalent number of season-matched days from the previous year. In the smoke group, we analyzed time periods containing at least 2 consecutive days with an air quality index >100 (indicating the air quality is unhealthy or hazardous) and an equivalent number of baseline days with air quality index  $\leq 50$ (indicating good air quality) during the same month. None of the COVID and smoke dates overlapped. In total, 2 of the homes collected data in both conditions and are included in both analyses. Additionally, we removed dates in which the participant was outside the home more than half the day. Sensor performance was routinely monitored, and sensors were removed from analysis if their performance was not reliable. In a few instances, all sensors failed to report information for a given date. When this occurred, we removed the date from consideration. In total, we analyzed 1990 days for the COVID group and 1568 days for the smoke group.

# **Digital Behavior Markers**

We defined a collection of digital markers that could be extracted from ambient sensor readings and used to describe daily behavior. The markers describe sleep, time out of the home, and activity level. These behavioral categories are reported to be influenced by poor air quality and pandemic shutdowns [21,22,30-33]. These behaviors in turn impact physiological and psychological well-being, particularly for individuals managing chronic health conditions [34-39].

In this analysis, nighttime sleep is detected between 9pm and 7am when motion sensor readings are  $\geq$ 5 minutes apart and the most-recently sensed location of the resident is the bedroom. If there are >2 contiguous motion sensor readings outside the bedroom, the state is considered awake. If the awake state is surrounded by sleep in the same evening, the awake state is a sleep interruption rather than the end of the night's sleep.

The motion sensors combined with the door sensors define when a participant is out of the home. Specifically, if the person's most recent state was awake, >20 minutes elapsed between motion sensor readings, and the most recent sensor readings are from an external door or door area, the person is considered out of the home until >2 sensor readings occur inside the home.

Finally, activity level is estimated by the normalized count of motion sensor readings occurring when the participant is home. The number of sensors inside a person's home varies depending on the size of the residence and the number of rooms. To accommodate the resulting differences in sensor quantity and density, all markers that rely on a motion sensor count are normalized with a standard scaler based on each person's daily motion sensor counts.

Figure 1 shows a plot of motion observed in 1 home during the prepandemic shutdown (left) and during the pandemic shutdown (right). In this plot, where each ring signifies a distinct day, we can observe some of the changes that were sensed between these times. Black regions indicate a lack of motion sensor readings. Before the shutdowns, black occurred throughout the day when the resident was out of the home and throughout nighttime sleep. During the shutdown, the number of daytime outings is greatly reduced. Furthermore, while sleep can still be detected at night, the person is more restless at night, with the black regions being replaced by more magenta and cyan periods. To analyze changes in these characterizing behaviors, we define the digital markers for each day as follows: sleep duration = the time spent in bed between the night's first and last detected sleep (Textbox 1).



Figure 1. Radial plots for 1 home showing activity level by time of day; 1 ring per day. (Left) Prepandemic behavior and (right) pandemic shutdown behavior. Colors indicate an increasing amount of motion from black (little or no motion) to yellow.



Textbox 1. Definition for digital markers for each day

- Sleep duration: the time spent in bed between the night's first and last detected sleep.
- Sleep efficiency: following recommendations by the National Science Foundation [40], this is defined as the nighttime ratio of sleep time to time spent in bed.
- Sleep restlessness (normalized): the number of motion sensor readings that are generated while the person is asleep.
- Time out: time spent outside the home.
- Activity level (normalized): the number of motion sensor readings generated divided by the time spent at home.

# **Data Analysis**

We apply an interrupted time series (ITS) analysis to assess the impact of an event that disrupts an ongoing time series [41]. Behavior markers  $X_t$  are collected for each day, t. This marker sequence forms a time series that is interrupted by an event, E:

# (1)X-3,X-2,X-1,(E),X+1,X+2,X+3

ITS allows us to perform a counterfactual analysis, estimating what would have happened to a person's behavior if the event had not occurred. In ITS, this is done by projecting the pre-event behavior trend (the counterfactual) into the postintervention trend. We perform segmented regression analysis to examine changes in level and trend over time, both before and during the event, allowing us to estimate its effect. We estimate the trend before the event, the immediate impact of the event, and the trend after the event, controlling for age, gender, and education. Where the results of the counterfactual analysis are not consistent across participants, we generate participant phenotypes using k-means clustering (k=3) and report statistics for individual groups.

Additionally, we use a machine learning classifier to predict if a set of behavior markers belongs to the nonevent or event group. This analysis captures nonlinear relationships and complex interactions between the variables to determine whether the event caused clear, measurable differences between the periods. For this analysis, we employ a random forest classifier

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with 100 trees and report results based on 5-fold cross-validation. We also use the classifier to quantify and rank the markers for their importance in distinguishing between nonevent periods, COVID periods, and wildfire smoke periods. Using random forests to promote interpretability of machine learning algorithms is a highlight of the method that has been explored by other researchers to predict events such as hospitalization among older adults [42]. Features are ranked by the Gini impurity (GI) measure, which guides the construction of the decision trees in the random forest.

# **Ethical Considerations**

This study was approved by Washington State University Institutional Review Board (IRB#15412). Studies from which data were collected for this secondary analysis were also reviewed and approved by the Institutional Review Board at Washington State University. All data were anonymized before performing analyses. Participants voluntarily consented after receiving information about the study and verbalizing their understanding. Participants' data were confidentially linked during their participation in the study and unlinked upon completion. After completing the study, participants received a US \$250 gift card.

# Results

Tables 3 and 4 summarize the ITS analysis results forCOVID-19 and wildfire smoke events, showing differences in

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the type, degree, and direction of behavior changes between the 2 events. Similarly, Figure 2 shows the values of the markers as a function of the day in the time series before and during each event, though these values are aggregated over the entire sample. Before the pandemic shutdown, behavior markers remained stable, with changes of less than 0.08%. In contrast, the immediate impact of the event was more pronounced. Sleep

duration increased slightly, while sleep restlessness showed a significant rise of 946.74%. Sleep efficiency remained relatively constant, but indoor activity decreased by 38.89%. As expected, time out of the home reflected the largest change, decreasing from 5.97 hours daily to an average of 2.17 hours, a statistically significant reduction.

**Table**. Results of interrupted time series analysis applied to daily behavior markers for the COVID-19 event (n=13). Model strength is reported as F test scores; sleep duration and time out of home are reported in seconds. Results are summarized for pre-event baseline (initial), trend before the event occurred (pre-event trend), impact on the first day of the event (immediate impact), and trend from the beginning to the end of the monitored event (long-term trend). Results are further broken down by gender.

Variable	Variable		F test		Initial		rend	Immediate impact		Long-term trend	
		F score (df)	P value	Value	P value	Value	P value	Value	P value	Value	P value
Sleep dura	tion (seconds	s)			,	-	,				
	Total	11.96 (3, 9)	<.001	28,900	<.001	4.00	<.001	22.00	.98	-1.96	<.001
	Female	12.84 (3, 9)	<.001	29,070	<.001	4.24	<.001	-451.64	.69	-0.47	<.001
	Male	13.78 (3, 9)	<.001	29,030	<.001	0.24	.86	-476.21	.74	0.48	.87
Restlessne	ss <sup>a</sup>										
	Total	6.58 (3,9)	<.001	-0.09	.047	-6.65e-05	<.001	0.762	<.001	0.00	<.001
	Female	10.59 (3, 9)	<.001	-0.18	<.001	-7.00e-05	<.001	1.11	<.001	-2.00e-03	.28
	Male	2.064 (3, 9)	.10	0.14	.13	-5.00-04	.09	0.00	.99	3.00e-04	.61
Sleep effic	iency <sup>b</sup>										
	Total	45.93 (3, 9)	<.001	0.79	<.001	0.00	<.001	0.00	.97	0.00	.75
	Female	53.37 (3, 9)	<.001	0.78	<.001	2.00e-04	<.001	0.03	.38	-7.00e-05	.28
	Male	49.83 (3, 9)	<.001	0.87	<.001	8.35e-05	<.001	-0.14	<.001	2.00e-04	<.001
Activity le	vel <sup>c</sup>										
	Total	25.17 (3, 9)	<.001	0.54	<.001	0.00	<.001	-0.21	.27	0.00	.88
	Female	12.37 (3, 9)	<.001	0.52	<.001	-6.07	.001	-0.61	.002	1.10e-03	.003
	Male	1.534 (3, 9)	.20	0.47	<.001	-4.00e-04	.18	0.67	.04	0.00	.001
Time out (	seconds)										
	Total	14.55 (3, 9)	<.001	21,500	<.001	-6.00	<.001	-13,700	<.001	26.00	<.001
	Female	20.84 (3, 9)	<.001	22,090	<.001	-9.88	<.001	-5330	.03	8.05	.07
	Male	3.77 (3,9)	.01	19,090	<.001	18.36	<.001	-30,130	<.001	44.31	<.001

<sup>a</sup>Number of motion sensor readings that are generated while the person is asleep.

<sup>b</sup>Nighttime ratio of sleep time to time spent in bed.

<sup>c</sup>Number of motion sensor readings generated divided by the time spent at home.

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**Table**. Results of interrupted time series analysis applied to daily behavior markers for the wildfire smoke event (n=30). Model strength is reported as F test scores; sleep duration and time out of home are reported in seconds. Results are summarized for pre-event baseline (initial), trend before the event occurred (pre-event trend), impact on the first day of the event (immediate impact), and trend from the beginning to the end of the monitored event (long-term trend). Results are further broken down by gender.

Variable	F test	F test		Initial		end	Immediate impact		Long-term trend	
	F score (df)	P value	Value	P value	Value	P value	Value	P value	Value	P value
Sleep dura- tion (sec- onds)	-	-		-					,	
Total	46.51 (3, 24)	<.001	30,860	<.001	-0.17	.69	-1652.49	.28	-1.95	.01
Female	24.78 (3, 24)	<.001	30,790	<.001	-0.02	.98	-977.25	.58	-1.48	.14
Male	33.15 (3, 24)	<.001	28,320	<.001	0.77	.20	-1214.66	.52	-2.79	<.001
Restless- ness <sup>a</sup>										
Total	3.83 (3, 24)	.01	0.15	.06	0.00	.001	-0.18	.29	0.00	.13
Female	2.06(3,24)	.10	0.15	.17	-2.00e-04	.03	-0.11	.61	9.00e-05	.47
Male	4.04 (3, 24)	.008	0.11	.14	-1.00e-04	<.001	-0.16	.24	1.00e-04	.07
Sleep effi- ciency <sup>b</sup>										
Total	123.50 (3, 24)	<.001	0.92	<.001	0.00	.64	-0.06	.13	0.00	<.001
Female	49.83 (3, 24)	<.001	0.92	<.001	4.56e-06	.77	-0.02	.60	-8.53e-05	<.001
Male	71.55 (3, 24)	<.001	0.87	<.001	4.11e-06	.82	-0.06	.30	-1.00e-04	<.001
Activity level <sup>c</sup>										
Total	0.46(3,24)	.71	0.07	.46	0.00	.94	-0.08	.65	0.00	.49
Female	1.53 (3, 24)	.21	-0.12	.30	2.00e-04	.04	0.19	.39	-1.00e-04	.29
Male	1.41 (3, 24)	.24	0.15	.26	-8.22e-05	.26	-0.26	.27	2.00e-04	.10
Time out (seconds)										
Total	1.48 (3, 24)	.22	26,180	<.001	0.86	.25	1969	.46	-2.00	.16
Female	3.77 (3, 24)	.01	27,640	<.001	0.34	.77	1916	.56	0.84	.65
Male	7.89 (3, 24)	<.001	22,280	<.001	2.78	.007	4676	.15	-5.10	.002

<sup>a</sup>Number of motion sensor readings that are generated while the person is asleep

<sup>b</sup>Nighttime ratio of sleep time to time spent in bed.

<sup>c</sup>Number of motion sensor readings generated divided by the time spent at home.



Figure 2. Trend lines for the markers across event occurrences and participants. The x-axis of each plot indicates the date in the time series and the y-axis indicates the mean value of the marker at that point in the sequence.



The overall impact of events is relatively consistent when we consider participants by gender, though a few differences are noted. Specifically, female participants experienced more of a long-term decrease in sleep duration and sleep efficiency during the COVID-19 lockdown. They also decreased their activity level at the beginning of the event, though it did increase as the event continued. Additionally, male participants experienced a greater impact of the event in terms of decreased time out of the home, though this time increased more than for the women as the pandemic continued.

Unlike the COVID-19 shutdown, none of the immediate behavior changes were significant when wildfire smoke began. Participants decreased their sleep duration by 5.36% and sleep efficiency by 6.52%, but sleep appeared to improve in quality, with a 120% decrease in restlessness. Indoor activity decreased by 114.29%, while time out of the home increased by 7.52%, an average of 32.82 additional minutes a day.

Postevent trends also revealed notable differences. During the pandemic, sleep duration initially increased but gradually declined over time, while time out of the home, though initially reduced, gradually rose over the 66-day shutdown. In contrast, during extended periods of wildfire smoke, both "time out of the home" and "nighttime sleep duration" gradually decreased.

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Differences between gender subgroups were largest for time spent out of the home. At the beginning of wildfire smoke events, male participants spent more time out of the house. As the poor air quality continued for multiple days, however, this group significantly decreased their time spent out of the home each day.

Behavior changes due to wildfire smoke were neither large nor statistically significant. However, some participants reported experiencing health and behavior changes during these times. To determine whether results vary between subgroups, we used k-means clustering (k=3) to identify participant phenotypes. The results, shown in Figure 3, highlight some important differences. Clusters 0 and 2 show minor behavior differences: cluster 0 exhibits a slight increase in time spent out of the home, while cluster 2 shows a slight increase in activity level and decrease in sleep efficiency. In contrast, participants in cluster 2 exhibit more pronounced changes, with a 182.93% increase in sleep restlessness (P=.002) and a 176.14% decrease in activity level (P=.06).

To assess the predictive nature of event behaviors, we examined the random forest predictions and the results are summarized as follows. Accuracy was 0.68 for classifying a participant as COVID, no COVID, smoke, or no smoke; 0.72 for classifying as positive (COVID or smoke) versus negative (no COVID, no
smoke); 0.76 for predicting COVID versus no COVID; and 0.71 for predicting smoke versus no smoke. For comparison, expected accuracy using a random classifier was 0.25 for the 4-class case and 0.50 for the 3 binary classification tasks. Because we analyze an equal number of pre-event and mid-event days, these class distributions are balanced. As a result, we use predictive accuracy as the performance metric. The results indicate that all behavior predictions were significantly more accurate than random guessing (P<.001). While the difference

in behavior between prepandemic and postpandemic periods was the most predictable, behavior differences between smoke and no-smoke periods were also highly predictive. We ranked the behavior markers by their predictive value for each event. The most predictive marker was time out of the home (GI=.108), followed by sleep restlessness (GI=.078), sleep efficiency (GI=.071), activity level (GI=.068), and sleep duration (GI=.050). Features were ranked in this order for all the prediction tasks.

**Figure 3.** Phenotypes of smoke impact on participant behavior. Plots show the difference of the behavior marker mean for each participant between the event (smoke) period and the nonevent period. Cluster sizes are (cluster 0: n=7, cluster 1: n=11, cluster 2: n=10).



# Discussion

# **Principal Findings**

Sensor data represent a new form of "informatics evidence" that supports informatics triage—a future requirement for home-based health technologies. These data provide objective evidence to inform decision support tools and clinical judgments. Aligned with value-based care ideals [43], information derived

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from smart home sensors can help prevent (re)hospitalizations and reduce unnecessary emergency room visits, promoting overall health and extending independence through health maintenance support. However, for smart home data to meaningfully reflect the impacts of external events on older adults or to predict health risks, we must understand how routine behaviors change with exposure. This study provides evidence that ambient sensing reliably captures exposure-related behaviors. The selected digital markers and analysis offer insight

into how exposures are behaviorally expressed when older adults are in their home, where they are arguably their most authentic selves.

Discerning behavior changes by type, degree, and trend is essential. Changes from baseline (nonevent) to new (event) behavior may involve variations in activity frequency, timing, duration, or location. Clinically relevant findings included restlessness during sleep and reduced time spent outside the home, both associated with heightened health risks. Poor sleep quality is associated with increased risk for all-cause cardiovascular mortality [44]. Decreased physical activity and social interaction increase the risk for poor mental health [45], dementia [46], cardiovascular disease, and cancer care outcomes [44]. As a result, clinicians commonly rely on knowledge of such behavior trends for clinical decision-making.

Objective, real-time evidence of key behavior changes creates opportunities for impactful, low-cost interventions, such as activity cueing [47,48], as well as community-level interventions addressing social determinants of health. For example, older Asian immigrants experienced unique needs during the pandemic lockdowns where, besides managing their health, they also managed an associated external event related to Asian hate [49], leading many older Asian Americans to remain at home for safety purposes. Behavior changes detected from the smart home digital markers we illuminate here could assist clinicians and community-based organizations in prioritizing and mobilizing community health workers among their constituents [50]. Indeed, discrimination reported by older Asian Americans during the pandemic resulted in unhealthy behavior changes, which could be investigated using similar methods [51].

#### **Case Exemplar**

One compelling case exemplar from our study is Anna (pseudonym), an 80 - 90-year-old female who lived alone during the pandemic due to recently becoming widowed. She experienced significant mental and physical decline soon after the lockdown began. She reported "feel[ing] isolated" and increasingly "tired" and "worried" and informed her doctor about feeling short of breath and fatigued. Medical tests were inconclusive. We posit that the clinical team may have benefited from knowing that her sleep duration over 3 months had decreased 1.3%, her sleep restlessness increased 13.9% and efficiency decreased 3.7%, and her time spent out of the home decreased 27.5%—all derived from the digital markers and methods in this study.

Based on these findings and follow-up interviews, the clinical research team determined Anna was likely lonely and needed more social interactions. With her permission, we reached out to community leaders who implemented regular check-ins, including home visits, group walking outdoors, and group puzzling over a web-based platform. Anna responded positively to these interventions, later reporting "feeling better."

# Integrating Ambient Sensor Information for a Learning Health Care System

A learning health care system could greatly benefit from in-home ambient sensor informatics, which provide insights

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into the impacts of external events on individuals and populations. Such systems rely on continuously available, objective data to adapt and improve [52]. Smart homes could play a pivotal role by systematically collecting real-time evidence to support clinical decision-making and enhance care effectiveness. By unobtrusively assessing and updating information about patients between care points, the system enables an iterative feedback loop of assessment and intervention, fostering continuous learning and improvement. Additionally, sensor-derived data empower the health care system to address social determinants of health, promoting equitable outcomes for individuals facing external challenges, especially for those already affected by factors like race, gender, age, and income level, which can exacerbate health risks. Adding other opportunities for collecting whole life-space data by including smart watches or other wearables could improve understandings of behavior changes associated with adverse external events. Data from these devices also requires new analytic methods that machine learning is suited to address. Upstream interventions are key to mitigating these risks and improving health equity for these individuals [53]. Objective data and metrics that reveal behavior changes related to external events can help the health care system better address these disparities, allowing targeted individualized care planning based on observed behaviors, ultimately supporting more equitable health outcomes. Sensor-derived information could be used to plan individualized support such as guided indoor exercise programs for older adults unable to leave their home who are also showing less overall daytime activity, or digital mental health support for persons showing increased restless sleep patterns and reporting anxiety, or web-based socialization opportunities to reduce loneliness.

A learning health care system could greatly benefit from in-home ambient sensor informatics, which provide insights into the impacts of external events on individuals and populations. Such systems rely on continuously available, objective data to adapt and improve [52]. Smart homes could play a pivotal role by systematically collecting real-time evidence to support clinical decision-making and enhance care effectiveness. By unobtrusively assessing and updating information about patients between care points, the system enables an iterative feedback loop of assessment and intervention, fostering continuous learning and improvement. Additionally, sensor-derived data empower the health care system to address social determinants of health, promoting equitable outcomes for individuals facing external challenges, especially for those already affected by factors like race, gender, age, and income level, which can exacerbate health risks. Adding other opportunities for collecting whole life-space data by including smart watches or other wearables could improve understandings of behavior changes associated with adverse external events. Data from these devices also require new analytic methods that machine learning is suited to address. Upstream interventions are key to mitigating these risks and improving health equity for these individuals [53]. Objective data and metrics that reveal behavior changes related to external events can help the health care system better address these disparities, allowing targeted individualized care planning based on observed behaviors, ultimately supporting more equitable

health outcomes. Sensor-derived information could be used to plan individualized support such as guided indoor exercise programs for older adults unable to leave their home who are also showing less overall daytime activity, or digital mental health support for persons showing increased restless sleep patterns and reporting anxiety, or web-based socialization opportunities to reduce loneliness.

A learning health care system could greatly benefit from in-home ambient sensor informatics, which provide insights into the impacts of external events on individuals and populations. Such systems rely on continuously available, objective data to adapt and improve [52]. Smart homes could play a pivotal role by systematically collecting real-time evidence to support clinical decision-making and enhance care effectiveness. By unobtrusively assessing and updating information about patients between care points, the system enables an iterative feedback loop of assessment and intervention, fostering continuous learning and improvement. Additionally, sensor-derived data empower the health care system to address social determinants of health, promoting equitable outcomes for individuals facing external challenges, especially for those already affected by factors like race, gender, age, and income level, which can exacerbate health risks. Adding other opportunities for collecting whole life-space data by including smart watches or other wearables could improve understandings of behavior changes associated with adverse external events. Data from these devices also requires new analytic methods that machine learning is suited to address. Upstream interventions are key to mitigating these risks and improving health equity for these individuals [53]. Objective data and metrics that reveal behavior changes related to external events can help the health care system better address these disparities, allowing targeted individualized care planning based on observed behaviors, ultimately supporting more equitable health outcomes. Sensor-derived information could be used to plan individualized support such as guided indoor exercise programs for older adults unable to leave their home who are also showing less overall daytime activity, or digital mental health support for persons showing increased restless sleep patterns and reporting anxiety, or web-based socialization opportunities to reduce loneliness.

#### **Concerns of Older Adults**

Privacy, cost, safety, security (data, identity, and health), and reliability are concerns that older adults associate with smart home health monitoring [54-57]. Older adults have indicated they want to be *watched over* but not *watched* [58]. In addition, technologies offering specific health assistance are more desirable than ones that generally monitor and capture data about behaviors and activities unrelated to an older adult's diagnosis [59,60]. All technologies collecting continuous data aiming to support aging in place require designs that support and embody the ethical principles of autonomy, the right to self-determination, justice, and health equity [61,62].

#### **Limitations and Future Research**

A limitation of this work is the use of a convenience sample of data collected before and during the COVID-19 and wildfire smoke events. Expanding the sample to include greater

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heterogeneity (race, gender, or socioeconomic status) and representation from more geographic regions would support more generalizable results and potentially identify additional clusters of behavior changes. Sociodemographic factors likely influence behavioral responses to adverse events. Due to the small convenience sample, we were unable to determine the differential impact of sociodemographic factors. Additionally, health data for the case exemplar relied on participant recall, which may be subject to bias and recall error.

This study is further limited by variations in sensor density across participant homes. The number of sensors that were analyzed varied between homes, based on home size and sensor fidelity. While data were normalized to account for these differences, the results could be refined if the numbers were uniform across the sample. We also recognize the inherent limitations of smart home sensors, which capture broad behaviors like navigation patterns and door usage but may miss finer behaviors, such as specific gestures. The confinement of sensors to indoor settings also excludes activities performed outside the home, potentially biasing conclusions. Integrating ambient sensors with wearables and other IoT sources could enhance the breadth and detail of behavior markers. Future research could examine the effects of other external events on older adults' health, such as migration, economic and policy implications, and the impacts of advances in artificial intelligence.

In this study, we focused on markers that reflect time spent on activities of interest. Future studies may consider additional markers that consider the time of day and location for these markers and integrate new markers into the collection.

#### Conclusions

Older adults are increasingly exposed to adverse external events like wildfires. Exposure can lead to behavior changes, putting them doubly at risk. Smart homes offer an innovative solution, affording opportunities for upstream interventions supporting more equitable health outcomes and providing continuous data for the learning health care system. Findings from this study show that the COVID-19 pandemic and the United States Pacific Northwest wildfires impacted community-dwelling older adults' behaviors with a change in time spent out of the home as the most predictive digital marker, followed by sleep markers, overall activity levels, and the duration of time spent on activities. Findings offer a new type of evidence to support clinical decision-making that considers the context of social determinants of health, like social factors related to the pandemic and exposure to poor air quality.

The rising frequency of external events, combined with the widening gap between available caregivers and the growing population of older adults needing care [63], poses a global gerontological humanitarian challenge. These events disrupt daily routines for older adults, potentially worsening their health and limiting their independence. Smart homes are well-positioned to help bridge this gap by collecting and leveraging in-home ambient sensing data. Further exploration of ambient sensor data integration into clinical decision support tools and the learning health care system is essential. Innovations like these could provide families and health care teams with

timely, actionable information that enables person-centered care and supports interventions that promote health equity at scale.

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# **Conflicts of Interest**

None declared.

# References

- Tavares JL, Cohen MA, Silberman S, Popham L. Chronic inequities: measuring disease cost burden among older adults in the US. : National Council on Aging (NCOA); 2022 URL: <u>https://assets-us-01.kc-usercontent.com/</u> <u>ffacfe7d-10b6-0083-2632-604077fd4eca/de93d9f3-fa31-497f-adeb-2e1220431fd1/</u> 2022-Research Chronic%20Inequities Measuring%20Burden 3-4.pdf [accessed 2025-04-07]
- Rapid review: an intersectional analysis of the disproportionate health impacts of wildfires on diverse populations and communities. Government of Canada. 2024. URL: <u>https://www.canada.ca/en/public-health/services/publications/</u> healthy-living/rapid-review-intersectional-analysis-disproportionate-impacts-wildfires-diverse-populations-communities. html
- 3. Which populations experience greater risks of adverse health effects resulting from wildfire smoke exposure? United States Environmental Protection Agency. 2025. URL: <u>https://www.epa.gov/wildfire-smoke-course/</u> which-populations-experience-greater-risks-adverse-health-effects-resulting [accessed 2025-04-07]
- 4. McNeely CL, Schintler LA, Stabile B. Social determinants and COVID 19 disparities: differential pandemic effects and dynamics. World Med Health Policy 2020 Sep;12(3):206-217. [doi: 10.1002/wmh3.370]
- 5. Combi S. 80% of older adults face financial insecurity. NCOA. 2024. URL: <u>https://www.ncoa.org/article/</u>80-percent-of-older-adults-face-financial-insecurity/ [accessed 2025-04-07]
- 6. Tseng VS, Ying JJC, Wong STC, Cook DJ, Liu J. Computational intelligence techniques for combating COVID-19: a survey. IEEE Comput Intell Mag 2020;15(4):10-22. [doi: 10.1109/MCI.2020.3019873]
- Knell G, Robertson MC, Dooley EE, Burford K, Mendez KS. Health behavior changes during COVID-19 pandemic and subsequent "stay-at-home" orders. Int J Environ Res Public Health 2020 Aug 28;17(17):6268. [doi: <u>10.3390/ijerph17176268</u>] [Medline: <u>32872179</u>]
- 8. Tracking wildfire smoke. Department of Ecology State of Washington. 2023. URL: <u>https://ecology.wa.gov/Air-Climate/</u><u>Responding-to-climate-change/Wildfire-risks</u> [accessed 2023-05-12]
- 9. Buchholz RR, Park M, Worden HM, et al. New seasonal pattern of pollution emerges from changing North American wildfires. Nat Commun 2022 Apr 19;13(1):2043. [doi: 10.1038/s41467-022-29623-8] [Medline: 35440561]
- 10. Kirk WM, Fuchs M, Huangfu Y, et al. Indoor air quality and wildfire smoke impacts in the Pacific Northwest. Sci Technol Built Environ 2018 Feb 7;24(2):149-159. [doi: 10.1080/23744731.2017.1393256]
- 11. Musser A, Alonso MJ, Cao G, Søgnen O. Indoor air toxic gases levels in a net-zero energy house under multiple ventilation system settings. Presented at: Conference of the International Society of Indoor Air Quality and Climate; Jul 22-27, 2018; Philadelphia, PA, United States.
- 12. Musser A, et al. Simulations of indoor air quality based on future climate conditions. Presented at: Conference of the International Society of Indoor Air Quality and Climate; Jul 22-27, 2018.
- 13. Musser A, et al. The major role of temperature on indoor concentrations of air toxic vocs in 9 houses based on in-situ high time resolution measurements. Presented at: Conference of the International Society of Indoor Air Quality and Climate; Jul 22-27, 2018.
- 14. Deleawe S, Kusznir J, Lamb B, Cook DJ. Predicting air quality in smart environments. J Ambient Intell Smart Environ 2010;2(2):145-152. [doi: 10.3233/AIS-2010-0061] [Medline: 21617739]
- 15. Hajat A, Park C, Adam C, et al. Air pollution and plasma amyloid beta in a cohort of older adults: evidence from the Ginkgo Evaluation of Memory study. Environ Int 2023 Feb;172:107800. [doi: 10.1016/j.envint.2023.107800] [Medline: 36773564]
- Cacciottolo M, Wang X, Driscoll I, et al. Particulate air pollutants, APOE alleles and their contributions to cognitive impairment in older women and to amyloidogenesis in experimental models. Transl Psychiatry 2017 Jan 31;7(1):e1022. [doi: 10.1038/tp.2016.280] [Medline: 28140404]
- 17. Li W, Lin G, Xiao Z, et al. A review of respirable fine particulate matter (PM2.5)-induced brain damage. Front Mol Neurosci 2022;15. [doi: 10.3389/fnmol.2022.967174]

- Krendl AC, Perry BL. The impact of sheltering in place during the COVID-19 pandemic on older adults' social and mental well-being. J Gerontol B Psychol Sci Soc Sci 2021 Jan 18;76(2):e53-e58. [doi: <u>10.1093/geronb/gbaa110</u>] [Medline: <u>32778899</u>]
- 19. Burke M, Heft-Neal S, Li J, et al. Exposures and behavioural responses to wildfire smoke. Nat Hum Behav 2022 Oct;6(10):1351-1361. [doi: 10.1038/s41562-022-01396-6] [Medline: 35798884]
- 20. Balki E, Hayes N, Holland C. The indirect impact of educational attainment as a distal resource for older adults on loneliness, social isolation, psychological resilience, and technology use during the COVID-19 pandemic: cross-sectional quantitative study. JMIR Aging 2023 Nov 24;6:e47729. [doi: 10.2196/47729] [Medline: 37999938]
- 21. Gupta R, Grover S, Basu A, et al. Changes in sleep pattern and sleep quality during COVID-19 lockdown. Indian J Psychiatry 2020;62(4):370-378. [doi: 10.4103/psychiatry.IndianJPsychiatry 523\_20] [Medline: 33165382]
- Salfi F, Lauriola M, D'Atri A, et al. Demographic, psychological, chronobiological, and work-related predictors of sleep disturbances during the COVID-19 lockdown in Italy. Sci Rep 2021 Jun 1;11(1):11416. [doi: <u>10.1038/s41598-021-90993-y</u>] [Medline: <u>34075173</u>]
- 23. Morita PP, Sahu KS, Oetomo A. Health monitoring using smart home technologies: scoping review. JMIR Mhealth Uhealth 2023 Apr 13;11:e37347. [doi: 10.2196/37347] [Medline: 37052984]
- 24. Cook DJ, Schmitter-Edgecombe M. Fusing ambient and mobile sensor features into a behaviorome for predicting clinical health scores. IEEE Access 2021;9:65033-65043. [doi: 10.1109/access.2021.3076362] [Medline: 34017671]
- 25. Rajkumar A, Wallace B, Ault L, et al. Visualizing effects of covid-19 social isolation with residential activity big data sensor data. Presented at: 2020 IEEE International Conference on Big Data (Big Data); Dec 10-13, 2020; Atlanta, GA, USA. [doi: 10.1109/BigData50022.2020.9377830]
- 26. Leese MI, Bernstein JPK, Dorociak KE, et al. Older adults' daily activity and mood changes detected during the COVID-19 pandemic using remote unobtrusive monitoring technologies. Innov Aging 2021;5(4):igab032. [doi: <u>10.1093/geroni/igab032</u>] [Medline: <u>34671706</u>]
- Ceolotto N, Jagadeesan K, Xu L, et al. Assessment of restriction measures implemented during COVID pandemics on community lifestyle choices via wastewater-based epidemiology. J Hazard Mater 2024 Jun 5;471(5):134264. [doi: 10.1016/j.jhazmat.2024.134264] [Medline: <u>38640675</u>]
- Stewart T, Monroe A, Mullan K, Jones D, McIver A, Walker ES. Behavioral responses to wildfire smoke: a case study in Western Montana. J Community Health 2025 Feb;50(1):31-44. [doi: <u>10.1007/s10900-024-01390-1</u>] [Medline: <u>39183232</u>]
- 29. Hu G, Qin H, Su B, Bao Y, Liang Z, Wang Y. Assessment of restriction measures implemented during COVID pandemics on community lifestyle choices via wastewater-based epidemiology. Mol Psychiatry 2024;29:439-448. [doi: 10.1038/s41380-023-02338-y]
- 30. Brand R, Timme S, Nosrat S. When pandemic hits: exercise frequency and subjective well-being during COVID-19 pandemic. Front Psychol 2020;11:570567. [doi: 10.3389/fpsyg.2020.570567] [Medline: 33071902]
- Chen CJJ, Lim S. Examining the effect of COVID-19 pandemic on exercise behavior and perceived academic stress among U.S. college students. J Am Coll Health 2024 Jul 23;72(6):1850-1856. [doi: <u>10.1080/07448481.2022.2094202</u>]
- 32. Liu F, Zhou F, Zhang K, et al. Effects of air pollution and residential greenness on sleep disorder: a 8-year nationwide cohort study. Environ Res 2023 Mar 1;220:115177. [doi: <u>10.1016/j.envres.2022.115177</u>] [Medline: <u>36584850</u>]
- 33. Yang Y, Goh KY, Teo HH, Tan SSL. The impact of air pollution information on individuals' exercise behavior: empirical study using wearable and mobile devices data. JMIR Mhealth Uhealth 2024;12:e55207. [doi: <u>10.2196/55207</u>]
- 34. Tokac U, McKeever M, Razon S. Mental health and exercise during the COVID-19 pandemic: a Twitter sentiment analysis. J Health Psychol 2025 Mar;30(4):835-842. [doi: 10.1177/13591053241258208] [Medline: 39107994]
- Curtis AF, Jagannathan S, Musich M, Miller MB, McCrae CS. Mid-to-late-life anxiety and sleep during initial phase of COVID-19: age- and sex-specific insights to inform future pandemic healthcare. Brain Sci 2024 Mar 30;14(4):346. [doi: 10.3390/brainsci14040346] [Medline: <u>38671998</u>]
- 36. Livingston G, Huntley J, Sommerlad A, et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. Lancet 2020 Aug 8;396(10248):413-446. [doi: 10.1016/S0140-6736(20)30367-6] [Medline: 32738937]
- Sin DD, Doiron D, Agusti A, et al. Air pollution and COPD: GOLD 2023 committee report. Eur Respir J 2023 May;61(5):2202469. [doi: 10.1183/13993003.02469-2022]
- 38. Barnes BR. Behavioural change, indoor air pollution and child respiratory health in developing countries: a review. Int J Environ Res Public Health 2014 Apr 25;11(5):4607-4618. [doi: 10.3390/ijerph110504607] [Medline: 24776723]
- 39. Lee BJ, Kim B, Lee K. Air pollution exposure and cardiovascular disease. Toxicol Res 2014 Jun;30(2):71-75. [doi: 10.5487/TR.2014.30.2.071] [Medline: 25071915]
- 40. Ohayon M, Wickwire EM, Hirshkowitz M, et al. National Sleep Foundation's sleep quality recommendations: first report. Sleep Health 2017 Feb;3(1):6-19. [doi: 10.1016/j.sleh.2016.11.006]
- 41. McDowall D, McCleary R, Bartos BJ. Interrupted Time Series Analysis: Oxford University Press; 2019. [doi: 10.1093/oso/9780190943943.001.0001]
- 42. Buenrostro-Mariscal R, Montesinos-López OA, Gonzalez-Gonzalez C. Predicting hospitalization in older adults using machine learning. Geriatrics (Basel) 2025 Jan 4;10(1):6. [doi: 10.3390/geriatrics10010006] [Medline: 39846576]



- 43. Value-based care. Centers for Medicare & Medicaid Services. 2023. URL: <u>https://www.cms.gov/priorities/innovation/key-concepts/value-based-care</u> [accessed 2025-04-07]
- Huang BH, Duncan MJ, Cistulli PA, Nassar N, Hamer M, Stamatakis E. Sleep and physical activity in relation to all-cause, cardiovascular disease and cancer mortality risk. Br J Sports Med 2022 Jul;56(13):718-724. [doi: 10.1136/bjsports-2021-104046] [Medline: 34187783]
- 45. Scott AJ, Webb TL, Martyn-St James M, Rowse G, Weich S. Improving sleep quality leads to better mental health: a meta-analysis of randomised controlled trials. Sleep Med Rev 2021 Dec;60:101556. [doi: 10.1016/j.smrv.2021.101556] [Medline: 34607184]
- 46. Social Isolation and Loneliness in Older Adults: National Academies of Sciences, Engineering, and Medicine; 2020. URL: https://nap.nationalacademies.org/catalog/25663/social-isolation-and-loneliness-in-older-adults-opportunities-for-the [accessed 2025-04-07]
- 47. Minor B, Doppa JR, Cook DJ. Learning activity predictors from sensor data: algorithms, evaluation, and applications. IEEE Trans Knowl Data Eng 2017 Dec 1;29(12):2744-2757. [doi: 10.1109/TKDE.2017.2750669] [Medline: 29456436]
- 48. Schmitter-Edgecombe M, Brown K, Luna C, et al. Partnering a compensatory application with activity-aware prompting to improve use in individuals with amnestic mild cognitive impairment: a randomized controlled pilot clinical trial. J Alzheimers Dis 2022;85(1):73-90. [doi: 10.3233/JAD-215022] [Medline: 34776442]
- 49. Tessler H, Choi M, Kao G. The anxiety of being Asian American: hate crimes and negative biases during the COVID-19 pandemic. Am J Crim Justice 2020;45(4):636-646. [doi: 10.1007/s12103-020-09541-5] [Medline: 32837158]
- 50. Nickel S, von dem Knesebeck O. Effectiveness of community-based health promotion interventions in urban areas: a systematic review. J Community Health 2020 Apr;45(2):419-434. [doi: 10.1007/s10900-019-00733-7] [Medline: 31512111]
- 51. Zhang L, Cruz-Gonzalez M, Lin Z, Ouyang X, Zhao F, Alegría M. Association of everyday discrimination with health outcomes among Asian and non-Asian US older adults before and during the COVID-19 pandemic. Front Public Health 2022;10:953155. [doi: 10.3389/fpubh.2022.953155] [Medline: 36339195]
- 52. About learning health systems. Agency for Healthcare Research and Quality. 2019. URL: <u>https://www.ahrq.gov/learning-health-systems/about.html</u> [accessed 2025-04-07]
- 53. Schulz AJ, Mehdipanah R, Chatters LM, Reyes AG, Neblett EW Jr, Israel BA. Moving health education and behavior upstream: lessons from COVID-19 for addressing structural drivers of health inequities. Health Educ Behav 2020 Aug;47(4):519-524. [doi: 10.1177/1090198120929985]
- 54. Schomakers EM, Biermann H, Ziefle M. Users' preferences for smart home automation investigating aspects of privacy and trust. Telematics and Informatics 2021 Nov;64:101689. [doi: <u>10.1016/j.tele.2021.101689</u>]
- 55. Pirzada P, Wilde A, Doherty GH, Harris-Birtill D. Ethics and acceptance of smart homes for older adults. Inform Health Soc Care 2022 Jan 2;47(1):10-37. [doi: 10.1080/17538157.2021.1923500] [Medline: 34240661]
- Dermody G, Fritz R, Glass C, Dunham M, Whitehead L. Family caregiver readiness to adopt smart home technology to monitor care-dependent older adults: a qualitative exploratory study. J Adv Nurs 2024 Feb;80(2):628-643. [doi: 10.1111/jan.15826] [Medline: <u>37614010</u>]
- Dermody G, Fritz R, Glass C, Dunham M, Whitehead L. Factors influencing community-dwelling older adults' readiness to adopt smart home technology: a qualitative exploratory study. J Adv Nurs 2021 Dec;77(12):4847-4861. [doi: 10.1111/jan.14996] [Medline: 34477222]
- 58. Fritz RL, Corbett CL, Vandermause R, Cook D. The influence of culture on older adults' adoption of smart home monitoring. Gerontechnology 2016;14(3):146-156. [doi: <u>10.4017/gt.2016.14.3.010.00</u>]
- Tian YJA, Felber NA, Pageau F, Schwab DR, Wangmo T. Benefits and barriers associated with the use of smart home health technologies in the care of older persons: a systematic review. BMC Geriatr 2024 Feb 14;24(1):152. [doi: 10.1186/s12877-024-04702-1] [Medline: 38355464]
- 60. Fritz RL, Nguyen-Truong CKY, Leung J, et al. Older Asian immigrants' perceptions of a health-assistive smart home. Gerontechnology 2020 Dec 31;19(4):1-11. [doi: 10.4017/gt.2020.19.04.385]
- 61. Fritz RL, Nguyen-Truong CKY, May T, Wuestney K, Cook DJ. Bioethics principles in machine learning-healthcare application design: achieving health justice and health equity. Harv Public Health Rev (Camb) 2024;79. [doi: 10.54111/0001/aaaa1] [Medline: <u>39850650</u>]
- 62. Jedličková A. Ethical approaches in designing autonomous and intelligent systems: a comprehensive survey towards responsible development. AI & Soc 2024. [doi: 10.1007/s00146-024-02040-9]
- 63. Committee on Family Caregiving for Older Adults. Families Caring for an Aging America: National Academies Press; 2016.

# Abbreviations

**GI:** Gini impurity **ITS:** interrupted time series



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# Effect of Digital Tools on the Knowledge and Performance of Frontline Health Workers For Diabetes Control in Myanmar: Cost-Effective Analysis and Quasi Experimental Study

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# Abstract

**Background:** Diabetes has become a significant global health issue, particularly imposing a deep economic burden on low-income countries. Innovative and integrated digital solutions can reduce the impact of diabetes and enhance the quality of care. However, digital solutions have not been utilized before in Myanmar.

**Objective:** This study aimed to demonstrate the novel integrated effect of diabetes knowledge and registry tools on the performance of front-line health workers in primary health care settings.

**Methods:** A quasi-experimental study with an intervention and a control group was conducted in two townships from October 2022 to April 2023. For the first time, researchers trained the intervention group to use digital tools for diabetes control and performed monthly follow-ups. The study employed multiple linear regression models to explore the novel impact of digital tools on knowledge and performance scores, their correlations, and their association with covariates. Additionally, it assessed the cost-effectiveness of the intervention by using self-administered questionnaires as measurement tools formulated based on the National Diabetes Guidelines.

**Results:** A total of 96 participants were enrolled in the study, divided evenly into the two groups. The intervention group exhibited a significant increase in the mean knowledge scores from 85.81 to 99.25 (P<.001) and performance scores from 71.22 to 107.16 (P<.001). The intervention accounted for 43.2% of the variance in knowledge scores and 62.5% in performance scores (P<.001). A positive correlation was found between knowledge and performance scores (r=0.45, P<.001). The intervention was also cost-effective, with a cost-effectiveness analysis value of 0.711 and an incremental cost-effectiveness ratio of 10127.04 Kyats (US\$ 4.83).

**Conclusions:** As the new integrated intervention yields significant economic gains and positive effects, researchers suggest policy makers replicate this intervention as a nationwide program and recommend scaling up the use of digital tools to improve knowledge and performance for diabetes control in frontline health workers.

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# KEYWORDS

diabetes mellitus; digital tools; cost-effectiveness analysis; health personnel; Myanmar

# Introduction

# **Global Situation Regarding Diabetes**

Diabetes is a life-threatening chronic disease that requires effective and sustainable care and treatment. In 2021, it was responsible for 6.7 million deaths worldwide, and the number of people affected was estimated at 537 million, projected to rise to 783 million by 2045 [1]. Despite the increasing burden of diabetes, there is a shortfall of 5.9 million health care professionals required to provide quality care for people living

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with diabetes [2]. Moreover, many low-income countries face challenges in translating evidence-based knowledge, cost-effective guidelines, and electronic records into actionable solutions to enhance the ability of frontline health workers to deliver quality diabetes services [3].

Health IT has great potential for enhancing diabetes management by saving time and costs involved in data interpretation. Digital knowledge tools can serve as an effective resource for bridging knowledge gaps among health care providers; however, the integrated effect of knowledge tools and diabetes registry on

provider performance is not well known [4]. The World Health Organization (WHO) indicates that only 50% of countries use electronic diabetes registries and expects national data to be standardized when registry coverage exceeds 75% [5]. Many low-income countries still struggle to provide comprehensive digital tools for knowledge and registries for frontline health workers. Myanmar should seize these opportunities to improve community-level diabetes care management.

Cost-effective interventions are urgently needed to address the diabetes burden, which cost US\$ 966 billion globally in 2021. Southeast Asia's expenditure was significantly lower at US\$ 10.1 billion, compared to North America's US\$ 414.5 billion [6]. Therefore, it is vital to implement high-impact and affordable solutions in low-income countries. A meta-analysis shows that digital tools for diabetes knowledge can be cost-effective [7], yet there is limited evidence in low-income settings [8]. Therefore, it is essential to perform integrated and interdisciplinary research on digital tools for the effective implementation of diabetes control programs in the region.

#### **Myanmar Context for Diabetes**

Myanmar is one of the countries in Southeast Asia with a high burden of diabetes, with a prevalence among 10.5% of the population, which is comparatively higher than that in other countries in the region [9]. A diabetes prevalence survey conducted in 2014 revealed that the burden of the disease had doubled over a decade, and there were no effective strategies or guidelines implemented to raise awareness about diabetes management [10]. Additionally, health workers need to enhance their knowledge, and further research is necessary to improve the quality of diabetes control services at the primary health care level [11].

The rapid growth of mobile technology in Myanmar has created new opportunities for digital health. In 2014, the Ministry of Health established an electronic health management information system and a real-time District Health Information System for all townships. They also distributed 26,000 tablets with essential guidelines for frontline health workers [12]. However, the digital health information system is still in its early stages, and no specific digital application for the diabetes control program exists.

# **Objectives**

Unlike other studies, this study aimed to evaluate the novel integrated effects of digital tools on diabetes knowledge and registry in relation to diabetes control performance among frontline health care workers in Myanmar. The primary outcomes of the study were the knowledge and performance levels of the health workers, while the secondary outcome was the cost-effectiveness of the intervention.

# **Conceptual Frameworks**

Researchers designed the study based on two main theories: attribution theory, which examines how knowledge affects diabetes management [13]; and an economic principle assessing the cost-effectiveness of digital health technology [14]. The research hypothesized that integrated digital tools would enhance

frontline health workers' knowledge and performance by reducing diabetes program costs.

# Methods

# **Study Design**

A quasi-experimental study was conducted in Naypyitaw, the capital of Myanmar, between October 2022 and April 2023 (spanning 6 months). Two townships were selected for the intervention and control groups based on matched population characteristics, geographical conditions, and access to essential diabetes control packages offered by the diabetes control program. The selection criteria for the study areas included a high unknown prevalence of diabetes among the population and inadequate knowledge among health workers [15]. Baseline and endline assessments were carried out for both the groups.

### **Participants**

Frontline health staff, including midwives, lady health visitors, and public health supervisors, were selected for the study based on specific inclusion criteria: involvement in the diabetes control program, ability to use digital tools, and willingness to participate. Exclusion criteria included those absent for over 1 month, nearing retirement, deemed unfit for intervention, or not approved by supervisors. Using G\*Power software (version 3.1.9.2; Heinrich-Heine-Universitat Dusseldorf), the sample size was calculated for multiple linear regression with a 95% CI and power. The reference minimum effect size of the intervention on diabetes control was  $F_{4,75}$ =.25 [16]. The minimum sample required was 86 participants, and 96 were recruited to account for dropouts, finally assigning 48 participants to each group.

#### Interventions

The new intervention involved integrating the two new digital tools developed by the authors, Myanmar Diabetes Guides and Digital Registry. This is unique and significant because other studies measure the silo effects [17]. Researchers installed digital tools and provided 3 days of intensive training on how to use the tools. Additionally, researchers conducted monthly follow-ups and provided reorientation sessions to the intervention group.

#### Myanmar Diabetes Guide

This is a new comprehensive bilingual knowledge tool developed by researchers in collaboration with the National Diabetes Control Program. According to the WHO and National program guidelines, the tool addresses the risks and promotes the health, screening, diagnosis, care and treatment, and complication referrals. It includes interactive patient dialogues, video demonstrations, and diabetes-related wikis. The tool is open to access in both online and offline settings and can be used on mobile tablets [18].

### **Diabetes Registry Tool**

The electronic diabetes registry tool was designed using Kobo Toolbox, an open-source tool for field data collection in humanitarian response [19]. This tool collects vital patient information for diabetes management programs and replaces



paper-based reporting. The tools enable health workers to trace risk factors, analyze data, calculate prevalence, identify complications, and estimate the requirement of diabetes-related commodities. The application is available for online and offline use and is compatible with both tablets and computers with a user password to protect data privacy [19].

# Training for Utilization of the Application

Researchers conducted training on the orientation for using the digital tools that consisted of three components with lectures, demonstration, and practice sessions on (i) health promotion, identifying high-risk individuals, and establishing volunteer networks; (ii) training for the diabetes knowledge tools; and (iii) training for the diabetes registry tool.

### **Measurement Instruments**

The researchers developed self-administered questionnaires for data collection. The questionnaire was created in English and subsequently translated into the Burmese language. It included a scoring system for the primary outcomes, which assessed the knowledge and performance in five key domains of diabetes management: (i) health promotion, (ii) diabetes screening, (iii) care and treatment, (iv) referral, and (v) reporting, all referencing the WHO and National Diabetes Guidelines. The researchers established an expert panel to review the questionnaire to ensure content validity. This panel included a diabetes program manager, an expert clinician, and township health officers. The validity index for the questionnaire was scored at 0.6. Additionally, the reliability of the questionnaire was pretested by two different observers, with an interrater kappa value of 0.68 between the two observers.

The WHO-CHOICE (WHO's Choosing Interventions that are Cost-Effective) Analysis tool for noncommunicable diseases was used to measure costing data [20]. This costing data included direct costs (intervention costs, program costs, and treatment costs) and indirect costs (communication, consulting, value of time, and work). The cost-effectiveness analysis aimed to demonstrate the economic benefits of the intervention for future investments.

# **Data Collection and Statistical Analysis**

The principal investigator and two research assistants collected baseline and endline data. Before data collection began, the study's purpose was explained to authorities and participants. Primary cost data were obtained from participants, while secondary data on treatment costs came from the township hospital and program costs from the township health departments. The team checked the accuracy of the questionnaires, addressed any missing responses, and cross-verified participant data with the secondary data. Health assistants from the townships were followed-up monthly on using the tools.

Data analysis was conducted using SPSS software (version 22.0; IBM Corp). Knowledge and performance scores followed the National Diabetes Control Guideline criteria. Sociodemographic data differences were assessed with the  $\chi^2$  test, mean outcome data with the *t* test, and outcome correlations with the Pearson correlation test. The impact of the intervention was evaluated using multiple logistic regression analysis. All tests were statistically significant at a 95% CI. Cost-effectiveness was assessed through the cost-effectiveness ratio and incremental cost-effectiveness ratio.

# **Ethical Considerations**

The study received approval from the Chulalongkorn University Ethics Review Committee (090.2/64, COA No. 177/2022). The Ministry of Health, Naypyitaw Department of Health, granted permission for data collection (NPT/NCD/007-2021/5925). Participation in the research was voluntary; informed consent was obtained, and data confidentiality was ensured. During the registration, an internet package (US\$ 2) and a 50 pcs box of surgical masks were provided to participants as compansation for participating the research.

# Results

# **Patient Inclusion**

Ninety-six participants enrolled in the study, and 1 patient dropped out. Figure 1 shows the flow chart of the quasi-experimental study design.





# **Participant Sociodemographic Characteristics**

The study used the  $\chi^2$  test to examine participant characteristics in relation to the sociodemographic variables, work-related variables, and variables related to diabetes control (Table 1). Significant differences between the two groups were observed based on gender (*P*=.02), job designation (*P*=.02), distance from the township (*P*=.001), and duration of internet use (*P*=.001). Independent *t* tests analyzed differences in mean knowledge and performance scores. The mean knowledge scores were statistically associated with gender (P=.001), job designation (P<.001), and diabetes control training (P=.02). The mean performance scores were statistically associated with gender (P=.04). job designation (P=.009), diabetes control training (P=.02), diabetes registry training (P=.02), number of postings (P=.03), level of facilities (P=.02), and experiences with diabetes campaigns (P=.007).



Table . Sociodemographic variables of the participants (n=96).

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Sociodemographic variables	Total (n=96)	Intervention group (n=48)	Control group (n=48)	<i>P</i> value
Age (years), mean (SD)	32.71 (9.52)	31.75 (9.18)	33.67 (9.55)	.33 <sup>a</sup>
Gender, n (%)				.02 <sup>b,c</sup>
Male	14 (14)	3 (6.3)	11 (22.9)	
Female	82 (82)	45 (93.7)	37 (77.1)	
Marital status, n (%)				33 <sup>b</sup>
Single	31 (32.3)	14 (29.2)	17 (35.4)	
Married	65 (67.7)	34 (70.8)	31 (64.6)	
Educational status, n (%)				.58 <sup>b</sup>
High school	24 (25)	11 (22.9)	13 (27.1)	
Graduate	72 (75)	37 (77.1)	35 (72.9)	
Designations, n (%)				.02 <sup>b,c</sup>
Lady health visitors	8 (8.3)	4 (8.3)	4 (8.3)	
Midwives	55 (57.3)	34 (70.9)	21(43.8)	
Public health supervisor	33 (34.4)	10 (20.8)	23 (47.9)	
Number of postings, n (%)				.73 <sup>b</sup>
1st posting	55 (57.3)	27 (56.3)	28 (58.3)	
2nd-5th posting	30 (31.3)	16 (33.3)	14 (29.2)	
>5th posting	11 (11.4)	5 (10.4)	6 (12.5)	
Level of facilities, n (%)				.74 <sup>b</sup>
Township	19 (19.8)	11 (22.9)	8 (16.7)	
Rural health center	21 (21.9)	10 (20.8)	11 (22.9)	
Subcenter	56 (58.3)	27 (56.3)	29 (60.4)	
Distance from township, n (%)				.001 <sup>b,c</sup>
≤10 miles	55 (57.3)	19 (39.6)	36 (75)	
>10 miles	41 (42.7)	29 (60.4)	12 (25)	
DM <sup>d</sup> control training, n (%)				.50 <sup>b</sup>
Received before	67 (69.8)	33 (68.8)	34 (70.8)	
Never received	29 (30.2)	15 (31.2)	14 (29.2)	
DM registry training, n (%)				.21 <sup>b</sup>
Received before	47 (49)	26 (54.2)	21 (43.8)	
Never received	49 (51)	22 (45.8)	27 (56.2)	
DM campaign experiences, n (%)				.11 <sup>b</sup>
Received before	57 (59.4)	25 (52.1)	32 (66.7)	
Never received	39 (40.6)	23 (47.9)	16 (33.3)	
Duration of internet usage, n (%)				.001 <sup>b,c</sup>
≤5 years	49 (51)	35 (72.9)	14 (29.2)	
>5years	47 (49)	13 (27.1)	34 (70.8)	

<sup>a</sup>independent t-test.

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 ${}^{b}\chi^{2}$  test.  ${}^{c}$ statistically significant *P*<.05.  ${}^{d}$ DM: diabetes mellitus.

### Effect of Intervention on Knowledge

An average of 94.2% of the intervention group (45/48) regularly utilized diabetes knowledge tools. During the baseline assessment, no significant difference in the mean knowledge scores was noted between the two groups (P=.20). However, a significant difference emerged between the two groups at the endline (P<.001). The mean (SD) knowledge score in the intervention group rose significantly from 85.04 (9.73) to 99.25

(5.33; *P*<.001). In contrast, the mean (SD) knowledge score in the control group slightly declined from 83.58 (11.17) to 80.47 (16.99) (Figure 2); however, this change was not significant (*P*=.21; Table 2). The multiple linear regression model, after adjusting for potential confounding factors, showed a significant effect, with an adjusted  $r^2$  of 0.43, an unstandardized  $\beta$  coefficient of 17.769, and a standardized  $\beta$  coefficient of 0.569 (*P*<.001; Table 3).



Figure 2. Comparison of mean outcomes between the intervention and control: (A) mean knowledge scoring, (B) mean performance scoring.





Table . Comparison of mean outcome variables between the intervention and control groups

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Outcome variable	Total	Intervention group	Control group	<i>P</i> value <sup>c</sup>
	Mean (SD)	Mean (SD)	Mean (SD)	
	N <sup>Ba</sup> =96	N <sup>B</sup> =48	N <sup>B</sup> =48	
	N <sup>ED</sup> =95	N <sup>E</sup> =48	N <sup>E</sup> =47	
Knowledge Scoring				
Total knowledge scoring B	85.04 (9.73)	85.81 (8.20)	83.58 (11.17)	.20
Total knowledge scoring E	87.25 (21.67)	99.25 (5.33)	80.47 (16.99)	<.001 <sup>d</sup>
Health promotion <sup>B</sup>	20.01 (2.51)	20.00 (2.37)	19.95 (2.71)	.76
Health promotion <sup>E</sup>	20.22 (4.83)	22.35 (1.53)	19.31 (3.96)	<.001 <sup>d</sup>
Screening and diagnosis <sup>B</sup>	19.23 (3.52)	19.25 (3.55)	19 (3.44)	.55
Screening and diagnosis <sup>E</sup>	19.93 (5.34)	22.68 (2.41)	18.41 (4.46)	<.001 <sup>d</sup>
Care and treatment <sup>B</sup>	16.82 (3.12)	17.68 (2.69)	15.97 (3.29)	.08
Care and treatment <sup>E</sup>	18.15 (5.46)	21.54 (1.67)	15.72 (4.55)	<.001 <sup>d</sup>
Referral of severe cases <sup>B</sup>	14.34 (2.44)	14.43 (1.85)	14.10 (2.91)	.47
Referral of severe cases <sup>E</sup>	14.63 (3.94)	16.46 (1.43)	13.50 (3.42)	<.001 <sup>d</sup>
Reporting and registry <sup>B</sup>	14.52 (2.24)	14.43 (2.21)	14.54 (2.33)	.89
Reporting and registry <sup>E</sup>	14.45 (3.86)	16.21 (1.50)	13.52 (3.19)	<.001 <sup>d</sup>
Performance scoring				
Total performance scoring B	72.33 (9.73)	71.22 (28.35)	73.29 (35.66)	.75
Total performance scoring E	88.50 (33.50)	107.16 (15.62)	70.04 (29.72)	<.001 <sup>d</sup>
Health promotion <sup>B</sup>	9.23 (4.22)	9.54 (3.99)	8.91 (4.23)	.46
Health promotion <sup>E</sup>	10.59 (3.8)	12.42 (2.15)	8.77 (3.44)	<.001 <sup>d</sup>
Screening and diagnosis <sup>B</sup>	9.41 (4.32)	9.38 (4.28)	9.42 (4.26)	.97
Screening and diagnosis <sup>E</sup>	10.37 (4.1)	12.56 (2.89)	8.17 (3.13)	<.001 <sup>d</sup>
Care and treatment <sup>B</sup>	38.93 (20.83)	37.17 (19.57)	40.54 (22.06)	.43
Care and treatment <sup>E</sup>	49.01(21.6)	59.08 (12.21)	38.95 (21.17)	<.001 <sup>d</sup>
Referral of severe cases <sup>B</sup>	4.24 (4.14)	3.89 (4.21)	4.73 (4.21)	.34
Referral of severe cases <sup>E</sup>	5.37 (5.3)	7.13 (6.24)	3.60 (3.49)	.001 <sup>d</sup>
Reporting and registry <sup>B</sup>	10.42 (6.23)	11.23 (5.68)	9.56 (6.58)	.19
Reporting and registry <sup>E</sup>	13.24 (6.5)	15.95 (4.20)	10.54 (6.78)	<.001 <sup>d</sup>

<sup>a</sup>B=baseline.

<sup>b</sup>E=endline.

<sup>c</sup>independent t-test.

<sup>d</sup>statistically significant P<.05.

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Table . Effect of intervention on total knowledge scoring after adjusting for all possible confounding variables (full model multiple linear regression analysis).

Variables	Total knowledge score at endline (n=95)					
	β	SE	95% CI	Standardized $\beta$ coefficient	t test (df)	<i>P</i> value
Intervention town- ship	17.767	2.942	11.92 to 23.61	0.569	6.040 (7)	<.001 <sup>a</sup>
Baseline knowl- edge score	.497	0.137	0.23 to 0.77	0.311	3.630 (7)	<.001 <sup>a</sup>
Gender	-1.876	3.932	-9.69 to 5.93	-0.042	-0.477 (7)	.63
Designation of work	2.726	2.168	-2.69 to 7.96	0.105	1.258 (7)	.21
Distance from township	2.633	2.697	-3.50 to 7.29	0.083	0.983 (7)	.33
Duration of internet usage	.042	0.423	-0.79 to 0.88	0.009	0.100 (7)	.92
Diabetes control training	6.004	2.745	0.549 to 11.46	0.177	2.187 (7)	.03 <sup>a</sup>

<sup>a</sup>significant at *P*<.05.

 ${}^{b}r^{2}=0.472.$ 

<sup>c</sup>Adjusted r<sup>2</sup>=0.430.

<sup>d</sup>Fitness Sample Corrected Akaike's Information Criterion (AICC)=758.765.

# **Effect of Intervention on Performance**

A total of 91.2% (44/48) of the intervention group regularly used the registry tool and registered 1747 diabetes patients within 6 months. The mean (SD) performance score in the intervention group significantly increased from 71.22 (28.35) to 107.16 (15.62; P<.001). In contrast, the control group experienced a decrease in the mean (SD) performance scores

from 73.29 (35.66) to 70.04 (29.72; P=.22). At baseline, the two groups had no significant difference in the mean performance scores (P=.75). At the endline, a significant difference was noted between the two groups (P<.001; Table 1). A multiple linear regression model, adjusted for potential confounding factors, indicated a significant effect, with an adjusted  $r^2$  of 0.642, an unstandardized  $\beta$  coefficient of 33.143, and a standardized  $\beta$  coefficient of 0.554 (P<.001; Table 4).



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Table. Effect of intervention on the total performance score after adjusting for all possible confounding variables (full model multiple linear regression analysis).

Variables	Total performance score at endline (n=95)					
	β	SE	95% CI	Standardized $\beta$ coefficient	t test (df)	<i>P</i> value
Intervention town- ship	33.143	4.520	24.15 to 42.13	0.554	7.332 (11)	<.001 <sup>a</sup>
Baseline perfor- mance score	.499	0.67	0.36 to - 0.63	0.532	7.483 (11)	<.001 <sup>a</sup>
Gender	8.706	6.134	-3.49 to 20.90	0.103	1.419 (11)	.16
Designation of work	3.054	4.103	-5.11 to 11.21	0.061	0.744 (11)	.46
Distance from township	7.419	4.247	-1.03 to 15.86	0.123	1.747 (11)	.08
Duration of internet usage	670	0.668	-1.99 to 0.66	-0.71	-1.003 (11)	.32
Diabetes control training	339	5.795	-11.86 to 11.18	-0.005	-0.058 (11)	.95
Diabetes registry training	1.886	5.210	-8.47 to 12.25	0.31	0.362 (11)	.72
Diabetes campaign experience	170	4.319	-8.76 to 8.42	-0.003	-0.039 (11)	.97
Level of facility	2.906	2.552	-2.17 to 7.98	0.077	1.138 (11)	.26
Number of postings	773	2.210	-5.167 to 3.62	-0.028	-0.350 (11)	.73

<sup>a</sup>significant at *P*<.05.

 $^{b}r^{2}=0.684.$ 

<sup>c</sup>Adjusted  $r^2=0.642$ .

<sup>d</sup>Fitness Sample Corrected Akaike's Information Criterion (AICC)= 845.994.

# **Correlation Between Knowledge and Performance**

The study showed a significant positive correlation between total knowledge and performance scores, with a correlation coefficient of r=0.45 (P<.001) at the endline (Figure 3). A

significant correlation was found in the intervention group compared to the control group, with r=0.34 (P=.02). However, no significant correlation was observed in the control group, with r=0.02 (P=.89)



**Figure 3.** Correlation between mean knowledge and performance scoring (n=95). (A) Total scoring, (B) health promotion, (C) screening and diagnosis, (D) care and treatment, (E) referral, (F) registry and reporting.



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### **Cost-Effectiveness of the Intervention**

Researchers categorized the cost data into three main categories: (1) intervention costs, which included web application development, training, internet usage, and stationery; (2) program implementation costs, covering travel expenses, costs for consultation and communication, loss of income due to diabetes-related work, and other miscellaneous costs; and (3) treatment costs for complications. The total cost for the intervention group was 22,213,000 Kyats (US\$ 10,586.71), while the control group incurred a total cost of 22,779,000 Kyats

<b>Table</b> . Summary of costing and outcome for cost-enective analysis	Table .	Summary	of costing a	and outcome f	for cost-effective	analysis.
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(US\$ 10,856,4714) (Table 5). The intervention was deemed cost-effective, with a cost-effectiveness ratio of 0.711, and it was considered cost-effective when the cost-effectiveness ratio was less than 1. The study also analyzed the incremental cost-effectiveness ratio for comparative investment. The incremental cost-effectiveness ratio indicated saving 10,127.04 Kyats (US\$ 4.83) for both outcomes, 30,154.50 Kyats (US\$ 14.40) for knowledge, and 15,247.84 Kyats (US\$ 7.27) in performance. The visibility of cost-effectiveness was demonstrated by plotting bootstrap results against outcomes and expenses (Figure 4).

Overall and detailed costs	Intervention group	Control group
Intervention cost (Kyats) <sup>a</sup>		
Training and software cost	2,000,000 (US\$ 953.20)	0 (US\$ 0)
Internet cost	4,662,000 (US\$ 221.91)	1,878,000 (US\$ 895.05)
Stationary cost	949,000 (US\$ 452.29)	1,262,000 (US\$ 601.47)
Sub total	7,611,000 (US\$ 3627.40)	3,140,000 (US\$ 1496.52)
Hospital expense (Kyats)		
Care and treatment cost due to diabetes complications	4,600,000 (US\$ 2192.36)	6,000,000 (US\$ 2859.6)
Sub total	4,600,000 (US\$ 2192.36)	6,000,000 (US\$ 2859.6)
Staff expense (Kyats)		
Travel cost	2,460,000 (US\$ 1172.44)	3,484,000 (US\$ 1660.47)
Consultation cost for diabetes	1,825,000 (US\$ 869.79)	2,524,000 (US\$ 1202.94)
Communication cost	1,716,000 (US\$ 817.85)	1,891,000 (US\$ 901.25)
Loss of income due to extra workload	1,280,000 (US\$ 610.05)	2,807,000 (US\$ 1337.82)
Miscellaneous cost	2,721,000 (US\$ 1296.83)	2,933,000 (US\$ 1397.87)
Sub total	10,002,000 (US\$ 4766.95)	13,639,000 (US\$ 6500.35)
Total cost (Kyats)	22,213,000 (US\$ 10,586.72)	22,779,000 (US\$ 10,856.47)
Outcomes		
Outcome scoring		
Mean knowledge scoring	99.25	80.48
Mean performance scoring	107.16	70.04
Total outcome score	206.41	150.52

<sup>a</sup>A currency exchange rate of Kyat 1=US \$0.72 is applicable.



**Fotal costs** 



**Total outcomes** 

200

250

150

# Discussion

# **Principal Findings**

The intervention of new integrated digital tools saved costs and yielded significant positive outcomes in knowledge and performance of diabetes control among frontline health workers. Although the study is quasi-experimental, the researcher minimized confounding by matching selection criteria and adjusting covariates through multiple linear logistic regression. Consequently, the study achieved its goals through a consistent design and reliable analytical methods, resulting in valid outcomes. The overall results align with other research on digital solutions to enhance diabetes control [21].

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# **Comparison With Previous Studies**

# Digital Knowledge Solution for Diabetes Control

This study significantly observed that using integrated digital tools could enhance five key domains of knowledge and performance related to health promotion, screening, care and treatment, referral, and reporting diabetes in primary health care settings. Integrating digital knowledge tools and a registry tool is an effective intervention for diabetes control among frontline health workers. A systematic review of evidence-based medicine found that digital knowledge tools can improve diabetes control

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knowledge among primary health care staff [22]. Digital tools can improve the screening process, as supported by other meta-analyses regarding the performance of diabetes screening [23]. Additionally, positive effects of digital tools on providers' performance were observed in areas such as reminders, clinical care decisions, glycemic control, and web-based training and education programs [24].

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While this study concentrated solely on the provider side, digital tools can offer numerous patient benefits, such as increased awareness, improved understanding, and enhanced self-management skills within the community [25]. However, a meta-analysis conducted in Southeast Asia found that patients' knowledge of diabetes was inadequate, especially among women with low education levels and poor diabetes control [26]. Therefore, further research and tailored training in digital interventions are recommended to improve knowledge and awareness among patients, their families, and the community.

# Diabetes Registry for Electronic Health Records

A meta-analysis using electronic health records for diabetes across 12 countries showed positive outcomes [27]. A diabetes registry can enhance the quality of patient care in rural areas, both in high-income countries like the United States of America [28] and in various low-income countries [29]. Unlike other studies, this research connected the positive results of using a

digital diabetes registry and knowledge tools in routine diabetes program reporting, especially for resource-limited settings. The findings showed that reporting performance was significantly improved, and several patients were registered correctly. Therefore, the authors recommend adopting an open-resource, low-cost digital diabetes registry as a nationwide program for diabetes control in Myanmar and other low-income countries.

# **Cost-Effectiveness on Diabetes Interventions**

This study is significant because it measures the direct and indirect costs associated with diabetes management using the WHO-CHOICE formula. Furthermore, the cost analysis was conducted on both knowledge and performance outcomes. Digital monitoring for diabetes has gained popularity alongside increased access to high-speed internet. This advancement has helped reduce costs, lower the number of hospital visits, save time, and improve the quality of life for those managing diabetes [30]. However, some studies suggest that the cost categories related to diabetes are too complex to provide accurate data [31,32]. Additionally, other research indicates that cost analyses may be inadequate due to factors, such as underlying socioeconomic conditions, underreporting, the severity of complications, and the long-term effects of diabetes [32].

Generally, an intervention is considered cost-effective when the cost-effectiveness ratio is less than 1. This study demonstrated cost-effectiveness with a cost-effectiveness ratio of 0.711. Similar evidence supporting cost-effectiveness has been observed in consumer-based solutions, digital tools for blood glucose, and diabetes self-management education in the United Kingdom [33]. This study explored the incremental cost-effectiveness ratio to assess the additional investment needed to enhance knowledge and performance scores for diabetes control. In contrast, another study conducted in Sweden examined incremental cost-effectiveness ratio results related to diabetes control through patients' quality-adjusted life years [31]. Nevertheless, this study urges policy makers to consider further investments in digital tools, even though a sophisticated cost-effectiveness framework has not yet been developed.

# Limitations

According to this study, despite several benefits, the rollout and sustainability of the digital diabetes registry encountered some limitations. Initially, the studies intended to measure baseline, midterm, and endline assessments. However, the authority approved only two measurements based on the country's political situation and the expectation of no significant variation in the midterm. Although the initial goal was to collect real-time data, health staff could only upload information monthly due to being overburdened with competing priorities. The study focused on Naypyitaw, which limits generalizability to the entire country, and only has a 6-month duration, so it cannot evaluate the long-term impacts. The study population focused solely on public providers, excluding private providers, patients, and the wider community. Furthermore, the digital tools were not interoperable with the District Health Information System.

# Conclusions

The intervention used a multidisciplinary approach for frontline health personnel at the grassroots level, significantly improving knowledge and performance and reducing program costs. Unlike other studies, this research demonstrated the integrated and correlated effects of digital knowledge and reporting tools. Given these strengths and limitations, researchers recommend that policy makers replicate the intervention nationwide, develop clear standard operating procedures, establish a reporting schedule, and provide an internet data package to enhance the use of digital tools. Furthermore, the diabetes registry operates in isolation, necessitating the creation of an interoperable system to connect with the District Health Information System. Additionally, extensive studies on long-term population research and economic evaluations are essential to evaluate the sustainability of digital tools. We suggest engaging outstanding community nurses as champions to share their best practices of digital applications, and these measures could ensure data quality and sustainability of digital tools to enhance diabetes control in Myanmar and other low-income countries.

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# **Data Availability**

The datasets for this study will be available in Chulalongkorn University's i-Thesis system and can also be obtained from the corresponding author upon reasonable request.

# **Authors' Contributions**

KT contributed to the conceptualization, design, methodology, development of measurement tools, data collection and analysis, provision of training, follow-up, visualization, and the writing of the original paper. SP contributed to the conceptualization, supervision, and provision of overall advice for structuring the original paper. MNT contributed to developing measurement

tools, supporting data collection and analysis, and reviewing the paper. All authors take responsibility for data integrity, and all authors have read and approved the final version of the manuscript.

# **Conflicts of Interest**

None declared.

# References

- 1. International Diabetes Foundation. Diabetes Atlas 10th edition, Global Website, International Diabetes Foundation. 2021. URL: <u>https://diabetesatlas.org/atlas/tenth-edition/</u> [accessed 2025-05-06]
- Boulton A, Voice D. Why nurses are vital in the global fight against diabetes. Diabetes Res Clin Pract 2020 Nov;169:108568 [FREE Full text] [doi: 10.1016/j.diabres.2020.108568] [Medline: 33298308]
- Golden SH, Maruthur N, Mathioudakis N, et al. The case for diabetes population health improvement: evidence-based programming for population outcomes in diabetes. Curr Diab Rep 2017 Jul;17(7):51. [doi: <u>10.1007/s11892-017-0875-2</u>] [Medline: <u>28567711</u>]
- 4. Klonoff AN, Andy Lee WA, Xu NY, Nguyen KT, DuBord A, Kerr D. Six digital health technologies that will transform diabetes. J Diabetes Sci Technol 2023 Jan;17(1):239-249. [doi: <u>10.1177/19322968211043498</u>] [Medline: <u>34558330</u>]
- 5. World Health Organization. Registries and information systems for diabetes care in the WHO European Region: preliminary findings for consultation.: World Health Organization; 2021. URL: <u>https://www.who.int/europe/publications/m/item/</u> registries-and-information-systems-for-diabetes-care-in-the-who-european-region--preliminary-findings-for-consultation [accessed 2025-05-06]
- 6. Statista. Diabetes Statistics and Facts.: John Elflein, Global Website, Statista; 2024. URL: <u>https://www.statista.com/topics/</u> <u>1723/diabetes/#editorsPicks</u> [accessed 2025-05-06]
- Dahal PK, Rawal LB, Mahumud RA, Paudel G, Sugishita T, Vandelanotte C. Economic evaluation of health behavior interventions to prevent and manage type 2 diabetes mellitus in Asia: a systematic review of randomized controlled trials. Int J Environ Res Public Health 2022 Aug 30;19(17):10799. [doi: <u>10.3390/ijerph191710799</u>] [Medline: <u>36078539</u>]
- Morris T, Aspinal F, Ledger J, Li K, Gomes M. The impact of digital health interventions for the management of type 2 diabetes on health and social care utilisation and costs: a systematic review. Pharmacoecon Open 2023 Mar;7(2):163-173. [doi: 10.1007/s41669-022-00377-9] [Medline: 36495462]
- World Health Organization, WHO Global report on diabetes. 2016. URL: <u>https://www.who.int/publications/i/item/</u> 9789241565257 [accessed 2025-05-06]
- 10. Latt TS, Zaw KK, Ko K, et al. Measurement of diabetes, prediabetes and their associated risk factors in Myanmar 2014. Diabetes Metab Syndr Obes 2019;12:291-298. [doi: <u>10.2147/DMSO.S156270</u>] [Medline: <u>30881072</u>]
- 11. Aye T, Aung M, Oo E. Diabetes mellitus in Myanmar: Socio-cultural challenges and strength. Journal of Social Health and Diabetes 2014 Jun;02(1):009-013. [doi: 10.4103/2321-0656.120255]
- 12. Ministry of Health Myanmar. Electronic health management information system. 2016. URL: <u>https://mohs.gov.mm/Main/</u> <u>content/page/electronic-health-management-information-system</u> [accessed 2025-05-06]
- 13. McLeod S. Attribution theory in psychology: definition and examples. Simply Psychology. 2023. URL: <u>https://www.simplypsychology.org/attribution-theory.html</u> [accessed 2025-05-06]
- 14. Olsen JA. Principles in Health Economics and Policy.: Oxford University Press; 2017. URL: <u>https://global.oup.com/</u> academic/product/principles-in-health-economics-and-policy-9780198794837?cc=th&lang=en [accessed 2025-05-06]
- 15. World Health Organization, WHO Report on National Survey of Diabetes Mellitus and Risk Factor for Non-communicable Diseases in Myanmar.: World Health Organization; 2014. URL: <u>https://www.who.int/publications/m/item/</u>2014-steps-country-report-myanmar [accessed 2025-05-06]
- Shen Y, Wang F, Zhang X, et al. Effectiveness of internet-based interventions on glycemic control in patients with type 2 diabetes: meta-analysis of randomized controlled trials. J Med Internet Res 2018 May 7;20(5):e172. [doi: <u>10.2196/jmir.9133</u>] [Medline: <u>29735475</u>]
- 17. Alharbi NS, Alsubki N, Jones S, Khunti K, Munro N, de Lusignan S. Impact of Information technology-based interventions for type 2 diabetes mellitus on glycemic control: a systematic review and meta-analysis. J Med Internet Res 2016 Nov 25;18(11):e310. [doi: 10.2196/jmir.5778] [Medline: 27888169]
- 18. Google play. Diabetes. URL: <u>https://play.google.com/store/apps/details?id=com.visikon.diabetesguide&hl=en\_US</u> [accessed 2025-05-06]
- 19. KoboToolbox. URL: https://kc.humanitarianresponse.info/minnwetun [accessed 2025-05-06]
- Bertram MY, Chisholm D, Watts R, Waqanivalu T, Prasad V, Varghese C. Cost-effectiveness of population leveland individual level interventions to combat non-communicable disease in Eastern Sub-Saharan Africa and South East Asia: A WHO-CHOICE analysis. Int J Health Policy Manag 2021 Nov 1;10(11):724-733. [doi: <u>10.34172/ijhpm.2021.37</u>] [Medline: <u>34273918</u>]
- 21. Celik A, Forde R, Sturt J. The impact of online self-management interventions on midlife adults with type 2 diabetes: a systematic review. Br J Nurs 2020 Mar 12;29(5):266-272. [doi: 10.12968/bjon.2020.29.5.266] [Medline: 32167825]

- 22. ElSayed NA, Aleppo G, Aroda VR, et al. 1. Improving care and promoting health in populations: standards of care in diabetes—2023. Diabetes Care 2023 Jan 1;46(Supple 1):S10-S18. [doi: 10.2337/dc23-S001] [Medline: 36507639]
- Echouffo-Tcheugui JB, Simmons RK, Prevost AT, et al. Long-term effect of population screening for diabetes on cardiovascular morbidity, self-rated health, and health behavior. Ann Fam Med 2015 Mar;13(2):149-157. [doi: 10.1370/afm.1737] [Medline: 25755036]
- 24. Yang Y, Lee EY, Kim HS, Lee SH, Yoon KH, Cho JH. Effect of a mobile phone–based glucose-monitoring and feedback system for type 2 diabetes management in multiple primary care clinic settings: cluster randomized controlled trial. JMIR Mhealth Uhealth 2022;8(2):e16266. [doi: 10.2196/16266]
- 25. Selen F, Polat Ü. The effect of web based type 2 diabetes education on diabetes self management. Digit Health 2023;9:20552076231205739. [doi: 10.1177/20552076231205739] [Medline: 37822962]
- 26. Lim PC, Rajah R, Lee CY, Wong TY, Tan SSA, Karim SA. Systematic review and meta-analysis of diabetes knowledge among type 2 diabetes patients in Southeast Asia. Rev Diabet Stud 2021 Nov 1;17(2):82-89. [doi: <u>10.1900/RDS.2021.17.82</u>] [Medline: <u>34852899</u>]
- 27. Bak JCG, Serné EH, Kramer MHH, Nieuwdorp M, Verheugt CL. National diabetes registries: do they make a difference? Acta Diabetol 2021 Mar;58(3):267-278. [doi: 10.1007/s00592-020-01576-8] [Medline: 32770407]
- Pollard C, Bailey KA, Petitte T, Baus A, Swim M, Hendryx M. Electronic patient registries improve diabetes care and clinical outcomes in rural community health centers. J Rural Health 2009;25(1):77-84. [doi: 10.1111/j.1748-0361.2009.00202.x] [Medline: 19166565]
- 29. Jackson-Morris AM, Sembajwe R, Nugent R. National registries as a catalyst to development of diabetes care in low-income and middle-income countries. Lancet Diabetes Endocrinol 2021 Apr;9(4):199-200. [doi: 10.1016/S2213-8587(21)00029-2] [Medline: 33577750]
- 30. Li J, Sun L, Hou Y, Chen L. Cost-effectiveness analysis of a mobile-based intervention for patients with type 2 diabetes mellitus. Int J Endocrinol 2021 Jul 1;2021:1-7. [doi: 10.1155/2021/8827629] [Medline: 8827629]
- Johansson P, Ostenson CG, Hilding AM, Andersson C, Rehnberg C, Tillgren P. A cost-effectiveness analysis of a community-based diabetes prevention program in Sweden. Int J Technol Assess Health Care 2009 Jul;25(3):350-358. [doi: 10.1017/S0266462309990079] [Medline: 19619354]
- Bosetti R, Tabatabai L, Naufal G, Menser T, Kash B. Comprehensive cost-effectiveness of diabetes management for the underserved in the United States: a systematic review. PLoS ONE 2021;16(11):e0260139. [doi: 10.1371/journal.pone.0260139] [Medline: 34793562]
- 33. Gillett M, Dallosso HM, Dixon S, et al. Delivering the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cost effectiveness analysis. BMJ 2010 Aug 20;341(aug20 1):c4093. [doi: 10.1136/bmj.c4093] [Medline: 20729270]

# Abbreviations

**WHO:** World Health Organization **WHO-CHOICE:** WHO's Choosing Interventions that are Cost-Effective

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# Nursing and Continuing Care Management Work Plan for People Living With COVID-19: Case Study of the Nakhon Pathom Province

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# Abstract

**Background:** Patients with post-COVID-19 continue to experience lingering physical and psychological symptoms, requiring coordinated and continuous care. Addressing these needs is essential, especially in resource-limited settings.

**Objective:** The objectives of this paper are to study the issues and needs, as well as the nursing and continuous care systems for residents living with COVID-19, to design and develop a database system, develop continuous care guidelines, and evaluate the effectiveness of the database system for continuous monitoring and care for residents living with COVID-19 in Nakhon Pathom Province, Thailand.

Methods: Participatory action research was used to engage stakeholders and guide the development process.

**Results:** A total of 375 patients and family members affected by post-COVID-19 symptoms reported that symptoms persisted for approximately 6 months, with common symptoms including persistent cough and easy fatigue. These patients experienced reduced access to health care services, relying mainly on symptomatic treatment at local facilities and using telehealth nursing systems. They expressed a need for continuous care support from 50 professional nurses and village health volunteers. As a result, health care guidelines for post-COVID recovery were developed, comprising 5 core components: (1) self-care through digital information retrieval, (2) care via telehealth nursing systems, (3) physical health care services postrecovery, (4) mental health services postrecovery, and (5) continuous care for referral in case of postrecovery incidents. These guidelines were used to design a database system for continuous monitoring and care, which was evaluated as highly effective (mean 4.51, SD 0.59).

**Conclusions:** This research highlights the critical need for a proactive and comprehensive approach to managing post-COVID-19 care in Nakhon Pathom Province. By developing and implementing a database system for continuous monitoring and care, along with clear guidelines, the study effectively addresses the ongoing needs of individuals recovering from COVID-19. The integration of technology, along with continuous care provided by professional nurses and village health volunteers, has been shown to be highly effective in improving the quality of care. The findings suggest that adopting these strategies, along with implementing supportive policies on data management and communication systems focused on home visits, will significantly enhance health service management and better prepare the region for future public health challenges.

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#### **KEYWORDS**

post-COVID-19 symptoms; continuous care; database system; COVID-19; care; nursing; care management; Coronavirus; case study; needs; nurse; design; develop; database system; continuous monitoring; participatory research; Thailand; Asia; Asian; cough; fatigue; recovery; quality of care

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# Introduction

# Background

As of October 1, 2022, the COVID-19 pandemic has transitioned from a global pandemic to an endemic disease. According to the latest data from the Department of Disease Control, the global number of confirmed cases from December 2019 to October 2021 reached 224,423,325, with 65,446 currently hospitalized and 4,963,653 cumulative deaths. In Thailand, from April 2021 to October 2022, there have been 4,660,878 cumulative cases, 2616 new cases, and 32,828 cumulative deaths. Specifically, in Nakhon Pathom Province, from April 2021 to October 2022, there have been 83,004 cumulative cases, 30 new cases, and 802 cumulative deaths [1,2]. These statistics show a declining trend in infections; however, there is still no clear report on the long-term effects on those who have recovered from COVID-19.

It is well known that the impact of the COVID-19 pandemic has caused rapid and severe shock, significantly affecting the global economy to the greatest extent in 150 years. The pandemic has impacted tourism for no less than 6 months, resulting in a loss of income exceeding 250 billion baht [3,4]. Despite the reopening of the country and the resumption of tourism, the economic recovery is still in progress and uncertain. The future trajectory of the pandemic and its long-term effects on those infected remain unclear.

Based on the experience in designing health service systems, nursing systems, and continuing care for at-risk populations and those infected with COVID-19 over the past 3 - 4 years, the Faculty of Nursing at Nakhon Pathom Rajabhat University has found that the establishment of a database system to monitor the symptoms of at-risk individuals and patients with COVID-19 under the university's rapid response system still lacks a comprehensive database system to support care within Local Quarantine Centers, Home Isolation, and Community Isolation.

Due to the spread of COVID-19, the health service system has not yet identified suitable methods for living and adapting to the ongoing presence of infectious diseases. There has been no planning or design of a system to access medical care and develop health care guidelines for COVID-19 patients to ensure they can correctly and safely manage their initial care. Additionally, there is no established guideline for postrecovery care for patients returning to normalcy after recovering from COVID-19 to ensure they can resume their normal work activities.

Based on initial interviews, information on people recovering from COVID-19 in Nakhon Pathom over the past 3 - 4 years indicates that no agency has monitored the symptoms of those who have recovered, tracked their postrecovery lifestyle, or followed up on long COVID symptoms. Additionally, there has been no data collection on vaccination for people who had COVID-19. This group has been informed that they would develop immunity after infection, leading to a lack of follow-up booster vaccinations.

Given this situation, there is a significant opportunity to design a health service system that includes nursing and continuous

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care for people living with COVID-19 in Nakhon Pathom. This system should leverage health technology, as the majority of the population now has greater access to technology for health promotion and treatment. It should also include plans to support measures for preventing further outbreaks or new epidemics. This approach would address health maintenance, disease prevention, social distancing, and the adoption of new lifestyle behaviors to live safely with COVID-19.

Therefore, the research team recognizes the importance of addressing these issues and has undertaken the development of a work plan for managing nursing systems and continuous care for people living with COVID-19: A Case Study of Nakhon Pathom Province. This plan aims to examine the nursing and continuing care management work plan for individuals living with COVID-19 in Nakhon Pathom Province and to explore the effectiveness of integrated care approaches, including telehealth and community-based services, by improving access to services, enhancing the care, and providing nursing for patients with post-COVID-19 both at home and within the community. To enhance access to services and improve the quality of care and nursing for post-COVID-19 patients at home and in the community, the following steps are necessary: screening: implement self-assessment tools for evaluating the risk and symptoms post-COVID-19 recovery; tracking and tracing: monitor and record follow-up data by community health service units; surveillance system: establish a system for ongoing observation and reporting; and information transfer system: use health technology to ensure seamless data transfer and communication. By implementing this comprehensive plan, the goal is to prepare the community in Nakhon Pathom to live with COVID-19, ensuring high-quality care and support through the effective use of health technology.

#### **Research Purpose**

The purpose of this article is (1) to study the issues, needs, and systems of nursing and continuous care for people living with post-COVID-19 in Nakhon Pathom Province; (2) to design and develop a database system for continuous monitoring and care of individuals with post-COVID-19 in Nakhon Pathom Province; (3) to develop guidelines for the continuous care of patients recovering from post-COVID-19 in the community in Nakhon Pathom Province; and (4) to evaluate the effectiveness of the database system for continuous monitoring and care of individuals with post-COVID-19 in Nakhon Pathom Province.

#### **Conceptual Framework**

The study is guided by 2 key conceptual frameworks that provide a theoretical basis for the research and the development of the health care system. These frameworks were selected based on their relevance to the goals of the study and their ability to provide a comprehensive approach to managing nursing and continuous care for patients with post-COVID-19.

#### Transitional Care or Transaction Model

The Transitional Care or Transaction Model model [5] emphasizes the importance of continuous care during transitions between health care facilities and home. It focuses on ensuring that patients receive consistent, high-quality care throughout the different stages of their recovery. The model includes three

stages: (1) pretransition: the period before the patient leaves the hospital, where the focus is on preparing the patient for the transition to home care; (2) midtransition: the actual transition period, where the patient moves from the hospital to home or another care setting; and (3) posttransition: the period after the patient has returned home, where the focus is on ensuring that the patient continues to receive the care they need to recover fully.

Each stage of the transition requires attention to 4 critical factors:

Information: ensuring that accurate and relevant information is provided to both patients and caregivers. This includes providing clear instructions on medication, follow-up appointments, and any other aspects of the patient's care plan.

Communication: using effective communication strategies to keep all stakeholders informed and involved. This includes regular updates to the patient's care team, as well as clear communication with the patient and their family.

Support: offering immediate support to patients and their families as they navigate the health care system. This includes providing access to resources such as social workers, financial counselors, and other support services.

Time: allowing sufficient time for each stage of the transition to be completed successfully. This includes ensuring that the patient has enough time to adjust to their new care setting and that any necessary adjustments to their care plan are made promptly.

The continuous care concept for patients with post-COVID-19 also applies. The primary care behavioral health model by Reiter and team [6] includes the following components: access to health information: ensuring patients and providers have access to relevant health data; health management: efficiently managing health care processes and resources; health coordination: coordinating care among different providers and services; teamwork: facilitating collaborative efforts among health care teams; budget responsibility: managing financial resources effectively; supporting health information technology: using technology to support and enhance health information; and service quality and safety: ensuring high standards of care and safety for patients.

The researchers analyzed, connected, and supported the 2 conceptual frameworks within the context of Nakhon Pathom Province, leading to the design of a database system for data transfer, management, and continuous care for individuals with COVID-19 in the area. The research process involved surveying the situation, issues, and needs of the nursing and continuous care system from the perspectives of professional nurses, public health officials, and patients with post-COVID-19, as well as the general public. This resulted in a practical database system for data transfer, management, and continuous care, which includes the following: information: providing accurate and useful data; communication: using effective communication methods; support: offering timely support as needed; and time: ensuring appropriate and sufficient time for processes. The system addresses health management, coordination, teamwork, and budget responsibility, aiming to ensure safety in daily life.

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# Methods

# **Study Design**

This research uses a research and development approach with 3 stages.

# Stage 1

Study the problems and needs: this stage investigates the current issues and needs of the nursing and continuous care system for individuals with post-COVID-19 in Nakhon Pathom Province.

#### Stage 2

Design, develop, and test: this stage is to design and develop the database system for continuous monitoring and care of individuals with post-COVID-19 in Nakhon Pathom Province. Subsequently, we synthesized the data from the system to create guidelines for continuous care for patients with post-COVID-19 in community settings within the province.

#### Stage 3

Evaluate the effectiveness: we aimed to assess the effectiveness of the database system for continuous monitoring and care of individuals with post-COVID-19 in Nakhon Pathom Province.

#### **Research** Area

The research area is Nakhon Pathom Province.

#### **Population**

The included population was patients and families who have had COVID-19 within the past year and have recovered for at least 3 months, residing in Nakhon Pathom Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom

In the Province, there were a total of 15,117 people. Among them, professional nurses, public health officials, and directors of the community health promotion hospitals in the Mueang District area of Nakhon Pathom Province were included, totaling 50 people.

#### Sampling

The sample group was selected using Krejcie and Morgan's (1970) formula with a 5% margin of error from the total population. For patients and families who have had COVID-19, the sample size is 375 people. For professional nurses, public health officials, and directors of community health promotion hospitals in the Mueang District of Nakhon Pathom Province, all 50 individuals were selected.

#### **Tools of Research**

This study used questionnaires as the primary data collection tool and adopted both qualitative and quantitative methods:

Stage 1 used qualitative tools, which include focus group guidelines; interview guidelines; questionnaire for note-taking; and analysis guidelines and participatory observation.

Stage 2 used the findings from stage 1 to develop a database system for continuous monitoring and care of individuals with post-COVID-19 in Nakhon Pathom Province, which includes system design. We also developed a data management system that collects and stores information on computers and through

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internet-based databases. Moreover, for data synthesis, we applied matrix-based comparative analysis principles to synthesize the collected data; and created guidelines using the synthesized data to establish guidelines for continuous care of patients with post-COVID-19 in community settings within Nakhon Pathom Province.

Stage 3 involves evaluating the effectiveness of the database system for continuous monitoring and care of individuals with post-COVID-19 in Nakhon Pathom Province. This stage uses quantitative tools by creating a custom questionnaire: developing a specifically designed questionnaire to assess the effectiveness of the database system. This tool will gather quantitative data on how well the system performs in terms of functionality, usability, and overall impact on patient care and management.

The quantitative tool used is a questionnaire designed for data collection, which underwent review by experts in various fields: nursing experts, continuous care nursing experts, epidemic nursing experts, and database system development experts. A total of 3 experts reviewed the questionnaire for content validity, resulting in an Index of Item-Objective Congruence of 0.98. Following the revision of the content based on their feedback, the revised tool was tested for reliability with a sample group of 30 individuals similar to the actual target sample. The reliability analysis of the questionnaire, specifically designed for patients who have had COVID-19 and their families, yielded a content validity index of 0.91.

Qualitative tools included note-taking forms, analysis guides, participatory observation, focus group and interview guidelines, and workshop protocols. Content validity was confirmed by experts, with a Content Validity Index of 0.90 for the nurse or public health questionnaire and 1.00 for interviews with hospital directors, ensuring tool reliability.

#### **Data Collection**

Data were collected with 2 years of follow-up in 3 steps as follows.

#### Step 1

Step 1 involves studying the problems and needs of the nursing and continuous care system for individuals with COVID-19 in Nakhon Pathom Province. The focus group involves examining the situation, identifying issues, and determining requirements from a total of 375 participants. The qualitative data are synthesized to create a comprehensive map of the issues and needs of the nursing and continuous care system for individuals with COVID-19 in Nakhon Pathom Province. The summarized results will inform and guide the development process in step 2.

# Step 2

In step 2, the researchers designed a database system for continuous monitoring and care of individuals with COVID-19 in Nakhon Pathom Province using data from step 1. This involved developing the system with technology through 4 datasets: information, communication, support, and time. The goal is for the community health promotion hospitals in Nakhon Pathom to use the database system for data transfer, management planning, and continuous care, enabling individuals in Mueang

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District, Nakhon Pathom Province, to lead live safe and stable lives while managing their condition. The system design also incorporated measures from the Personal Data Protection Act.

Test and pilot the database system: Tests and trial runs of the database system will be conducted for continuous monitoring and care of individuals with COVID-19 in Nakhon Pathom Province. This involves evaluating the system's functionality, usability, and effectiveness in real-world scenarios to ensure it meets the needs of managing and supporting the affected population.

Develop guidelines for continuous care: The researchers used the analysis results from step 1, combined with relevant data from additional research, to create guidelines for the continuous care of patients with post-COVID-19 in community settings within Nakhon Pathom Province. This involved synthesizing the information to establish practical and effective care practices tailored to the needs of the local population.

### Step 3

Step 3 involves evaluating the effectiveness of the database system for continuous monitoring and care of individuals with COVID-19 in Nakhon Pathom Province.

The evaluation will involve a sample group consisting of professional nurses, public health officials, and Directors of Community Health Promotion Hospitals. In total, 50 individuals from the Mueang District of Nakhon Pathom Province will be involved in assessing the system's performance and effectiveness.

Summarize the effectiveness of the database system: The data on the performance and effectiveness of the database system for continuous monitoring and care of individuals with COVID-19 in Nakhon Pathom Province will be compiled and analyzed. This includes evaluating how well the system meets its objectives and supports patient management.

Develop recommendations and user manual: Recommendations will be provided based on the evaluation findings and a comprehensive user manual for the database system will be prepared. The manual will guide users on how to effectively operate the system and integrate it into their continuous care practices for individuals with COVID-19 in Nakhon Pathom Province.

#### **Ethical Considerations**

This research has received ethical approval from the Human Research Ethics Committee of Nakhon Pathom Rajabhat University, with approval numbers 047/2565-047/2566. Participants in the research are free to withdraw from providing information or participating in activities at any time during the data collection process. They can also withdraw from the research process altogether if they are uncomfortable with using the data or engaging in the activities.

#### **Data Analysis**

In steps 1 and 2, the analysis focuses on understanding the problems, needs, and continuous care system for individuals with COVID-19 in Nakhon Pathom Province. This involves process analysis, content comparison, interpretation,

summarization, transcription, categorization, synthesis of sentences, and validation: triangulating data by cross-checking findings from multiple sources and methods to ensure accuracy and reliability. This approach ensures a comprehensive and reliable analysis of qualitative data.

In step 3, which involves evaluating the effectiveness of the database system for continuous care of individuals with COVID-19 in Nakhon Pathom Province, the analysis focuses on descriptive statistics, percentages, frequency distribution, mean and SD. These statistical methods help summarize and interpret the quantitative data collected during the evaluation of the database system, providing insights into its effectiveness and performance.

# Results

# Phase 1: The Problems and Needs of the Nursing and Continuous Care System for Individuals With COVID-19 in Nakhon Pathom Province

The results of phase 1 revealed 5 key issues regarding the health care system and continuous care needs for the public living with COVID-19 in Nakhon Pathom province.

# Issues With Health Care Service

When the rapid antigen test results are positive, patients receive management to enter the health care system according to the hospital's primary health care promotion unit in the area they reside. However, some individuals do not access the service system, instead focusing on self-care using principles of isolation from family members and primarily treating themselves with herbal remedies.

"Long wait times for service, being ill without income, recovered but symptoms persist." After recovering, issues arise due to reflections that the patient group accessing hospital services receives care at the provincial hospital, undergoes hospital checks after staying at the field hospital for 10 days, then returns home for 4 days of continued care at the local health promotion hospital via line group reporting and community health volunteers. Friends and neighbors help report symptoms through line groups and report complications or additional symptoms, with the hospital sending medication to take.

To address the needs for care and nursing following recovery from COVID-19, the following steps are recommended:

Facility preparation: Local service facilities should prepare beds for bedridden patients or elderly individuals recovering from COVID-19. This includes setting up systems for meal delivery in the area to facilitate convenience during isolation.

Continued follow-up: There should be continuous monitoring and follow-up after recovery from COVID-19. It is crucial to advise individuals to maintain their health and provide education on self-care, particularly regarding monitoring symptoms such as fatigue and shortness of breath post-COVID.

Vaccination guidance: Guidance should be provided regarding vaccination. It's important to emphasize that vaccination against COVID-19 and influenza can strengthen immunity and prevent

re-infection with COVID-19. This also reduces the risk of transmitting the virus again in the community.

These measures aim to ensure comprehensive care and support for individuals postrecovery, promoting their well-being and reducing the likelihood of recurrence or complications related to COVID-19.

The issue of providing health information and preparing health data for patients with COVID-19 should be led by health care professionals in the area, especially professional nurses, public health officials, and community health volunteers. They should serve as information leaders for self-care among patients with COVID-19. Communication channels should emphasize awareness through voice messaging systems and community outreach via TV, Facebook, and the internet. Information should be obtained from local health authorities, neighbors, family members, hospitals, and local health promotion hospitals. This ensures that individuals receive clear and adequate information on self-care and COVID-19 prevention efforts.

Communication strategies appropriate during various stages—awareness, illness, recovery, and reintegration into society—include discreet doctor notification via phone to contact health services upon symptoms or diagnosis. During illness, nurses may inquire daily for the initial treatment group, approximately 10 - 15 days, while those self-treating with family monitor health, consumption, and home isolation postrecovery. Initially worried about social acceptance post-COVID, more recently adjusting, radio communication shares self-care after diagnosis and primary care treatments

The key support factors during illness, recovery, and postreintegration into society include increased family caregiving, mutual encouragement among friends, and involvement from doctors, nurses, and relevant officials. Family members, community health volunteers, and local health authority representatives play pivotal roles in communication and primary care. Spouses, children, and extended family members provide assistance during isolation, particularly for COVID-19 cases or households with elderly members requiring separate care, ensuring continuous support.

The issue concerning the timeframe after recovering from COVID-19 spans approximately 1 week to 6 months, with varying durations of symptoms for each individual. Some may experience symptoms for up to 15 days, isolating from household members for about 10 - 15 days due to fear of social stigma and concern about others' perceptions of ongoing illness. They separate their food and personal items, use a separate room for rest, meals, and medication, and gradually return to normal life after recovery. However, lingering symptoms such as cough, fatigue, and underlying health conditions persist.

# Phase 2 Outcomes: Development and Design of a Database System for Continuous Monitoring and Care for Residents Living With COVID-19 in Nakhon

# Pathom Province, Specifically for Patients With Post-COVID-19 in Community Settings

# Dataset for Developing a Continuous Monitoring and Care Database System for Residents Living With COVID-19

Part 1: General information, which includes household member general information, information related to household head, characteristics of occupations, household security information, household environmental management information, health information, and communication information.

Part 2: Continuous care management data, which include chronic diseases, persistent symptoms after recovering from COVID-19 1 year later, and health care guidelines for the population after recovering from COVID-19.

Part 3: Management outcome data. Analyzing data from parts 1 and 2 to analyze the outcomes resulting from comprehensive management efforts as follows:

- CODE\_PC1 : Seeking health knowledge and management post-COVID-19
- CODE\_PC2 : Risk control and safety post-COVID-19 by telenursing
- CODE\_PC3: Self-care post-COVID-19
- CODE\_PC4: Self-control psychological health post-COVID-19
- CODE\_PC5: Satisfaction with referral care post-COVID-19

# Health Care Guidelines for the Population After Recovering From COVID-19

# Guidelines for Self-Care

Using digital resources related to COVID-19 includes recommending the use of apps, websites, and information from health promotion hospitals to provide information on COVID-19 infection; recommend vaccination information; and advise on using apps and websites related to COVID-19 for village health volunteers.

# *Guidelines for Managing COVID-19 Remotely Through Telenursing Systems*

These guidelines include the following: providing consultation and advice via phone by community health promotion hospitals; organizing remote educational activities on self-protection, hand hygiene, wearing masks, and updated information on COVID-19 for patients, families, and communities; conducting remote disease management and nursing activities by health care experts; and assessing and screening post-COVID symptoms, interpreting rapid antigen test results, managing medications, and monitoring respiratory symptoms.

# *Guidelines for Providing Post-COVID-19 Physical Health Care Services*

These guidelines include the following: annual health check-ups, particularly chest X-rays and disease screening; home visits by community health volunteers; remote home care services by community nurses or public health professionals; providing advice on self-care through purchasing medications and treatments from pharmacies, medical clinics, and nursing clinics

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in the area; and organizing campaigns to encourage vaccination against COVID-19 and influenza.

# Guidelines for Providing Mental Health Services Postrecovery From COVID-19

These guidlines are used for providing services to assess and screen for depression and offering mental health counseling through hotline services.

# Continuous Care Guidelines for Referral in Case of Emergencies Postrecovery From COVID-19

These guidelines include the following: arranging services for severe symptoms or emergencies providing remote nursing services for continuous treatment information dissemination.

The outcome is the database of results from the continuous care management of COVID-19 infection 1 year postrecovery.

# Phase 3: Evaluate the Effectiveness of the Database System for Continuous Monitoring and Care of Individuals With Post-COVID-19 in Nakhon Pathom Province

The researchers implemented a database system for continuous monitoring and care for the public affected by COVID-19 in Nakhon Pathom Province. They evaluated its effectiveness among 50 health care professionals, including registered nurses, public health officers, and directors of sub-district health promotion hospitals in Mueang District, Nakhon Pathom Province. The overall effectiveness was found to be at the highest level (mean 4.51, SD 0.59), with the highest performance specifically in data security (mean 4.59, SD 0.57). Following closely was the capability to perform tasks effectively (mean 4.53, (SD 0.56).

# Discussion

# **Principal Findings**

This study aimed to develop a nursing and continuous care management work plan for individuals living with COVID-19 in Nakhon Pathom Province, focusing on identifying needs, designing an integrated database system, and evaluating its effectiveness. The findings highlight significant challenges in the health care service system, including limited access to care, reliance on self-treatment, and the persistence of post-COVID-19 symptoms. In response, a comprehensive care model was designed to address gaps in service delivery through the use of digital technologies, community-based care strategies, and structured follow-up mechanisms. The final phase demonstrated the system's high level of effectiveness in practice, particularly in data security and task performance, as evaluated by health care professionals. Results showed high overall effectiveness (mean 4.51, SD 0.59), with data security rated highest (mean 4.59, SD 0.57), followed by task performance (mean 4.53, SD 0.56). This confirmed the system's capacity to support sustainable, technology-enabled post-COVID care at the community level.

Based on the situation of health care and continuous care systems for the public living with COVID-19 in Nakhon Pathom Province, it was found that symptoms persist approximately 6

months postinfection. According to Davis et al [7] for the majority of respondents (>91%), the time to recovery exceeded 35 weeks. Common post-COVID symptoms include persistent cough and fatigue, consistent with studies by Thekgungsakdakul et al [8] and Ruengsong et al [9]. However, other research suggests that patients with COVID-19 may have an increased risk of developing respiratory diseases, and the risk increases with the severity of infection and reinfection [10].

There is also evidence of anxiety and social withdrawal, echoing findings by Tongtaeng and Sisawang [11], which highlight significant psychological impacts such as depression that necessitate evaluation following COVID-19 infection management protocols [12]. This research defines self-management outcomes in mental health post-COVID symptom onset.

From the study findings, it was observed that patients experiencing post-COVID symptoms have reduced access to treatment services at local facilities and increasingly rely on telehealth systems for care. They still require support from professional nurses and community health volunteers for continuous care. Consequently, the research analysis proposes health care guidelines for the public following recovery from COVID-19, consisting of five key strategies: (1) self-care guidance through digital information access related to COVID-19; (2) management of COVID-19 via telehealth nursing systems; (3) physical health care services postrecovery; (4) mental health care services postrecovery; and (5) continuous care guidelines for referral cases reported after recovery. The integration of telehealth systems has played a critical role in enhancing nursing care during the COVID-19 pandemic. Prior studies have demonstrated that telemedicine not only supports effective monitoring of patients with COVID-19 while minimizing transmission risks but also contributes to the continuity and quality of care delivery [13,14].

These align with the findings of Thongnopakun et al's [15] study on knowledge and attitudes towards patient follow-up among community health volunteers before and after training, indicating significant differences. They also follow the guidelines of the Medical Research and Technology Evaluation Institute [16], emphasizing self-care and receiving services from local health units or seeking telemedicine advice if symptoms persist beyond 2 months to consult specialized physicians for developing health care strategies for patients experiencing post-COVID symptoms, including the studies of Chugamnern et al [17], which emphasize the importance of evaluating data from patients' families and communities, thereby reflecting the importance and necessity of designing a continuous care tracking database system for the public living with COVID-19 to improve service provision in the future.

#### Suggestions

A network for emergency care or urgent assistance among local volunteers and the health service network to prevent diseases should be established.

Health service units should establish policies on data management for health service leaders, communication systems to develop a continuous care system focusing on home visits, and support management to care for patients with post-COVID or patients with other epidemic diseases.

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# **Conflicts of Interest**

None declared.

# References

- 1. Department of Medical Services. Long-term health impact of COVID-19 survivors and service delivery guidelines. Med J Dep Med Serv 2022;47(2):5-8 [FREE Full text]
- 2. Department of Disease Control. Coronavirus disease 2019 (COVID-19). URL: <u>https://ddc.moph.go.th/viralpneumonia</u> [accessed 2025-05-22]
- 3. Saenyen TN, Wenbapp W, Chuanprasit W, Sarayut K, Haso A. Analysis of coping with COVID-19: impact on the airline industry. J Humanit Soc Sci 2020;3(2):209-220 [FREE Full text]
- 4. Janthapong S, Tonghui T. The impact of the COVID-19 crisis on the global economy. URL: <u>https://www.bot.or.th/Thai/</u> <u>ResearchAndPublications/articles/Pages/Article\_18Mar2020.aspx</u> [accessed 2025-05-22]
- Groenvynck L, de Boer B, Hamers JPH, van Achterberg T, van Rossum E, Verbeek H. Toward a partnership in the transition from home to a nursing home: the TRANSCIT model. J Am Med Dir Assoc 2021 Feb;22(2):351-356. [doi: 10.1016/j.jamda.2020.09.041] [Medline: <u>33223451</u>]
- 6. Reiter JT, Dobmeyer AC, Hunter CL. The primary care behavioral health (PCBH) model: an overview and operational definition. J Clin Psychol Med Settings 2018 Jun;25(2):109-126. [doi: 10.1007/s10880-017-9531-x] [Medline: 29480434]

- Davis HE, Assaf GS, McCorkell L, et al. Characterizing long COVID in an international cohort: 7 months of symptoms and their impact. EClinicalMedicine 2021 Aug;38:101019 [FREE Full text] [doi: 10.1016/j.eclinm.2021.101019] [Medline: 34308300]
- 8. Thekgungsakdakul S. Factors influencing post-COVID-19 condition at Nang Rong Hospital, Buriram Province. J Med Sci Srisaket Hosp 2023;38(2):449-461 [FREE Full text]
- 9. Ruengsong W. Post-COVID-19 symptoms: diagnosis and treatment. Krabi Med J 2022;5(1):51-64 [FREE Full text]
- Meng M, Wei R, Wu Y, et al. Long-term risks of respiratory diseases in patients infected with SARS-CoV-2: a longitudinal, population-based cohort study. EClinicalMedicine 2024 Mar;69:102500 [FREE Full text] [doi: 10.1016/j.eclinm.2024.102500] [Medline: 38389713]
- 11. Thongtaeng P, Sisawang J. Post-COVID-19 conditions in elderly patients with chronic diseases. Nurs Sci J Thailand 2024;42(2):1-18 [FREE Full text]
- 12. Khamanek S, Reunphet K, Hiransawanit A, Make A, Saelim P. The role of nurses in caring for patients with post-COVID-19 depression. J Nurs Health Care 2022;40(4):1-9 [FREE Full text]
- Ivanova J, Cummins MR, Soni H, et al. Mental health providers' challenges and solutions in prescribing over telemedicine: content analysis of semistructured interviews. JMIR Hum Factors 2025 Mar 20;12:e65419. [doi: <u>10.2196/65419</u>] [Medline: <u>40112291</u>]
- Chang YL, Lin CY, Hsu J, et al. Leveraging smart telemedicine technology to enhance nursing care satisfaction and revolutionize COVID-19 Care: prospective cohort study. JMIR Hum Factors 2025 Jan 21;12:e53456. [doi: <u>10.2196/53456</u>] [Medline: <u>39838732</u>]
- 15. Thongnopakun S, Thuaychot T, Wattanaburanon O, Wisnuyothin S. Knowledge attitudes and factors related behaviors on the prevention and control of COVID-19 among village health volunteers in Chanthaburi province. Public Health J Burapha Univ 2022;17(2):42-55.
- 16. Medical Research and Technology Evaluation Institute. Long-term health effects of COVID-19 survivors and health service management guidelines. Med J Dep Med Serv 2023;47(2):1-8 [FREE Full text] [doi: 10.31524/bkkmedj.2023.22.001]
- 17. Chugamnern S, Intranonrong K, Wongpradit S. Essential competencies of professional nurses in COVID-19 patient care: a scoping review. J Nurs Health Res 2022;23(2):71-86 [FREE Full text]

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# Patients' Perception of a Brief Web- and Mindfulness-Based Intervention for Pain Following Discharge After Total Joint Arthroplasty: Qualitative Description

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# Abstract

**Background:** Important levels of pain are reported upon discharge from major surgery, with a risk of becoming chronic. Further, individuals express the need for support in managing pain after discharge. However, very few studies address pain management interventions in the postdischarge phase after surgery, including for individuals undergoing total joint arthroplasty (TJA). We have conducted a pilot randomized controlled trial testing a brief mindfulness intervention targeting people at risk for chronic postsurgical pain 2 weeks after surgery. Although the intervention we proposed was judged acceptable based on ratings obtained through a questionnaire, the nuanced perceptions of why and how it is considered acceptable are critical in refining the intervention. Moreover, the acceptability of mindfulness interventions in the perioperative context remains generally unknown and even more so in the postdischarge setting.

**Objective:** The purpose of this study was to use qualitative data to explore the individual perception of acceptability of a brief 4-week, Web- and mindfulness-based intervention for pain following discharge after a TJA.

**Methods:** A qualitative description was used to assess patients' perception of the preliminary version of the intervention for pain management following discharge after surgery. The qualitative assessment was done at the end of the 4-week intervention (6 weeks after surgery). Semistructured interviews with open-ended questions were used to encourage free expression from participants (n=16) before proceeding to content analysis.

**Results:** When reflecting on the benefits of the intervention, the main themes that emerged were mindfulness, pain acceptance, and supplementary relief. Overall, the intervention was perceived as relevant and suitable during recovery, although participants experienced a few challenges related to the novelty of mindfulness practice. Engagement and readiness were discussed in relation to adherence to the intervention. Addressing expectations and personal beliefs before the intervention could improve participants' adherence. Offering additional support when spikes of pain occur could help overcome some challenges related to mindfulness practice during postoperative recovery.

**Conclusions:** Given the increasing number of TJA surgeries performed annually and the effectiveness of nonpharmacological interventions, such as mindfulness-based approaches, in supporting recovery and well-being, efforts should be made to increase patient access to these promising adjunctive treatments. Combining nonpharmacological interventions before and after surgery may be an interesting avenue to optimize pain relief and recovery, as well as prevent complications. Finally, the use of technology could improve the accessibility, scalability, and adoption of these promising approaches for individuals with limited resources and mobility.

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# KEYWORDS

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pain; mindfulness; online; surgery; web; arthroplasty; patient perception

# Introduction

Pain after total joint arthroplasty (TJA) is expected, but little is known about pain after discharge [1]. As the length of hospital stay after surgery continues to decrease, it is essential to develop our knowledge regarding pain and its management in the subacute postoperative phase. A recent meta-analysis found the prevalence of moderate to severe postoperative pain ranges from 51%, one day after discharge, to 58%, 1-2 weeks after discharge [1]. Two weeks after surgery marks the beginning of the subacute phase and is the time when pain and analgesic consumption are expected to decrease or when persistent postsurgical pain begins to be evident [2]. Hence, these pain rates may be unnecessarily high and put patients at elevated risk for developing chronic postsurgical pain (CPSP) [3,4], prolonged opioid use, and adverse effects of nonopioid agents [5-7]. Very few studies address pain management interventions in this setting, including after TJA [2,8,9], despite documented concerns and lack of support reported by individuals during their recovery following TJA [10]. Multiple barriers are also involved with this gap in the continuum of care [11,12]. Based on prior research with both clinicians and patients [12,13], there are promising opportunities for training postoperative patients in self-management of pain. Given the risks associated with pharmacological approaches, efficient nonpharmacological interventions for pain should be developed and offered to these individuals.

A variety of educational and psychoeducational interventions exist for individuals undergoing TJA that have been shown to have minimal impact on pain in the perioperative setting [9]. recently, traditional 8-week mindfulness-based More interventions (MBIs) have been delivered preoperatively to patients with TJA, and early evidence indicates they improve outcomes [14,15]. However, in addition to a lack of interest to engage in such interventions in the preoperative period, the accessibility and scalability of 8-week MBIs are limited by feasibility and acceptability challenges, including the substantial time commitment required to participate in an 8-week intervention, the extended gap between starting the intervention and undergoing surgery, and logistical barriers such as scheduling multiple treatment sessions over several weeks [14,15]. To address some of these limitations, our team and others have recently adapted MBIs to address the needs of patients in the preoperative period [14-23]. Brief MBIs delivered preoperatively have been shown to have medium to large effects on orthopedic surgical patients' acute pain, pain unpleasantness, opioid use, and pain medication desire [19,20]. These novel brief MBIs are promising but have not been delivered in a targeted manner in the first few weeks after surgery to patients with a different postoperative pain trajectory associated with worse outcomes, showing warning signs for transitioning to CPSP [24].

However, providing patients with effective pain management in the subacute period after TJA is complicated by shortened postoperative hospital stays, mobility challenges, and uncertainty about who is responsible for pain management after discharge [11,25]. As a result, patients are often left to self-manage pain, which can be overwhelming and lead to inconsistent or

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inadequate care. In an effort to address barriers to the implementation of pain management interventions after discharge and to increase their accessibility, we proposed a Web-based asynchronous version of a brief MBI, which showed positive outcomes [26]. However, the acceptability of these MBIs, including individual experiences and perceptions in the perioperative context, remains generally unknown, and the very few studies address traditional 8-week formats [14,27]. Although the intervention we proposed was judged as acceptable based on ratings obtained through a questionnaire [26], the nuanced perceptions of why and how it is considered acceptable are missing. It is critical to capture this aspect to understand which intervention elements are perceived as effective and appropriate and how we can tailor the intervention and further improve its acceptability and efficacy. Therefore, the purpose of this study was to use qualitative data to explore the individual perception of acceptability of a brief 4-week MBI for pain following discharge after a major orthopedic surgery, for example, total hip or knee arthroplasty. The data and results presented in this paper are secondary to a pilot randomized controlled trial (RCT) that was conducted to evaluate the feasibility and preliminary effects of this intervention after TJA in 36 older adults [26].

# Methods

# Design

This study is part of a pilot RCT that examined the impact of a brief 4-week MBI intervention on pain and other postoperative outcomes [26]. Data collection was completed in August 2022. A qualitative description [28] was used to assess patients' perception of the preliminary version of the intervention for pain management following discharge after surgery. This approach matched the needs of this study by allowing the analysis to stay close to the data and the informants' point of view without imposing a specific philosophical or theoretical framework (eg, grounded theory and phenomenology) [28,29]. Qualitative descriptive analyses are particularly useful when developing and refining clinical interventions in the context of health services research, where patients' perspectives are the ultimate evaluation [29-32]. This design allowed us to describe the extent to which the intervention is acceptable and what ingredients are helpful or need improvement from a patient's perspective.

#### **Ethical Considerations**

The project received ethics approval from Florida State University's institutional review board in January 2022 (#STUDY00001771) and was preregistered (NCT04848428). Informed and written consent was obtained from each participant. During the initial meeting with the research team, besides providing details on the study and the nature of participation, it was emphasized that participating was completely voluntary and that participants could refuse or withdraw at any time without affecting their care. Strict measures were implemented in collaboration with our clinical partners to protect privacy throughout the study. Confidentiality and anonymity were also ensured by assigning a code to each participant during data collection, analysis, and the use of illustrative verbatim in the current manuscript.

#### Procedure

Nurses from the preoperative clinic introduced the study to potential participants. If interested, an experienced research assistant (RA) explained the study, answered any patient questions, and signed the consent form during a preoperative visit 1 week before surgery. Two weeks after surgery (T0), the RA called each participant to confirm their eligibility and collect baseline sociodemographic and clinical data. Two weeks correspond to the first follow-up with the surgeon, and waiting 2 weeks before beginning the interventions also allowed participants to recover from acute surgical pain and experience the challenges of managing persistent pain in their daily activities. Participant inclusion criteria included the following: (1) 18 years and older; (2) first elective TJA; (3) presence of pain during movement  $\geq 4/10$  [33] 2 weeks after surgery; (4) ability to understand and complete questionnaires in English; (5) ability to use an electronic device such as a smartphone and computer or tablet; and (6) completed the brief 4-week MBI. Patients were not eligible for the study if they were unable to consent because of physical or mental incapacity. Participants received gift cards of US \$25 at each of the data collection time points (T0: 2 wk after surgery, T1: 6 wk after surgery). After a prescreening and a baseline assessment, participants were randomized to receive the brief 4-week MBI (experimental group) or a pain-coping educational intervention (active control group). A total of 18 participants were assigned to the experimental group receiving the new brief Web-based MBI. An assessment of the acceptability of the intervention was conducted at the end of the intervention using a questionnaire. Semistructured individual interviews (telephone) were then conducted by the RA with all intervention arm participants to explore their individual perceptions. The sample size was thus not based on data saturation, but on involvement in the experimental group.

#### Intervention

In addition to usual care, participants received the brief MBI delivered remotely, asynchronously through prerecorded videos. Across the 4 weeks, participants received a weekly link via email or text message that allowed them to access their intervention videos. The intervention videos were embedded in Qualtrics to allow optimized viewing from any type of device, for example, a computer, tablet, or smartphone. Participants were invited to watch the videos as much as needed or desired. Over the course of the 4-week intervention, participants received reminders to view their weekly video if they had not viewed it. In an effort to promote self-management, the interventional support.

The brief MBI is an adaptation of mindfulness-oriented recovery enhancement (MORE) [34]. The traditional MORE program is an efficacious, 8-week treatment for chronic pain and opioid misuse [35-37] that integrates 3 core therapeutic elements (ie, mindfulness, positive reappraisal, and savoring) to promote positive patient outcomes. The brief, 2-hour version of MORE brief mindfulness-oriented recovery enhancement (ie, [B-MORE]) that was used in this study retained each of these 3 core therapeutic elements and was delivered through four 20-minute prerecorded videos. The first video provided information about pain and mindfulness before introducing an 11-minute body scan practice. The second video introduced MORE's core mindful pain management technique. This technique helps pain patients disengage and shift attention from affective to sensory processing of pain sensations [38] and then to reorient attention to an object of their choice via mindful breathing. The third video introduced positive reappraisal and a mindful reappraisal practice exercise to familiarize participants with the mindful reappraisal worksheet. Then, participants were guided through the mindful reappraisal worksheet in the service of reappraising pain. A 5-minute mindful breathing practice was also used in this video to facilitate pain reappraisals. The fourth video introduced savoring along with a 10-minute mindful savoring practice. After each session, participants were prompted to reflect on the best parts of the mindfulness practice and any challenges that may have arisen. The final video ended with guidance for creating an at-home mindfulness practice routine.

#### **Data Collection**

The qualitative assessment was done at the end of the 4-week intervention (6 weeks after surgery). Semistructured interviews with open-ended questions were used to encourage free expression from participants and the richness and authenticity of data [28,39]. Interviews lasted between 30 and 45 minutes and were conducted on the phone for patients' convenience, but also to allow for data collection to take place in the participants' natural setting as proposed by a qualitative descriptive approach [28,32]. Interviews were completed by an RA who was trained and supervised by the first author (GM), who has expertise in qualitative research and were audio recorded before being professionally transcribed. Field notes were taken by the RA as needed during interviews to allow for complementary information during the analysis. As part of the larger project, participants first rated the intervention components in terms of four attributes: (1) appropriateness in helping patients manage pain, (2) effectiveness in promoting pain self-management, (3) suitability, and (4) willingness to adhere, with the use of the treatment acceptability and preference (TAP) questionnaire [40,41]. The TAP questionnaire relies on a 5-point scale ranging from not at all (0) to very much (4). It has demonstrated adequate internal consistency (alpha >0.80) [41] and was previously validated in a surgical population receiving a web-based intervention for pain [13]. Patients' rating of each component was used to elicit additional feedback on their perception of the intervention's acceptability and on the need for further modifications during interviews. Table 1 presents the semistructured interview guide. These questions were not pilot tested in this study, but they were used and validated in previous acceptability studies conducted by the principal investigator (PI) [12,13,42].



Table .	Semistructured in	nterview of	questions	based on	the treatment	t acceptability	and	preference	questionnaire'	s attributes.
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Themes	Questions
Effectiveness	<ul> <li>What do you find the most/least helpful about the intervention?</li> <li>In what way do you think the intervention helped/did not help you manage your pain after surgery?</li> <li>In what way do you think the intervention helped/did not help you decrease the impact of pain on your recovery?</li> <li>In what way do you think the intervention helped/did not help you improve your ability to do your postoperative exercises?</li> </ul>
Appropriateness	<ul> <li>What do you find appropriate/not appropriate about the intervention?</li> <li>What strategies seem appropriate/inappropriate to manage postoperative pain?</li> <li>In what way are the strategies appropriate/not appropriate to pain management after surgery?</li> <li>What additional information (if any) would you like covered by the intervention?</li> </ul>
Suitability	<ul> <li>What pain management strategies in the intervention do you find easy to apply/not easy to apply?</li> <li>What do you think of the timing of the intervention?</li> <li>What do you think of the length of the intervention?</li> <li>What do you think of the therapist?</li> </ul>
Willingness to adhere	<ul> <li>What is easy/not easy about completing the intervention?</li> <li>What (if anything) could be done to make the intervention more convenient?</li> </ul>

#### **Data Analysis**

Descriptive statistics were used to summarize the sociodemographic and clinical characteristics of the participants at baseline and postintervention. Transcripts of the semistructured interviews were content analyzed to identify patterns and generate themes related to participants' experiences with the intervention and their perception of its acceptability [43]. More specifically, our content analysis approach based on Miles and Huberman [43] included the following phases: coding of data, recording of insights and reflections on the data, identifying similar phrases, patterns, themes, sequences, and important features, searching for commonalities and differences, progressively deciding on generalizations that hold true for the data, and examining these generalizations in the light of existing knowledge. Our content analysis process aligned with a qualitative descriptive method by being focused on staying close

to data and informants' perspectives while also allowing the emergence of themes present across all interviews [28,29,39].

To address critiques about the subjectivity of qualitative descriptive work and enhance its rigor, steps were taken to preserve authenticity and integrity during analysis [39], and a combination of deductive and inductive approaches to coding was used. Although a particular theoretical view was not adopted to ensure data-driven coding and categorizing, a deductive approach was used to reduce researcher's subjectivity with a preliminary generation of codes that were based on the attributes of acceptability highlighted by Sidani et al [40,41] which are directly aligned with the questionnaire used before the interviews: effectiveness, appropriateness, suitability, and willingness to adhere. Definitions of these attributes are presented in Table 2. Additional codes (subcategories) were created inductively as necessary. Reliability was ensured by performing double coding. The PI and the RA independently coded interviews.

Attributes	Definition
Effectiveness	Patient's perception of the extent to which the treatment is helpful
Appropriateness	Patient's perception of the overall treatment's reasonableness/logicalness
Suitability	Patient's judgment of the treatment's intrusiveness, consistency with individual lifestyle
Willingness to adhere	Patient's perception of the extent to which they are willing to follow the treatment

Table . Definition of acceptability attributes (Sidani et al [40]).

Essentially, transcripts of interviews were read several times by the PI and RA, and the content of these transcripts was first categorized under each acceptability attribute (effectiveness,

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appropriateness, suitability, and willingness to adhere), giving way to a more focused form of the data to help identify key themes and patterns. Then, the identification of redundant

phrases and themes led to the emergence of a new category (eg, pain acceptance) before searching for differences and commonalities under each new category (eg, feeling frustrated vs feeling in control). Results were then compared, and differences were discussed until a consensus was reached. If needed, the co-PI (AH) was involved in the consensus meeting. When a new code was generated, it was discussed as well. Last, it is important to note that the researcher's bias was also reduced by not involving the PI in the interviews. These strategies are consistent with the Consolidated Criteria for Reporting Qualitative Research (COREQ; Checklist 1) [44].

# Results

# **Sample Characteristics**

Participants in our qualitative sample (n=18) were older adults (mean age 67.44 years, SD 6.22 years), mostly women (13/18, 72.2%), White/Caucasian (14/18, 77.8%), and undergoing a total knee replacement (14/18, 77.8%). Table 3 shows the

sociodemographic profile of the participant subset. Of note, B-MORE participants, when compared with controls, reported significantly higher baseline levels of pain interference (d=-0.74, W=93.5, P=.03) and anxiety (d=-0.61, W=108, W=108,P=.04). Out of the 18 participants completing the brief MBI intervention, 16 individuals completed the postintervention assessment. No adverse events were reported during the study. For contextual purposes, statistically significant differences were found in favor of the B-MORE participants, with lower pain intensity, pain interference, and medication use observed at follow-up. Regarding the acceptability of quantitative ratings, detailed results are presented in the article reporting the RCT [26]. Overall, participants judged B-MORE as acceptable (total mean score 3.32, SD 0.73) based on how effective, appropriate, and suitable they perceived it, as well as their willingness to adhere to it. Of note, the perceived appropriateness of the intervention received the highest score (3.5, SD 0.73), and their willingness to adhere was the lowest score B-MORE received (3.19, SD 0.75) as reflected by the TAP questionnaire.
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Table . Sociodemographic characteristics of participants at baseline (n=18).

Characteristic	Value
Age (years), mean (SD)	67.44 (6.22)
Civil status, n (%)	
Divorced/separated	3 (16.7)
Married	11 (61.1)
Single	3 (16.7)
Widowed	1 (5.5)
Gender, n (%)	
Female	13 (72.2)
Male	5 (27.8)
Race, n (%)	
Native American	0 (0.0)
Black or African American	4 (22.2)
White	14 (77.8)
Living, n (%)	
Alone	4 (22.2)
With other family members	14 (77.8)
Education, n (%)	
College	7 (38.9)
Graduate School	2 (11.1)
High School	9 (50.0)
Employment, n (%)	
Full Time	0 (0.0)
On Leave	1 (5.6)
Retired	16 (88.9)
Unemployed	1 (5.6)
Surgery type, n (%)	
Total hip replacement	4 (22.2)
Total knee replacement	14 (77.8)
Currently involved in a rehabilitation program, n (%)	
No	2 (11.1)
Yes	16 (88.9)

### **Acceptability Perception of B-MORE**

Based on our content analytic approach, we categorized our findings related to the perception of the intervention's acceptability into 4 main themes: perception of the effectiveness of the intervention, perception of the appropriateness of the intervention, perception of the suitability of the intervention, and perception of their willingness to adhere to the intervention. We present the categories that emerged for each theme. Table 4 presents a summary of results along with additional excerpts from interviews.



Table. Results from the content analysis on patients' perception of the intervention's acceptability (n=16).

Acceptability attribute and category	Verbatim (Participant ID)
Effectiveness	
Mindfulness practice	<ul> <li>"I'd say [the most helpful was] practicing and concentrating on things other than the pain." [P5]</li> <li>"When you had to stop and repeat the strategy in the middle of thinking" [P14]</li> <li>"I had a mental and physical feeling of warmth" [P4]</li> </ul>
Pain acceptance	<ul> <li>"In the beginning I was totally frustrated [] I think the questions were set up just right for the timing." [P9]</li> <li>"[] that made you aware there would be pain, but it won't last forever." [P1]</li> </ul>
Supplementary relief	<ul> <li>"[the strategies] gave me an opportunity to try another method of pain control, especially when I lay down at night" [P11]</li> <li>"Pain medication was the most helpful for me" [P8]</li> </ul>
Appropriateness	
Relevance	<ul> <li>"I found it appropriate to concentrate on things other than the pain" [P8]</li> <li>"I thought the strategies were fine" [P10]</li> </ul>
Challenges	<ul> <li>"The first one we had to look at something and focus on it. That was quite easy. After that, it seemed to get into spaces where I wasn't sure where I was going." [P14]</li> <li>"I don't think I followed the last one correctly" [P6]</li> </ul>
Suitability	
Timing/schedule	<ul><li>"I thought the timing was really good" [P10]</li><li>"It's been in a very timely and appropriate time frame" [P12]</li></ul>
Length	<ul> <li>"I like the shorter ones because they are easier to go through and concentrate on" [P7]</li> <li>"Long enough but not so long that you couldn't stay focused" [P10]</li> </ul>
Technology	<ul> <li>"It was easy to do throughout the day since I had it on my phone" [P15]</li> <li>[it's] difficult [] to steady myself down" [P13]</li> </ul>
Willingness to adhere	
Engagement	<ul> <li>"Really, you just got to make up your mind to do the sessions and put in the effort so that it works" [P3]</li> <li>"You just need to make time for it" [P11]</li> </ul>
Readiness	<ul> <li>"I was definitely surprised to see that I was able to change the focus and that it was helpful" [P3]</li> <li>"I thought it would be too long and detailed" [P7]</li> <li>"I don't dwell on pain" [P13]</li> </ul>

### Effectiveness of the Brief Web-Based MBI

### **Overview**

Many patients expressed positive feedback on the program's effectiveness in helping them manage pain postsurgery. When asked about how the intervention was helpful, 3 categories were delineated in participants' responses: mindfulness practice, pain acceptance, and supplementary relief.

### Mindfulness Practice

Mindfulness practice was central to participants' experiences in B-MORE, as many highlighted the usefulness of specific mindfulness techniques in managing their discomfort and improving their focus. Mindfulness practices such as body scanning (session #1), mindful breathing (session #2), and savoring (session #4) helped patients redirect their attention away from pain and toward a sense of calm and control. One participant noted, "The relaxation part where you start at the top and move down to each segment [...] took my mind off the pain" [P15], illustrating how structured mindfulness practices

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helped shift their focus to the present moment rather than the physical sensations of pain. Additionally, participants described the value of concentrating on pleasant or neutral thoughts rather than pain, with one participant explaining, for example, that "[the most helpful part of the program was] concentrating on pleasant things rather than pain" [P9]. Another participant mentioned, "I was focusing on what I needed to do so it was relaxing" [P7]. Breathing exercises were also frequently mentioned, with some participants using mindful breathing regularly as a way to remain grounded during daily activities. For example, one participant stated that "the breathing exercises were easy to apply and think about throughout the day" [P5]. Through these mindfulness techniques, patients found a sense of relief and relaxation, which many expressed was a beneficial addition to their postoperative recovery.

### Pain Acceptance

Acceptance also featured prominently in patients' reflections on B-MORE, particularly as it helped them reshape their relationship with pain. Many participants expressed that B-MORE encouraged them to acknowledge pain as a natural part of their healing journey, rather than something to be resisted or feared. This shift in mindset allowed patients to feel more in control, as they recognized pain as temporary and manageable. One participant shared, "The [mindful reappraisal] questions [in session #3] reminded me that yes, I'm going to have pain [...] I think what helped me was that there were a lot of questions that made you aware there would be pain, but it won't last forever" [P1], illustrating how the program's emphasis on acceptance through mindful reappraisal provided reassurance and resilience in the face of discomfort. This perspective was empowering for patients, who felt that viewing pain as part of recovery made it less distressing and even motivated them to engage more actively with the mindfulness exercises. Another participant described, "In the beginning I was totally frustrated and stressed and in a lot of pain. My reaction to the questions then was different than it is today. I think the questions were set up just right for the timing." [P9]. By accepting rather than fighting their pain, the intervention helped them cope more effectively throughout the recovery process.

### Supplementary Relief

Several participants perceived the program as an additional method of relief rather than an essential strategy. For example, one participant commented that "it was easier to do once the pain was under control" [P8], suggesting that it was not a first-choice strategy to relieve pain. Some expressed that they appreciated having access to an additional modality of pain relief and used it according to their individual needs. For example, one person commented, "[the strategies] gave me an opportunity to try another method of pain control, especially when I lay down at night" [P11]. One respondent shared that "The [mindful] pain strategies were helpful... but the pain medication was the most helpful" [P8], highlighting that mindfulness alone wasn't sufficient in cases where pain levels were especially high. The observed variation in participant responses indicates that while B-MORE was effective for most participants, others needed a combination of mindfulness and traditional pain management strategies to achieve optimal relief.

### Appropriateness of the Brief Web-Based MBI

### Overview

Nearly all participants found B-MORE well-suited to their recovery needs, viewing B-MORE as a constructive tool for managing postoperative pain. The perception regarding the intervention's reasonableness/logicalness was illustrated by 2 categories: relevance and challenges.

### Relevance

Many appreciated the direct relevance of the different mindfulness practices, in coping with their physical discomfort. One patient stated, "[...] it seemed like everything was [relevant] to me" [P1]. Another reflected, "I thought [the program] was very well done, and you just kinda had to focus and follow through" [P12], suggesting that the exercises did not require excessive effort to implement. Others echoed this sentiment, "Everything I was told to do/did was appropriate" [P11]. Additionally, mindfulness strategies resonated with some patients as suitable life skills beyond pain management. One participant stated, "Meditation is appropriate for life and pain management" [P2], showing an appreciation for the program's relevance both within and beyond their immediate recovery period.

### Challenges

Although the majority of participants found B-MORE thoughtfully designed and relevant to their recovery, some participants felt certain components of the program were challenging. One individual found it difficult to follow the program, "I had trouble concentrating on everything and remembering to do them most days" [P3], and another found the first session more relatable than the later sessions, "The first [session] everything was appropriate. After that, it seemed more out there and harder to figure out" [P7]. Another participant reflected on overcoming challenges by commenting, "It started out hard to do the exercises, but it got easier as I did them" [P5]. These insights suggest that while the program's overall approach was appropriate, adjusting the pacing and sequencing of mindfulness exercises could enhance engagement and tailoring for individual needs.

### Suitability of the Brief Web-Based MBI

### **Overview**

Suitability refers primarily to how the intervention was delivered. Suitability was discussed in terms of how easy the strategies were to apply or use. Several preferences regarding the timing/schedule, the exercises, and the use of technology emerged.

### Timing and Schedule

Participants generally felt that the timing of the B-MORE intervention (ie, beginning 2 weeks after surgery) was appropriate and well-integrated into their recovery process, although opinions varied slightly based on individual recovery progress. Some participants highlighted that having this intervention during their rehabilitation program was helpful, for instance, "in the middle of rehab, so the timing was okay" [P9]. However, some participants expressed that they would

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have started earlier at the time of discharge by saving, "I personally would've been better to have started about a week earlier" [P11], while some highlighted that "the first couple of weeks were rough to focus" [P8] or reported "trouble focusing because of pain" [P9]. Last, one participant mentioned starting before surgery but was referring to postoperative pain specifically, "I think most chronic pain is before surgery, so I think this would be helpful to start this before surgery" [P1]. Regarding the schedule, a participant found that the program's schedule was suitable because "It was in a routine and worked fine" [P5], reflecting a positive view of the weekly pacing. Many appreciated the consistent, scheduled nature of the program, as it provided a structured approach that aligned well with their recovery. One participant noted, "I thought that was great

because I think anything less than that, I'd forget" [P1], underscoring how the schedule and duration of sessions supported retention and engagement. Overall, most participants found the timing and schedule to be helpful and well-suited to their needs, although a few felt minor adjustments could enhance its alignment with the early stages of postoperative recovery.

### Length of Mindfulness Exercises

Participants expressed a range of thoughts regarding the length of the sessions and exercises, with many favoring shorter durations. One participant noted that the shorter sessions helped maintain their interest and concentration, saying, "I didn't get bored or want to quit." [P1]. Another echoed this sentiment, stating, "10-minute exercises were the best" [P3], while others mentioned that "anything longer" than 10 - 15 minutes made it challenging to stay focused. Some found 20-minute meditation sessions acceptable but desired "less explanation" and more practice. Overall, most participants seemed to agree that shorter exercises facilitated better concentration and engagement, with a few suggesting that some sessions felt a bit long but were still satisfactory. Overall, the feedback highlights a preference for concise sessions that balance engagement and focus.

### **Technology**

A number of preferences were expressed regarding the use of technology. The asynchronous nature of the mindfulness program provided participants with the flexibility to engage in pain management exercises at their convenience, fitting seamlessly into their daily routines. This flexibility allowed our surgical patients to access mindful pain management strategies when they felt most comfortable and ready, whether that was during a quiet moment at home or while on the go, "[the strategies] gave me an opportunity to try another method of pain control, especially when I lay down at night" [P11]. One participant noted, "It's easy to do since it's on my phone" [P12], highlighting the convenience of accessing the sessions from any device. This on-demand availability meant that participants could practice mindfulness techniques at times when they experienced heightened pain or stress, thereby maximizing the intervention's effectiveness. The ability to revisit the exercises as needed also empowered participants to take control of their pain management. However, patients who were less accustomed to such practices found it challenging to focus. For instance, one participant commented, "I can find a quiet spot but trying to stop and focus is the hardest part" [P13], reflecting that the

lack of a real-time guide or live feedback sometimes made it difficult to stay engaged. Of note, one participant mentioned that although convenient, she preferred an in-person interaction, "I know with COVID this was not possible, but I prefer a face-to-face thing" [P7]. Overall, technology was a positive aspect contributing to the personalization of B-MORE and self-management practices.

### Willingness to Adhere

### **Overview**

Participants' willingness to adhere was driven by their commitment or engagement toward the program and their readiness for a mindfulness program.

### Engagement

Participants expressed the importance of fulfilling their commitment and putting effort into the sessions. For example, some participants stated, "Really, you just got to make up your mind to do the sessions and put in the effort so that it works" [P3], "I said I would do it, so I did it [...] it forced me to sit down with it" [P5]. Remote communication with the team (eg, emailed links and reminders via text messages) and the digital relationship with the therapist also contributed to and supported that engagement. As one participant commented, "I think y'all stayed in touch" [P12]. Another one referred to the therapist by saying, "I liked to listen to him talk" [P9]. Nonetheless, adherence was challenging for patients facing high or low levels of discomfort. In such cases, intense pain could overshadow the motivation to engage in mindfulness. A patient noted, "the first couple of weeks were rough to focus [...] now that I'm off the medication, my mind is clearer" [P8]. Another one stated, "I had trouble focusing because of pain" [P9], showing that factors like pain intensity and fatigue could interfere with adherence to mindfulness practices. For patients like these, added support or adaptive pacing within the program might help them maintain adherence, even during particularly challenging recovery phases. In contrast, one participant reported that their pain level had decreased to such a degree during the 4-week intervention that they no longer needed the intervention, "I think that personally my pain had decreased so I don't know how I related to it as much" [P4].

### Readiness

Readiness to engage in a MBI was also described by several participants. Expectations and personal beliefs were 2 aspects that were reflected when discussing readiness and adherence to the intervention. Regarding expectations, several participants expressed some uncertainty and pessimism that could have influenced their adherence initially by mentioning that they did not know what to expect and that they did not expect the intervention to be effective. They also mentioned that this perception changed throughout the intervention by commenting that what they got out of their participation was surprising and encouraging and that some strategies got easier to practice with, for instance, "It was really strange because I didn't have a lot of expectation that it would be a big help [...] just the fact of being able to focus, I found that very encouraging [P12]. Of note, one participant with previous experience with mindfulness stated, "I thought it was easy to focus because I've done this

before [...] I'm used to doing longer meditations with music [...] it left me wanting more" [P2]. In this case, although readiness does not seem to be an issue and the participant would be expected to adhere easily to the intervention, having previous experience and mindfulness skills could have led to different expectations and hindered her interest in pursuing the intervention and adhering to the full program. Personal beliefs seemed to have an influence on their readiness and willingness to adhere as well. Two opposite views with 2 different impacts appeared. A personal belief that meditation or mindfulness is beneficial naturally attracted some individuals to the intervention. Nevertheless, a few participants expressed that pain was of minimal importance, which could have hindered their willingness to adhere to the intervention, "I am active and busy [...] I don't have time to dwell on pain. I get up and on with my day" [P7].

In summary, while most patients viewed the mindfulness-based program as an acceptable and valuable approach to pain management, their feedback highlights areas where additional support or customization could enhance effectiveness, appropriateness, suitability, and adherence. Tailoring session length, offering guidance for those in severe pain, and potentially providing more interactive elements could strengthen the program's acceptability across patient experiences.

### Discussion

This is the first study to use a qualitative descriptive approach to explore the acceptability of a brief, Web-based MBI in the postdischarge recovery phase after TJA. Content analysis of the semistructured individual interviews clearly revealed that participants found the brief MBI helpful. These findings support and extend results from a recent pilot RCT, in which the brief MBI significantly reduced pain intensity, pain interference, and pain medication use relative to an active control condition [26]. Specifically, qualitative data from this study indicates that after completing the 4-week MBI, participants reported increased mindfulness leading to less concentration on the pain and more relaxation, increased pain acceptance leading to a positive attitude, and last, supplementary pain relief. Results from this study also align with previous qualitative studies on the benefits of MBIs for improved coping and relaxation among adults preparing for TJA [14] and for the management of postoperative pain and negative emotions during recovery from lumbar spine surgery [27].

Principally, results from this study contribute to understanding the acceptability of innovative ingredients addressing practical barriers and facilitating the implementation of MBI in the postdischarge period after TJA. First, the schedule of 4 weekly sessions starting 2 weeks after surgery seems to fit the recovery process and needs of most participants while promoting their participation as the worst pain levels are usually experienced within the first 2 weeks after surgery [45], and 6 weeks is the timeframe for normal tissue healing and recovery [46,47]. A few participants mentioned the possibility of starting earlier, as the pain did not seem to hinder their participation or had subsided quickly after starting the program. This aligns with a previous study with orthopedic postsurgical patients in which participants expressed this preference as they would have used the MBI strategies for other aspects of recovery than pain [27]. Second, the brief format (20 min sessions for 4 weeks), including short meditations, seemed to be appreciated by participants, which responds to feasibility and acceptability issues encountered in previous studies implementing a traditional 8-week format before surgery in this population [14,15]. Nevertheless, the only study assessing acceptability in the recovery phase after orthopedic surgery (lumbar spine) reported that 75% of patients were satisfied with 8 weekly sessions of over an hour [27]. Third, remote delivery in the postoperative period seems to offer more than convenience for participants with limited mobility; it makes their participation possible after a major surgery [12,27,48]. However, our program also addressed time and logistical constraints met by a variety of individuals [15,49-52]. As expressed by some participants, in addition to remote delivery, the asynchronous nature of the intervention allowed for even more convenience with accessibility to the program anytime from anywhere, according to individual needs and pain levels during recovery. Indeed, a previous study with adults after lumbar spine surgery reported that 25% of their participants had trouble finding an uninterrupted space at the time their session was scheduled [27]. Offering continuous access to therapeutic content acknowledges these differences during recovery [53]. Last, reminders also contributed to the acceptability of our program. As highlighted by others who evaluated the acceptability of Web-based MBIs qualitatively, check-ins are desired by most participants in order to maintain adherence and promote home practice [54] and call for hybrid approaches [12,55-57].

While participants identified multiple benefits and found the brief MBI appropriate during the early recovery period, they also noted some challenges that impacted their adherence. The main challenges were an initial uncertainty about what to expect from a "mindfulness" intervention and skepticism about its effectiveness. This hesitancy stemmed from mindfulness being unfamiliar to most participants, including reliance on traditional pharmacological approaches. This finding is resonant with the quantitative phase of this study, where the willingness to adhere item received the lowest rating on a multidimensional, Likert-type acceptability survey, despite no participant reporting unwillingness. This finding also converges with a recent qualitative analysis in which the impact of preoperative mindfulness-based stress reduction for patients with TJA was linked to their "openness" toward an MBI, health-related beliefs, and their motivations for participation [14], as well as another qualitative evaluation of an 8-week MBI after lumbar spine surgery in which some participants reported that the purpose was unclear and that they would have benefited more from the program had they understood earlier [27]. Other studies, both qualitative and quantitative, have also identified similar challenges, with participants reporting difficulty understanding the purpose of mindfulness practice [58], doubting the value or benefits [59], or dropping out of MBI groups at a higher rate than control groups, including some participants not attending any sessions [60,61]. Thus, by proactively addressing expectations and beliefs about mindfulness's ability to manage pain, we can reduce skepticism, foster greater acceptance, and enhance participant engagement and adherence from the outset.

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Of note, the MORE approach [34], used as a foundation for the brief intervention in this study, uses principles of reappraisal (cognitive-behavioral therapy) and savoring (positive psychology) to disrupt the spiral of chronic pain characterized by maladaptive thoughts and behaviors, including overreliance on pain medication. MORE targets populations facing opioid misuse [35,37].

Furthermore, while addressing initial expectations and beliefs is crucial for increasing readiness and reducing uncertainty about any treatment, a few participants identified known challenges unique to mindfulness practice [62]. Indeed, qualitative studies involving participants with various backgrounds and varying levels of familiarity with mindfulness have described challenges related to mindfulness practice [50,51,63]. It is not unusual for individuals to doubt their skills and knowledge. In this study, several participants reported having difficulty focusing, following some sessions, or feeling unsure of "spaces" they were "getting into." Mind wandering and feeling strange can be perceived as a barrier to mindfulness practice [50-52,59] and could impede participants' adherence to the intervention. Connecting with negative feelings is another barrier, as they can be challenging or overwhelming at times [49,51,63]. In this study, some participants reported similar barriers, expressing difficulty practicing mindfulness while experiencing elevated pain or during moments of general discomfort or frustration. Proactively providing participants with information about common challenges during mindfulness practices, as well as techniques for mitigating those challenges, would likely further enhance the acceptability and effectiveness of the brief MBI.

This study has several limitations. First, the homogenous sample limits our understanding of perceptions across diverse sociodemographic groups (older adults, White, female). Additionally, the reported perceptions are from individuals who agreed to participate, and 2 participants dropped out of the experimental group. Although a multilevel meta-analysis of RCTs using the MORE program for other conditions highlighted that diverse groups, including younger adults (mean age 25 - 59 years) as well as underrepresented racial/ethnic groups, have received this intervention [64], future qualitative studies could use quota sampling to include the perception of various subgroups, including those who refused to participate, thus enhancing our understanding of barriers to the intervention's uptake. While not necessarily a limitation, participants noted

that postoperative pain medication might have hindered their ability to follow the sessions, and that mindfulness practice was more challenging during pain spikes. Last, the qualitative analysis did not account for the time participants spent watching the videos or practicing mindfulness. Consequently, the level of comfort with the intervention may have been influenced by the amount of practice. Comparing acceptability attributes based on the amount of practice could provide valuable insights.

However, several barriers to adherence emerged in relation to the challenges of mindfulness practice in the postoperative recovery period, and these warrant further exploration to ensure the brief MBI's success in a future, fully powered, RCT. For instance, it would be interesting to assess if additional digital health tools, such as chatbots, would be beneficial in offering a more tailored support for patients who find mindfulness practice challenging during pain spikes. Furthermore, regarding the timing of the intervention, although we targeted a specific subgroup based on risk factors for CPSP (ie, pain<4/10 at 2 wk), some participants felt ready to start earlier, and some would have started later during recovery. Future studies could explore additional variables to help determine who would benefit from which timing of intervention or compare the value of different timings of intervention during postoperative recovery. Moreover, although the brief format (ie, 4-week sessions of 30 min) represented a positive aspect of the intervention, would some postoperative patients benefit from a full standard format of 8 weekly sessions of one hour?

Given the increasing number of TJAs performed each year and the ability of nonpharmacological interventions, such as MBIs, to support recovery and well-being, efforts should be made to increase patient access to these promising adjunctive treatments. In this study, semistructured interviews indicated that the brief MBI promoted self-management of pain during the early recovery period. Additionally, while most studies to date have tested the implementation of brief preoperative interventions for patients with TJA when postoperative pain is not present yet, our study highlights the acceptability of a postoperative MBI. Combining MBI interventions before and after surgery at different key time points of the perioperative continuum of care may be an interesting avenue to optimize pain relief and recovery, as well as prevent complications such as the development of CPSP. Finally, the use of technology could improve the accessibility, scalability, and adoption of these promising approaches.

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### **Data Availability**

The datasets used and analyzed during this study are available from the corresponding author upon reasonable request.

### **Conflicts of Interest**

None declared.



### Checklist 1

COREQ (Consolidated Criteria for Reporting Qualitative Research) checklist. [PDF File, 432 KB - nursing v8i1e69010 app1.pdf]

### References

- Park R, Mohiuddin M, Arellano R, Pogatzki-Zahn E, Klar G, Gilron I. Prevalence of postoperative pain after hospital discharge: systematic review and meta-analysis. Pain Rep 2023;8(3):e1075. [doi: <u>10.1097/PR9.000000000001075</u>] [Medline: <u>37181639</u>]
- 2. Wylde V, Dennis J, Gooberman-Hill R, Beswick AD. Effectiveness of postdischarge interventions for reducing the severity of chronic pain after total knee replacement: systematic review of randomised controlled trials. BMJ Open 2018 Feb 28;8(2):e020368. [doi: 10.1136/bmjopen-2017-020368] [Medline: 29490967]
- 3. Katz J, Seltzer Z. Transition from acute to chronic postsurgical pain: risk factors and protective factors. Expert Rev Neurother 2009 May;9(5):723-744. [doi: 10.1586/ern.09.20] [Medline: 19402781]
- 4. Kehlet H, Edwards RR, Brennan T. Persistent postoperative pain: pathogenic mechanisms and preventive strategies. In: Raja S, Sommer C, editors. Pain 2014: Refresher Courses: International Association for the Study of Pain (IASP) Press: Seattle; 2014:113-123.
- Shah R, Kuo YF, Westra J, Lin YL, Raji MA. Opioid use and pain control after total hip and knee arthroplasty in the US, 2014 to 2017. JAMA Netw Open 2020 Jul 1;3(7):e2011972. [doi: <u>10.1001/jamanetworkopen.2020.11972</u>] [Medline: <u>32729917</u>]
- 6. Wu CL, Raja SN. Treatment of acute postoperative pain. Lancet 2011 Jun 25;377(9784):2215-2225. [doi: 10.1016/S0140-6736(11)60245-6] [Medline: 21704871]
- 7. Clarke H, Soneji N, Ko DT, Yun L, Wijeysundera DN. Rates and risk factors for prolonged opioid use after major surgery: population based cohort study. BMJ 2014 Feb 11;348:g1251. [doi: <u>10.1136/bmj.g1251</u>] [Medline: <u>24519537</u>]
- Veronovici NR, Lasiuk GC, Rempel GR, Norris CM. Discharge education to promote self-management following cardiovascular surgery: an integrative review. Eur J Cardiovasc Nurs 2014 Feb;13(1):22-31. [doi: 10.1177/1474515113504863] [Medline: 24042728]
- 9. Moon M, Oh EG, Baek W, Kim YM. Effects of nurse-led pain management interventions for patients with total knee/hip replacement. Pain Manag Nurs 2021 Apr;22(2):111-120. [doi: <u>10.1016/j.pmn.2020.11.005</u>] [Medline: <u>33353818</u>]
- Taylor CEV, Murray CM, Stanton TR. Patient perspectives of pain and function after knee replacement: a systematic review and meta-synthesis of qualitative studies. Pain Rep 2022;7(3):e1006. [doi: <u>10.1097/PR9.000000000001006</u>] [Medline: <u>35558092</u>]
- 11. Martorella G, McDougall GJJ. Barriers and facilitators to the prevention of chronic pain in the subacute phase after cardiac surgery. Pain Manag Nurs 2021 Feb;22(1):28-35. [doi: <u>10.1016/j.pmn.2020.09.004</u>] [Medline: <u>33189543</u>]
- Martorella G, Graven L, Schluck G, Bérubé M, Gélinas C. Nurses' perception of a tailored web-based intervention for the self-management of pain after cardiac surgery. SAGE Open Nurs 2018;4:2377960818806270. [doi: 10.1177/2377960818806270] [Medline: 33415209]
- Martorella G, Gélinas C, Purden M. Acceptability of a web-based and tailored intervention for the self-management of pain after cardiac surgery: the perception of women and men. JMIR Res Protoc 2014 Nov 20;3(4):e63. [doi: <u>10.2196/resprot.3175</u>] [Medline: <u>25487135</u>]
- 14. Reynolds KA, Sommer JL, Roy R, Kornelsen J, Mackenzie CS, El-Gabalawy R. A qualitative analysis of the impact of preoperative mindfulness-based stress reduction on total knee arthroplasty surgical experiences. Pain Manag Nurs 2024 Aug;25(4):409-416. [doi: 10.1016/j.pmn.2024.04.002] [Medline: 38697887]
- Dowsey M, Castle D, Knowles S, et al. The effect of mindfulness training prior to total joint arthroplasty on post-operative pain and physical function: a randomised controlled trial. Complement Ther Med 2019 Oct;46:195-201. [doi: 10.1016/j.ctim.2019.08.010] [Medline: 31519279]
- Nelson EA, Dowsey MM, Knowles SR, et al. Systematic review of the efficacy of pre-surgical mind-body based therapies on post-operative outcome measures. Complement Ther Med 2013 Dec;21(6):697-711. [doi: <u>10.1016/j.ctim.2013.08.020</u>] [Medline: <u>24280480</u>]
- Hymowitz G, Hasan F, Yerramalli G, Cervoni C. Mindfulness-based interventions for surgical patients and impact on postoperative outcomes, patient wellbeing, and satisfaction. Am Surg 2024 May;90(5):947-953. [doi: 10.1177/00031348221117025] [Medline: 35940585]
- Chavez JL, Porucznik CA, Gren LH, et al. The impact of preoperative mindfulness-based stress reduction on postoperative outcomes in lumbar spine degenerative disease: 3-month and 12-month results of a pilot study. World Neurosurg 2020 Jul;139:e230-e236. [doi: 10.1016/j.wneu.2020.03.186] [Medline: 32278820]
- Hanley AW, Gililland J, Erickson J, et al. Brief preoperative mind-body therapies for total joint arthroplasty patients: a randomized controlled trial. Pain 2021 Jun 1;162(6):1749-1757. [doi: <u>10.1097/j.pain.00000000002195</u>] [Medline: <u>33449510</u>]

- 20. Hanley AW, Gililland J, Garland EL. To be mindful of the breath or pain: comparing two brief preoperative mindfulness techniques for total joint arthroplasty patients. J Consult Clin Psychol ;89(7):590-600. [doi: 10.1037/ccp0000657] [Medline: 34165999]
- 21. Dindo L, Zimmerman MB, Hadlandsmyth K, et al. Acceptance and commitment therapy for prevention of chronic postsurgical pain and opioid use in at-risk veterans: a pilot randomized controlled study. J Pain 2018 Oct;19(10):1211-1221. [doi: 10.1016/j.jpain.2018.04.016] [Medline: 29777950]
- 22. Hadlandsmyth K, Dindo LN, Wajid R, Sugg SL, Zimmerman MB, Rakel BA. A single-session acceptance and commitment therapy intervention among women undergoing surgery for breast cancer: a randomized pilot trial to reduce persistent postsurgical pain. Psychooncology 2019 Nov;28(11):2210-2217. [doi: 10.1002/pon.5209] [Medline: 31430830]
- 23. Linshaw DJ, Floyd EG, Rosenkranz KM, Stahl JE. Application of a mind-body tool in a rural population to improve post-operative outcomes in women with breast cancer: a pilot study. Surg Oncol 2020 Sep;34:63-66. [doi: 10.1016/j.suronc.2020.03.007] [Medline: 32891355]
- Singh JA, Lemay CA, Nobel L, et al. Association of early postoperative pain trajectories with longer-term pain outcome after primary total knee arthroplasty. JAMA Netw Open 2019 Nov 1;2(11):e1915105. [doi: 10.1001/jamanetworkopen.2019.15105] [Medline: <u>31722026</u>]
- Veal FC, Bereznicki LRE, Thompson AJ, Peterson GM, Orlikowski C. Subacute pain as a predictor of long-term pain following orthopedic surgery: an Australian prospective 12 month observational cohort study. Medicine (Baltimore) 2015 Sep;94(36):1. [doi: 10.1097/MD.00000000001498] [Medline: 26356717]
- Martorella G, Hanley A, Tong H, et al. Online brief mindfulness-based intervention for subacute pain after total hip or knee replacement: a pilot randomized controlled trial. Mindfulness (N Y) 2024 Apr;15(4):914-930. [doi: 10.1007/s12671-024-02329-2]
- 27. Brintz CE, Connors Kelly E, Polser G, et al. Feasibility, acceptability and modification of a post-surgical telehealth mindfulness-based intervention to enhance recovery after lumbar spine surgery: a prospective intervention study. Glob Adv Integr Med Health 2025;14. [doi: 10.1177/27536130251344843]
- 28. Sandelowski M. Whatever happened to qualitative description? Res Nurs Health 2000 Aug;23(4):334-340. [doi: <u>10.1002/1098-240x(200008)23:4<334::aid-nur9>3.0.co;2-g</u>] [Medline: <u>10940958</u>]
- Neergaard MA, Olesen F, Andersen RS, Sondergaard J. Qualitative description the poor cousin of health research? BMC Med Res Methodol 2009 Jul 16;9:52. [doi: <u>10.1186/1471-2288-9-52</u>] [Medline: <u>19607668</u>]
- 30. Kim H, Sefcik JS, Bradway C. Characteristics of qualitative descriptive studies: a systematic review. Res Nurs Health 2017 Feb;40(1):23-42. [doi: 10.1002/nur.21768] [Medline: 27686751]
- 31. Sullivan-Bolyai S, Bova C, Harper D. Developing and refining interventions in persons with health disparities: the use of qualitative description. Nurs Outlook 2005;53(3):127-133. [doi: <u>10.1016/j.outlook.2005.03.005</u>] [Medline: <u>15988449</u>]
- 32. Bradshaw C, Atkinson S, Doody O. Employing a qualitative description approach in health care research. Glob Qual Nurs Res 2017;4:2333393617742282. [doi: 10.1177/2333393617742282] [Medline: 29204457]
- Gewandter JS, Dworkin RH, Turk DC, et al. Research design considerations for chronic pain prevention clinical trials: IMMPACT recommendations. Pain 2015 Jul;156(7):1184-1197. [doi: <u>10.1097/j.pain.00000000000191</u>] [Medline: <u>25887465</u>]
- 34. Garland EL. Mindfulness-Oriented Recovery Enhancement for Addiction, Stress, and Pain, th edition: Cary, NC: NASW Press; 2013.
- Garland EL, Hanley AW, Riquino MR, et al. Mindfulness-oriented recovery enhancement reduces opioid misuse risk via analgesic and positive psychological mechanisms: a randomized controlled trial. J Consult Clin Psychol 2019 Oct;87(10):927-940. [doi: 10.1037/ccp0000390] [Medline: <u>31556669</u>]
- 36. Garland EL, Manusov EG, Froeliger B, Kelly A, Williams JM, Howard MO. Mindfulness-oriented recovery enhancement for chronic pain and prescription opioid misuse: results from an early-stage randomized controlled trial. J Consult Clin Psychol 2014 Jun;82(3):448-459. [doi: 10.1037/a0035798] [Medline: 24491075]
- 37. Garland EL, Hanley AW, Nakamura Y, et al. Mindfulness-oriented recovery enhancement vs supportive group therapy for co-occurring opioid misuse and chronic pain in primary care: a randomized clinical trial. JAMA Intern Med 2022 Apr 1;182(4):407-417. [doi: 10.1001/jamainternmed.2022.0033] [Medline: 35226053]
- 38. Garland EL. Psychosocial intervention and the reward system in pain and opioid misuse: new opportunities and directions. Pain 2020 Dec;161(12):2659-2666. [doi: 10.1097/j.pain.000000000001988] [Medline: 33197164]
- Milne J, Oberle K. Enhancing rigor in qualitative description: a case study. J Wound Ostomy Continence Nurs 2005;32(6):413-420. [doi: <u>10.1097/00152192-200511000-00014</u>] [Medline: <u>16301909</u>]
- 40. Sidani S, Braden CJ. Design, Evauation and Translation of Nursing Interventions: Wiley-Blackwell: Ames, IA; 2011.
- 41. Sidani S, Epstein DR, Bootzin RR, Moritz P, Miranda J. Assessment of preferences for treatment: validation of a measure. Res Nurs Health 2009 Aug;32(4):419-431. [doi: <u>10.1002/nur.20329</u>] [Medline: <u>19434647</u>]
- 42. Martorella G, Boitor M, Michaud C, Gélinas C. Feasibility and acceptability of hand massage therapy for pain management of postoperative cardiac surgery patients in the intensive care unit. Heart Lung 2014;43(5):437-444. [doi: 10.1016/j.hrtlng.2014.06.047] [Medline: 25064487]
- 43. Miles M, Huberman A. Qualitative Data Analysis: An Expanded Sourcebook: SAGE: Thousand Oaks, CA; 1994.

- 44. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care 2007 Dec;19(6):349-357. [doi: <u>10.1093/intqhc/mzm042</u>] [Medline: <u>17872937</u>]
- 45. Chan EY, Blyth FM, Nairn L, Fransen M. Acute postoperative pain following hospital discharge after total knee arthroplasty. Osteoarthr Cartil 2013 Sep;21(9):1257-1263. [doi: 10.1016/j.joca.2013.06.011]
- 46. Treede RD, Rief W, Barke A, et al. Chronic pain as a symptom or a disease: the IASP classification of chronic pain for the international classification of diseases (ICD-11). Pain 2019 Jan;160(1):19-27. [doi: 10.1097/j.pain.00000000001384] [Medline: 30586067]
- 47. Van Egmond JC, Verburg H, Mathijssen NMC. The first 6 weeks of recovery after total knee arthroplasty with fast track. Acta Orthop 2015;86(6):708-713. [doi: 10.3109/17453674.2015.1081356] [Medline: 26452995]
- 48. Bérubé M, Gélinas C, Feeley N, et al. A hybrid web-based and in-person self-management intervention aimed at preventing acute to chronic pain transition after major lower extremity trauma: feasibility and acceptability of iPACT-E-Trauma. JMIR Form Res 2018 Apr 30;2(1):e10323. [doi: 10.2196/10323] [Medline: 30684418]
- 49. Cohen-Katz J, Wiley S, Capuano T, Baker DM, Deitrick L, Shapiro S. The effects of mindfulness-based stress reduction on nurse stress and burnout: a qualitative and quantitative study, part III. Holist Nurs Pract 2005;19(2):78-86. [doi: 10.1097/00004650-200503000-00009] [Medline: 15871591]
- Spears CA, Houchins SC, Bamatter WP, Barrueco S, Hoover DS, Perskaudas R. Perceptions of mindfulness in a low-income, primarily African American treatment-seeking sample. Mindfulness (N Y) 2017 Dec;8(6):1532-1543. [doi: 10.1007/s12671-017-0720-3]
- 51. Sears SR, Kraus S, Carlough K, Treat E. Perceived benefits and doubts of participants in a weekly meditation study. Mindfulness (N Y) 2011 Sep;2(3):167-174. [doi: 10.1007/s12671-011-0055-4]
- Banerjee M, Cavanagh K, Strauss C. A qualitative study with healthcare staff exploring the facilitators and barriers to engaging in a self-help mindfulness-based intervention. Mindfulness (N Y) 2017;8(6):1653-1664. [doi: 10.1007/s12671-017-0740-z] [Medline: 29201248]
- 53. Opie JE, Vuong A, Welsh ET, Esler TB, Khan UR, Khalil H. Outcomes of best-practice guided digital mental health interventions for youth and young adults with emerging symptoms: part II. a systematic review of user experience outcomes. Clin Child Fam Psychol Rev 2024 Jun;27(2):476-508. [doi: 10.1007/s10567-024-00468-5] [Medline: 38634939]
- Reese HE, Brown WA, Summers BJ, Shin J, Wheeler G, Wilhelm S. Feasibility and acceptability of an online mindfulness-based group intervention for adults with tic disorders. Pilot Feasibility Stud 2021 Mar 24;7(1):82. [doi: 10.1186/s40814-021-00818-y] [Medline: <u>33757602</u>]
- 55. Baumeister H, Reichler L, Munzinger M, Lin J. The impact of guidance on Internet-based mental health interventions a systematic review. Internet Interv 2014 Oct;1(4):205-215. [doi: <u>10.1016/j.invent.2014.08.003</u>]
- 56. O'Connor S, Hanlon P, O'Donnell CA, Garcia S, Glanville J, Mair FS. Understanding factors affecting patient and public engagement and recruitment to digital health interventions: a systematic review of qualitative studies. BMC Med Inform Decis Mak 2016 Sep 15;16(1):120. [doi: 10.1186/s12911-016-0359-3] [Medline: 27630020]
- 57. Geraghty AWA, Torres LD, Leykin Y, Pérez-Stable EJ, Muñoz RF. Understanding attrition from international Internet health interventions: a step towards global eHealth. Health Promot Int 2013 Sep;28(3):442-452. [doi: <u>10.1093/heapro/das029</u>] [Medline: <u>22786673</u>]
- Martinez ME, Kearney DJ, Simpson T, Felleman BI, Bernardi N, Sayre G. Challenges to enrollment and participation in mindfulness-based stress reduction among veterans: a qualitative study. J Altern Complement Med 2015 Jul;21(7):409-421. [doi: <u>10.1089/acm.2014.0324</u>] [Medline: <u>26133205</u>]
- 59. Malpass A, Carel H, Ridd M, et al. Transforming the perceptual situation: a meta-ethnography of qualitative work reporting patients' experiences of mindfulness-based approaches. Mindfulness (N Y) 2012 Mar;3(1):60-75. [doi: 10.1007/s12671-011-0081-2]
- 60. Goldberg SB, Riordan KM, Sun S, Kearney DJ, Simpson TL. Efficacy and acceptability of mindfulness-based interventions for military veterans: a systematic review and meta-analysis. J Psychosom Res 2020 Nov;138:110232. [doi: 10.1016/j.jpsychores.2020.110232] [Medline: 32906008]
- 61. Powers A, Lathan EC, McAfee E, et al. Feasibility and acceptability of a virtual mindfulness intervention for Black adults with PTSD and depression: randomized controlled trial. J Mood Anxiety Disord 2024 Mar;5:5. [doi: 10.1016/j.xjmad.2024.100048] [Medline: 38606374]
- 62. Hunt CA, Hoffman MA, Mohr JJ, Williams AL. Assessing perceived barriers to meditation: the determinants of meditation practice inventory-revised (DMPI-R). Mindfulness (N Y) 2020 May;11(5):1139-1149. [doi: 10.1007/s12671-020-01308-7] [Medline: 33664878]
- 63. Lomas T, Cartwright T, Edginton T, Ridge D. A qualitative analysis of experiential challenges associated with meditation practice. Mindfulness (N Y) 2015 Aug;6(4):848-860. [doi: <u>10.1007/s12671-014-0329-8</u>]
- 64. Parisi A, Roberts RL, Hanley AW, Garland EL. Mindfulness-oriented recovery enhancement for addictive behavior, psychiatric distress, and chronic pain: a multilevel meta-analysis of randomized controlled trials. Mindfulness (N Y) 2022;13(10):2396-2412. [doi: 10.1007/s12671-022-01964-x] [Medline: 36124231]

### Abbreviations

B-MORE: brief mindfulness-oriented recovery enhancement
COREQ: Consolidated Criteria for Reporting Qualitative Research
CPSP: chronic postsurgical pain
MBI: mindfulness-based intervention
MORE: mindfulness-oriented recovery enhancement
PI: principal investigator
RA: research assistant
RCT: randomized controlled trial
TAP: treatment acceptability and preference
TJA: total joint arthroplasty

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# 2024: A Year of Nursing Informatics Research in Review

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# Abstract

Each year, nursing informatics researchers contribute to nursing and health informatics knowledge. The year 2024 emerged as yet another year of significant advances. In this editorial, I describe and highlight some of the key trends in nursing informatics research as published in *JMIR Nursing* in 2024. Artificial intelligence (AI), data science, mobile health (mHealth), and the integration of technology into nursing education and practice remain key research themes in the literature. Nursing informatics publications continue to grow in number. A greater number of AI and data science articles are being published, while at the same time, mHealth and technology research continues to be conducted in nursing education and practice contexts.

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### **KEYWORDS**

nursing informatics; health informatics; research; practice; education; trends; artificial intelligence; data science

## Introduction

The year 2024 proved to be a revolutionary year for nursing informatics and *JMIR Nursing*. Nurses, technology practitioners, and researchers who design, develop, and implement technologies used by nurses and nursing informatics specialists are moving forward in the field of study we know as nursing informatics. In 2024, we saw nursing informatics researchers focus on several key areas, namely artificial intelligence (AI), data science, and mobile health (mHealth), as well as integrating technologies into nursing practice and education. In this year's year-in-review editorial, I describe and highlight some of the key nursing informatics research themes published in *JMIR Nursing* and review 2024's published articles, using a thematic approach [1]. Findings from the review of the articles revealed many trends that I describe in more detail below.

# Artificial Intelligence

Over the past year, several articles were published that assessed the current state of the science of AI in nursing; the design of AI algorithms; and the effectiveness of AI's implementation in nursing contexts, such as hospital, community, and long-term care settings. Researchers have investigated the implications of applying AI to lifestyle monitoring in long-term care [2], detecting behavioral disorders [3], identifying depression [4], patient monitoring (eg, movement monitoring for continence care, sleep, and chronic conditions) [5], and supporting nurses' decision-making [6]. AI-supported technologies, such as robots [7] and chatbots [8], have also been studied and evaluated for their use by nurses in varying care contexts. Other researchers have begun the process of examining AI's integration into nursing education. Here, there has been an impetus to identify what is important and how to effectively integrate these technologies into nursing education [9].

# Data Science

Data science emerged as a key theme in the nursing informatics research. The development of data models and the analysis of nurse-generated data were considered by researchers as key to supporting nurses' decision-making in hospital [10], long-term care [11], and community settings [12]. This nursing informatics research aimed to conceptualize and develop electronic health record data models for nurses [13]. Researchers used data-centric approaches to understand and improve nursing workload measures, understand nurses' and patients' sentiments regarding COVID-19 [14], collect and present data used in the remote monitoring of patients with COVID-19 [12], and identify patient resources [15]. This research led to new findings that focused on optimizing nursing practice [10-19].

## Ethics and Privacy

Key research areas of concern for nurses who use AI and data science–centric approaches included ethical [19] and privacy considerations [16] associated with using technology. Software testing remained an important aspect of nursing informatics practice to ensure the quality and safety of technologies used in health care [17].

# Nursing Education

Nursing education remained an important theme in the literature [20,21]. The influence of AI on nursing education reflected the need for nurse educators and educational researchers to understand the impacts of these technologies upon nursing



education [18]. The role of digital tools and their integration into undergraduate and graduate nursing education were explored [18]. Digital tools used by practicing nurses were studied by researchers [18,19,22]. Here, nurses' use of multimedia tools to support patient education in cardiac care was a research highlight that emerged [22], and we saw an increase in the number of papers that focused on virtual care in the context of nursing education [20,21].

# mHealth Apps, Tablets, and the Internet

The development of mHealth apps for patients and nurses remained strong [23,24]. Peterson and colleagues [22] studied the effects of a gratitude exercise mindfulness app on neonatal intensive care nurses. Shiyab et al [5] examined nurses' use of mHealth apps for chronic conditions. Togo et al [25] investigated the effects of mindful breathing using a tablet on nervous system function and sleep. Nurses continued to study mobile apps, software, and devices to determine their influence on patient and nursing outcomes [5,23,24,26,27]. Nurse researchers continued to spearhead mHealth app design and improvements in design, with the aim of improving outcomes. Lastly, nurses evaluated new approaches to finding services on the World Wide Web [15].

In summary, nursing informatics research in 2024 extended our knowledge in the areas of AI and data science. Mobile apps, tablet use, the use of the internet, the integration of nursing informatics into nursing education, and the design of digital tools for nurses and patients continue to be important areas of research.

# Future Research Directions

Nursing informatics research in 2024 advanced in several key areas, including research on the design and use of mobile devices (eg, mHealth tools and tablets) and software apps in the context of nursing practice, education, and administration. In addition to this, several advances in the design and development of data analytics and AI algorithms by nurses have emerged to support and enhance nursing practice. Of importance is the need to study how these technologies can effectively and safely be integrated for use by nurses in acute care, long-term care, and home care settings. Future research will need to focus on how technologies are implemented and incorporated into nurses' work and patient care, so that there is a strong cognitive-sociotechnical fit between nurse information processing activities, the physical work of nurses, the technologies that are used by nurses, and the patients they care for [1,28,29]. To address these emerging issues in nursing informatics, there is a need to expand funding at the intersection of nursing informatics and AI, data analytics, and mHealth, and research funding extensions need to be made for understanding how these critical new technologies can be added to nursing education and practice [30].

# JMIR Highlights

*JMIR Nursing* also advanced in 2024. *JMIR Nursing* is now indexed in MEDLINE, PubMed, PubMed Central, Directory of Open Access Journals (DOAJ), Scopus, Sherpa Romeo, CINAHL, and the International Academy of Nursing Editors (INANE) directory of nursing journals. More importantly, in 2024, *JMIR Nursing's* CiteScore rose to 5.2, placing the journal in the 88th percentile. *JMIR Nursing* is now a Q1 journal for general nursing.

# Conclusion

The focus on nursing informatics and emerging technology trends in the field of nursing is proving that technology's influence upon nursing practice is growing and needs continuous research and support. Nursing informatics researchers and those who study nurses using technology continue to lead the way forward, influencing nursing and health care around the world. Future research directions will need to focus on the integration and incorporation of new and emerging technologies into nursing practice, education, and administration.

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### **Conflicts of Interest**

EB is the Editor-in-Chief of JMIR Nursing.

### References

- 1. Borycki EM, Lemieux-Charles L, Nagle L, Eysenbach G. Evaluating the impact of hybrid electronic-paper environments upon novice nurse information seeking. Methods Inf Med 2009;48(2):137-143. [doi: 10.3414/ME9222] [Medline: 19283310]
- Groeneveld S, Bin Noon G, den Ouden MEM, et al. The cooperation between nurses and a new digital colleague "AI-Driven Lifestyle Monitoring" in long-term care for older adults: viewpoint. JMIR Nurs 2024 May 23;7:e56474. [doi: <u>10.2196/56474</u>] [Medline: <u>38781012</u>]
- Fernandes S, von Gunten A, Verloo H. Using AI-based technologies to help nurses detect behavioral disorders: narrative literature review. JMIR Nurs 2024 May 28;7:e54496. [doi: <u>10.2196/54496</u>] [Medline: <u>38805252</u>]
- 4. Taylor B, Hobensack M, Niño de Rivera S, Zhao Y, Masterson Creber R, Cato K. Identifying depression through machine learning analysis of omics data: scoping review. JMIR Nurs 2024 Jul 19;7:e54810. [doi: <u>10.2196/54810</u>] [Medline: <u>39028994</u>]

5. Shiyab W, Rolls K, Ferguson C, Halcomb E. Nurses' use of mHealth apps for chronic conditions: cross-sectional survey. JMIR Nurs 2024 May 29;7:e57668. [doi: 10.2196/57668] [Medline: <u>38809593</u>]

- 6. Bresolin P, Steindal SA, Bingen HM, et al. Technology-supported guidance models to stimulate nursing students' self-efficacy in clinical practice: scoping review. JMIR Nurs 2024 Mar 8;7:e54443. [doi: <u>10.2196/54443</u>] [Medline: <u>38457802</u>]
- Kang A, Wu X. Assessing visitor expectations of ai nursing robots in hospital settings: cross-sectional study using the Kano model. JMIR Nurs 2024 Nov 27;7:e59442. [doi: 10.2196/59442] [Medline: 39602413]
- 8. Srinivasan M, Venugopal A, Venkatesan L, Kumar R. Navigating the pedagogical landscape: exploring the implications of AI and chatbots in nursing education. JMIR Nurs 2024 Jun 13;7:e52105. [doi: <u>10.2196/52105</u>] [Medline: <u>38870516</u>]
- 9. Ball Dunlap PA, Michalowski M. Advancing AI data ethics in nursing: future directions for nursing practice, research, and education. JMIR Nurs 2024 Oct 25;7:e62678. [doi: 10.2196/62678] [Medline: 39453630]
- 10. Ware A, Blumke T, Hoover P, Arreola D. Calculating optimal patient to nursing capacity: comparative analysis of traditional and new methods. JMIR Nurs 2024 Nov 22;7:e59619. [doi: <u>10.2196/59619</u>] [Medline: <u>39584562</u>]
- Strauven H, Wang C, Hallez H, Vanden Abeele V, Vanrumste B. Unobtrusive nighttime movement monitoring to support nursing home continence care: algorithm development and validation study. JMIR Nurs 2024 Dec 24;7:e58094. [doi: <u>10.2196/58094</u>] [Medline: <u>39718558</u>]
- 12. Cornelis J, Christiaens W, de Meester C, Mistiaen P. Remote patient monitoring at home in patients with COVID-19: narrative review. JMIR Nurs 2024 Nov 19;7:e44580. [doi: 10.2196/44580] [Medline: 39287362]
- Tiase VL, Sward KA, Facelli JC. A scalable and extensible logical data model of electronic health record audit logs for temporal data mining (RNteract): model conceptualization and formulation. JMIR Nurs 2024 Jun 24;7:e55793. [doi: 10.2196/55793] [Medline: 38913994]
- Ntiamoah M, Xavier T, Lambert J. Sentiment analysis of patient- and family-related sepsis events: exploratory study. JMIR Nurs 2024 Apr 1;7:e51720. [doi: 10.2196/51720] [Medline: 38557694]
- 15. Castro A, Lalonde-LeBlond G, Freitas Z, et al. In-home respite care services available to families with palliative care needs in Quebec: novel digital environmental scan. JMIR Nurs 2024 Apr 16;7:e53078. [doi: <u>10.2196/53078</u>] [Medline: <u>38625735</u>]
- 16. Lukkien DRM, Stolwijk NE, Ipakchian Askari S, et al. AI-assisted decision-making in long-term care: qualitative study on prerequisites for responsible innovation. JMIR Nurs 2024 Jul 25;7:e55962. [doi: <u>10.2196/55962</u>] [Medline: <u>39052315</u>]
- 17. Obigbesan O, Graham K, Benzies KM. Software testing of eHealth interventions: existing practices and the future of an iterative strategy. JMIR Nurs 2024 Jul 19;7:e56585. [doi: <u>10.2196/56585</u>] [Medline: <u>39028552</u>]
- Kleib M, Arnaert A, Nagle LM, et al. Digital health education and training for undergraduate and graduate nursing students: scoping review. JMIR Nurs 2024 Jul 17;7:e58170. [doi: <u>10.2196/58170</u>] [Medline: <u>39018092</u>]
- Sun L, Yang B, Kindt E, Chu J. Privacy barriers in health monitoring: scoping review. JMIR Nurs 2024 May 9;7:e53592. [doi: <u>10.2196/53592</u>] [Medline: <u>38723253</u>]
- Nowell L, Johnston S, Dolan S, Jacobsen M, Lorenzetti DL, Oddone Paolucci E. Exploring educators' perceptions and experiences of online teaching to foster caring profession students' development of virtual caring skills: sequential explanatory mixed methods study. JMIR Nurs 2025 Jan 15;8:e64548. [doi: <u>10.2196/64548</u>] [Medline: <u>39608377</u>]
- Hutchinson A, Khaw D, Malmstrom-Zinkel A, et al. Embedding the use of patient multimedia educational resources into cardiac acute care: prospective observational study. JMIR Nurs 2024 Jul 18;7:e54317. [doi: <u>10.2196/54317</u>] [Medline: <u>39024556</u>]
- 22. Peterson NE, Thomas M, Hunsaker S, Stewart T, Collett CJ. mHealth gratitude exercise mindfulness app for resiliency among neonatal intensive care unit staff: Three-arm pretest-posttest interventional study. JMIR Nurs 2024 Feb 16;7:e54561. [doi: 10.2196/54561] [Medline: 38363595]
- Johnsen HM, Nes AAG, Haddeland K. Experiences of using a digital guidance and assessment tool (the Technology-Optimized Practice Process in Nursing Application) during clinical practice in a nursing home: focus group study among nursing students. JMIR Nurs 2024 Sep 10;7:e48810. [doi: 10.2196/48810] [Medline: 39255477]
- 24. Nowell L, Dolan S, Johnston S, Jacobsen M, Lorenzetti D, Oddone Paolucci E. Exploring student perspectives and experiences of online opportunities for virtual care skills development: sequential explanatory mixed methods study. JMIR Nurs 2024 Aug 21;7:e53777. [doi: 10.2196/53777] [Medline: 39167789]
- 25. Togo E, Takami M, Ishigaki K. Evaluation of autonomic nervous system function during sleep by mindful breathing using a tablet device: randomized controlled trial. JMIR Nurs 2024 Jun 12;7:e56616. [doi: <u>10.2196/56616</u>] [Medline: <u>38865177</u>]
- 26. Hamarash MQ, Ibrahim R, Yaas MH, Abdulghani MF, Al Mushhadany O. Comparative effectiveness of health communication strategies in nursing: a mixed methods study of internet, mHealth, and social media versus traditional methods. JMIR Nurs 2024 Nov 19;7:e55744. [doi: 10.2196/55744] [Medline: 39622705]
- Slob J, van Houwelingen T, Kort HSM. Health care workers' expectations of the Mercury Advance SMARTcare solution to prevent pressure injuries: individual and focus group interview study. JMIR Nurs 2024 Apr 18;7:e47992. [doi: 10.2196/47992] [Medline: <u>38635323</u>]
- 28. Borycki EM, Kushniruk AW. Towards an integrative cognitive-socio-technical approach in health informatics: analyzing technology-induced error involving health information systems to improve patient safety. Open Med Inform J 2010 Sep 15;4:181-187. [doi: 10.2174/1874431101004010181] [Medline: 21594010]
- 29. Borycki EM, Kushniruk AW. Cognitive-socio-technical theory: application and use in health informatics. In: Research Handbook on Health Information Systems: Edward Elgar Publishing; 2025:45-59. [doi: 10.4337/9781802201307.00008]

 Borycki EM, Lai C, Kushniruk AW. Canada's digital health workforce: the role of innovation, research and policy. Stud Health Technol Inform 2024 Feb 19;312:77-81. [doi: <u>10.3233/SHTI231316</u>] [Medline: <u>38372315</u>]

### Abbreviations

AI: artificial intelligence DOAJ: Directory of Open Access Journals INANE: International Academy of Nursing Editors mHealth: mobile health

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# Using Large Language Models to Assess Burnout Among Health Care Workers in the Context of COVID-19 Vaccine Decisions and Health Beliefs: Retrospective Cohort Study

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# Abstract

**Background:** Burnout among health care workers affects their well-being and decision-making, influencing patient and public health outcomes. Health care workers' health beliefs and COVID-19 vaccine decisions may affect the risks of burnout. Therefore, understanding the interplay between these crucial factors is essential for identifying at-risk staff, providing targeted support, and addressing workplace challenges to prevent further escalation of burnout-related issues.

**Objective:** This study examines how burnout is impacted by health beliefs and COVID-19 vaccine decisions among health care workers. Building on our previously developed Health Belief Model (HBM) classifier based on the HBM framework, which explains how individual perceptions of health risks and benefits influence behavior, we focused on key HBM constructs, including the perceived severity of COVID-19, perceived barriers to vaccination, and their relationship to burnout. We aim to leverage natural language processing techniques to automatically identify theoretically grounded burnout symptoms from comments authored by nurses in a large-scale, national survey and assess their associations with vaccine hesitancy and health beliefs.

**Methods:** We analyzed 1944 open-ended comments written by 1501 vaccine-hesitant nurses, using data from the Nurses' Health Study surveys. We fine-tuned LLaMA 3, an open-source large language model with few-shot prompts and enhanced performance with structured annotation guidance and reasoning-aware inference. Comments were classified into burnout dimensions—Emotional Exhaustion, Depersonalization, and Inefficacy—based on the Maslach Burnout Inventory framework.

**Results:** The model achieved a high weighted accuracy of 92% and an  $F_1$ -score of 91% for Depersonalization. Emotional Exhaustion was identified in 52% (1003/1944) of comments, correlating strongly with perceived severity (189/323, 59%) and barriers to vaccination (281/650, 43%). Demographic analyses revealed significant variations in burnout prevalence, with older age groups reporting greater burnout.

**Conclusions:** This study highlights the relationship between burnout and vaccine decision-making among health care workers, uncovering areas for further exploration. By exploring the complex interplay between psychological strain and vaccine hesitancy, this study sets the stage for developing transformative interventions and policies that could redefine workforce resilience and public health strategies.

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### **KEYWORDS**

burnout; health care workers; nurses; COVID-19; health beliefs model; Maslach Burnout Inventory; text classification; LLMs; prompt engineering; LLaMA; fine-tuning; large language models



## Introduction

### Background

The COVID-19 pandemic has profoundly impacted health care workers, intensifying professional burnout and shaping vaccine-related decisions that are critical to public health outcomes [1]. Health care workers faced unprecedented challenges: extreme fatigue, overwhelming stress, and profound grief while managing increased workloads, critical staffing shortages, and limited access to protective equipment [2]. Burnout, defined by the World Health Organization as a syndrome resulting from unmanaged, chronic workplace stress [3], manifests through mental and physical exhaustion, feelings of detachment or cynicism toward one's job, and a diminished sense of personal accomplishment. These compounding pressures not only affected their well-being but also influenced their perceptions and decisions regarding COVID-19 vaccination, reflecting broader concerns about institutional credibility and policy-driven decisions [4].

Vaccination of health care workers serves a dual purpose: protecting this highly exposed group and preventing iatrogenic spread within health care settings. As one of society's most trusted professions, health care workers' attitudes toward vaccination significantly influence public perception and behavior [5]. However, efforts to promote COVID-19 vaccination through community engagement and trust-building initiatives often fell short in addressing health care workers' fundamental concerns about vaccine mandates, personal autonomy, perceived coercion of incentives, misinformation, and accessibility [6].

Despite substantial research on burnout and vaccine hesitancy, few studies have explored how these factors interact to shape decision-making among health care workers. This gap is especially pronounced in research involving nurses—a population that makes up the backbone of health care systems and has faced disproportionate levels of burnout during the COVID-19 pandemic. Recent studies highlight rising emotional exhaustion and diminished professional fulfillment among nurses, driven by excessive job demands and inadequate institutional support [7,8].

Two theoretical frameworks inform our understanding of the relationship between burnout and vaccine decisions. First, the Total Worker Health Model provides a holistic perspective on how occupational stress, including burnout, influences both personal health decisions and overall job performance [9]. This model evaluates multiple levels of contextual factors, worker characteristics, and organizational elements to assess their impact on both organizational outcomes and worker well-being. Second, the Health Belief Model (HBM) examines how individual perceptions influence health behaviors, including vaccination decisions, through key factors such as perceived susceptibility to disease, perceived severity, perceived benefits of action, and perceived barriers to action [10]. For health care workers experiencing burnout, these constructs may interact in complex ways, reshaping their decision-making processes and potentially exacerbating vaccine hesitancy [11].

Understanding how burnout intersects with vaccine-related health beliefs is critical, yet much of the existing literature relies on structured survey tools that fail to capture the complexity of health care workers' lived experiences. Free-text narratives provide richer insights into emotional and cognitive processes but pose analytical challenges at scale. To address this, this study applies large language models (LLMs), which excel at interpreting nuanced, unstructured textual data. Unlike traditional machine learning models-which require extensive feature engineering and often miss deeper linguistic or conceptual structures-LLMs can process entire sentences or paragraphs as coherent units, capturing context, tone, and latent psychological meaning [12]. Their capacity to generalize across varied linguistic expressions makes them particularly well suited to analyzing complex constructs such as burnout and vaccine hesitancy in narrative form.

### **Related Works**

A growing body of research has documented the psychological toll of the COVID-19 pandemic on health care workers, particularly those on the front lines with burnout and vaccine hesitancy emerging as key concerns [13,14]. Burnout—widespread among nurses during the pandemic—has been linked to emotional exhaustion, reduced engagement, and diminished adherence to public health responsibilities [15-17].

Researchers have used a variety of conceptual models to study these effects. Among these, the Maslach Burnout Inventory (MBI) provides a widely recognized framework for measuring and understanding burnout through three key dimensions: Emotional Exhaustion, Depersonalization, and Inefficacy [18]. Previous research has demonstrated that burnout emerged as the most prevalent mental health issue among health care workers during the COVID-19 pandemic, affecting nearly half of the workforce globally and heightening emotional exhaustion, distrust in systems, and impaired decision-making regarding public health measures [19,20].

Galanis et al [21] found that COVID-19-related burnout reduced health care workers' willingness to be vaccinated, with psychological resilience partially mitigating this effect. Similarly, Limbu et al [22] conducted a systematic review applying the HBM and concluded that perceived barriers, susceptibility, and severity were strong predictors of vaccine hesitancy among health care professionals.

Luna et al [23] applied latent profile analysis to identify distinct burnout patterns in health care workers, linking them to work-related variables such as shift type and job satisfaction, and calling for more personalized burnout interventions. More recently, Nagle et al [24] conducted a scoping review of conceptual burnout models and emphasized the need for integrative, theory-driven tools capable of capturing both individual and systemic drivers of burnout—particularly those that move beyond the limitations of existing instruments like the MBI. Notably, all these studies relied on structured survey instruments and predefined scales rather than open-ended narrative data or language-based classification, which our approach aims to complement.



Despite these advancements, few studies have brought together burnout theory, health behavior models, and LLM-driven text analysis to examine vaccine hesitancy among health care workers. This study addresses that gap by analyzing narrative data from nurses through the dual lenses of MBI and HBM, using LLMs to extract theoretically grounded, fine-grained burnout symptoms from large-scale free-text comments to reveal how burnout and belief structures jointly influence vaccine decisions. The following research questions guided the investigation.

The Main Research Question is: how does burnout correlate with COVID-19 vaccine decisions among health care workers during the pandemic, and how do these correlations vary across demographic factors?

To address this, we break down the main research question into four subquestions:

- How effective are LLMs in automatically identifying burnout symptoms among health care workers, based on the MBI framework, within the context of the COVID-19 pandemic?
- 2. What is the relationship between specific MBI burnout dimensions (Emotional Exhaustion, Depersonalization, and Inefficacy) and HBM constructs (barriers, severity, and susceptibility) among vaccine-hesitant (VH) health care workers during the COVID-19 pandemic, and which burnout dimensions are most strongly associated with each HBM construct?
- 3. How do demographic factors (eg, age, education, and region) influence the relationship between burnout dimensions and vaccine hesitancy?
- 4. What are the most common themes of the comments in the intersection of burnout dimensions and the HBM?

### Methods

### **Ethical Considerations**

The study was approved as Protocol 2020P001020 of the Institutional Review Board of Brigham and Women's Hospital in Boston, Massachusetts, which allowed voluntary survey completion to represent participant consent.

### Data Source, Study Design, and Study Participants

This study used data from our previous investigation of COVID-19 vaccine hesitancy among participants in the Nurses' Health Study II and Nurses' Health Study 3, conducted in Winter 2021 [25]. These large-scale, longitudinal cohorts include health care professionals who provided responses on their COVID-19 vaccination intentions and related beliefs. In the prior study, we identified VH individuals based on their responses to the survey question, "Do you plan to receive a COVID-19 vaccine?" Participants who answered "no" or "unsure" (excluding those already vaccinated, intending to get vaccinated, or with missing data) were classified as VH [26]. Of the 4242 participants who provided at least one open-ended comment in the survey (categorized under "vaccine" or "other"), 1501 were classified as VH and included in this analysis. We also considered the personal protective equipment-related comments of these VH participants because these comments are more likely to be

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work-related and might be a good source for finding work burnout. In total, we analyzed 1,944 open-ended comments provided by VH participants. The vast majority of survey participants (1380/1944,71%) were not actively working at the time of vaccination, while (n=564/1944, 29%) were actively practicing nurses. This cohort, therefore, represents both actively and formerly practicing nurses, highlighting unique perspectives from both groups regarding their vaccination decisions.

In the prior study, these comments were categorized according to constructs of the HBM using supervised learning: perceived barriers, perceived severity, perceived susceptibility, and a category for non-HBM-related comments. This classification enabled us to analyze the underlying health beliefs associated with vaccine hesitancy. This study builds upon this framework, linking these HBM categories with burnout dimensions based on the MBI to explore the intersection of psychological factors and health beliefs in vaccine hesitancy.

For a detailed description of the data collection process and the HBM categorization methodology, refer to our previous work [26].

### Model Selection and Classification Optimization Strategy

We selected LLaMA 3 8B for its open-source accessibility, balanced performance, and ability to run locally, essential for ensuring full control over sensitive health care narratives. The 8B variant offers a practical trade-off between language understanding and computational efficiency, making it suitable for fine-tuning on modest hardware. Its support for Low-Rank Adaptation, a parameter-efficient fine-tuning method, further reduces resource demands by updating only a small subset of model weights [27].

We fine-tuned LLaMA 3 8B on 340 labeled comments, including both original and augmented examples from a manually annotated subset of the dataset. The model was trained using the AdamW 8-bit optimizer, with a linear learning rate scheduler, gradient checkpointing, and mixed-precision (FP16) training. Training was conducted with a small batch size and capped at 60 steps to fit within resource constraints.

To further enhance model understanding of burnout categories, we used the Annotation Guidelines-based Knowledge Augmentation (AGKA) approach developed by Liu et al [28]. AGKA systematically enriches prompts with task-relevant information from annotation guidelines. It has three key components: (1) label definition knowledge, where detailed explanations for each class (eg, Emotional Exhaustion, Depersonalization, and Inefficacy) are retrieved from the annotation guidelines; (2) task instruction formatting, where prompts are carefully structured to include task claims and output expectations; and (3) representative few-shot examples, which demonstrate how to apply the label definitions in context. This design mimics the logic human annotators follow, reading label definitions and using representative cases for guidance. Details of the AGKA prompts are provided in Multimedia Appendix 1.

To improve reliability during inference, we implemented the Reasoning-Aware Self-Consistency (RASC) framework [29].

RASC performs iterative classification on each comment and collects multiple model outputs. When a consistent majority is reached (eg, 70% of outputs align), the system returns that label; otherwise, it continues sampling up to a maximum number of iterations before returning "Undecided." This approach helps stabilize predictions, particularly for ambiguous or borderline inputs.

### **Model Evaluation**

In evaluating the model's performance, we followed a 3-step process. First, we applied the RASC framework, which helped prioritize high-confidence outputs. Then, we measured the model's performance using metrics of weighted accuracy and  $F_1$ -score across the burnout dimensions: Emotional Exhaustion, Depersonalization, and Inefficacy. Finally, we conducted an error analysis to identify recurring misclassification patterns, particularly those involving ambiguous language or overlapping burnout symptoms.

This evaluation framework not only allowed us to assess classification quality but also demonstrated how LLMs can support scalable, interpretable analysis of psychological constructs in free-text narratives. By embedding our approach within the MBI framework and refining it with RASC and AGKA techniques, we provide a replicable methodology for investigating burnout and vaccine hesitancy in health care settings, one that bridges computational and behavioral science in a practical, privacy-preserving way.

### **Thematic Analysis**

To explore overarching themes at the intersection of burnout and health beliefs, we conducted a one-shot LLM-assisted thematic analysis. Using a prompt-based approach, we provided the base LLaMA 3 model with a single example and instructed it to generate a concise, central theme (limited to 7 words) for each participant's comment. This method enabled efficient and consistent interpretation of open-ended responses without additional fine-tuning. We then qualitatively reviewed and grouped the model-generated themes to identify recurring patterns related to the intersection of burnout experience and psychological strain.

# Results

# Effectiveness of LLMs in Identifying Burnout Dimension

To evaluate the effectiveness of LLaMA 3 in identifying burnout dimensions based on the MBI framework, we assessed classification accuracy for Emotional Exhaustion,

Table . Distribution of HBM<sup>a</sup> constructs across burnout dimensions<sup>b</sup>.

Depersonalization, and Inefficacy using a separate set of 150 unseen labeled comments (50 per dimension). Leveraging the RASC framework with AGKA, the model achieved weighted accuracy ranging from 82% to 92% and  $F_1$ -scores from 78% to 91%. The highest weighted accuracy of 92% and an average  $F_1$ -score of 91% was achieved for classifying Depersonalization. Emotional Exhaustion and Inefficacy showed slightly lower accuracies of 84% and 82%, respectively. Our classification revealed that Emotional Exhaustion accounted for 52% of the comments, followed by Depersonalization at 25%, and Inefficacy at 11%. This distribution underscores the prominence of Emotional Exhaustion and reflects its strong representation in the dataset.

To evaluate the effectiveness of LLaMA 3 in identifying burnout dimensions based on the MBI framework, we assessed classification performance for Emotional Exhaustion, Depersonalization, and Inefficacy using a separate set of 150 unseen labeled comments (50 per dimension). Leveraging the RASC framework with AGKA, the model achieved weighted accuracy ranging from 82% to 92% and  $F_1$  -scores from 78% to 91%. The highest weighted accuracy of 92% and an  $F_1$  -score of 0.91 were achieved for classifying Depersonalization, which also had a precision of 0.95 and recall of 0.88. Emotional exhaustion showed slightly lower performance, with a precision of 0.81, recall of 0.88,  $F_1$  -score of 0.78 and accuracy of 0.82.

### Analysis of Burnout and HBM Construct Intersections

We analyzed the association between specific burnout dimensions and previously categorized HBM constructs: perceived barriers to getting a vaccination, severity of COVID-19, and susceptibility to COVID-19. These associations are represented in Table 1, which illustrates the distribution of burnout dimensions across HBM constructs. Emotional Exhaustion correlated strongly with perceived severity (59%). Additionally, 43% of comments referenced barriers, highlighting both logistical and psychological obstacles to vaccination. Depersonalization was most closely linked to the perceived severity of the disease (27%) and perceived susceptibility to the disease (23%). A smaller proportion of those with depersonalization (17%) referenced perceived barriers, indicating a weaker link to barriers to obtaining the vaccine. Inefficacy showed weaker associations overall, with only 14% of comments reflecting the perceived severity of COVID-19, a total of 8% referenced perceived susceptibility to the disease, and 7% mentioned perceived barriers to getting vaccinated.

table - Distribution of fibre constructs deross burnout dimensions .				
Burnout dimension	Perceived barriers (%)	Perceived severity (%)	Perceived susceptibility (%)	Non-HBM (%)
Emotional exhaustion	43	59	52	56
Depersonalization	17	27	23	32
Inefficacy	7	14	8	15

<sup>a</sup>HBM: Health Belief Model.

<sup>b</sup>Emotional exhaustion shows the highest associations with perceived severity (59%) and non-HBM (56%), while depersonalization and inefficacy show lower percentages across all constructs.

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### **Demographic Analysis**

Further analysis of burnout dimensions by demographic factors revealed significant variations. To examine trends across age groups, we categorized participants into four bins and further assessed the impact of active versus inactive status. As shown in Table 2, Emotional Exhaustion remained consistently high across all groups ( $\geq$ 50%), with the highest prevalence among active nurses younger than 65 years (55%). Interestingly, inactive nurses older than 65 years of age reported similar levels (50%), suggesting that work status may not strongly influence this dimension.

Table. The prevalence of burnout dimensions among active and inactive nurses, stratified by age group<sup>a</sup>.

Group and burnout dimension	Age (<65 years), n (%)	Age (>65 years), n (%)	
Active			
Emotional exhaustion	255 (55)	50 (50)	
Depersonalization	136 (29)	21 (21)	
Inefficacy	74 (16)	6 (6)	
Inactive			
Emotional exhaustion	241 (51)	457 (50)	
Depersonalization	112 (24)	211 (23)	
Inefficacy	52 (11)	89 (10)	

<sup>a</sup>Emotional Exhaustion remains high across all groups, while Depersonalization and Inefficacy show notable differences, with active nurses younger than 65 years of age reporting the highest levels.

In contrast, Depersonalization and Inefficacy showed more variation. Active nurses, particularly those younger than 65 years, exhibited significantly higher rates of both compared to their inactive counterparts (29% vs 24% for Depersonalization; 16% vs 11% for Inefficacy). Chi-square tests confirmed statistically significant differences across burnout dimensions (P<.001), particularly for Depersonalization and Inefficacy across age and activity levels. These findings highlight the distinct stressors faced by active nurses and underscore the need for targeted interventions.

Regional differences in burnout prevalence were also observed (Figure 1). The Midwest reported the highest total burnout percentage (87%), with Emotional Exhaustion, Inefficacy, and Depersonalization contributing 30%, 29%, and 28%, respectively. The South followed with a total burnout percentage of 80%, while the Northeast region reported a similar pattern at 71%. The West exhibited a lower total burnout percentage of 59%.



Burnout dimensions across regions



# Key Themes at the Intersection of Burnout and HBM Constructs

To address subquestion 4, our thematic analysis identified overlapping concerns at the intersection of burnout dimensions and HBM constructs. Health and safety concerns, including vaccine side effects, efficacy, and misinformation, were dominant among comments highlighting perceived barriers to vaccination. Emotional and psychological strain, characterized by stress, loss, and work-life challenges, further underscored the mental toll of burnout in shaping vaccine hesitancy. In some cases, participants cited low perceived risk due to high COVID-19 recovery rates, which reduced the urgency for vaccination.

Broader themes reflected distrust toward government and political systems, frustrations with systemic obstacles, and the pandemic's impact on social and family dynamics. Faith and resilience were also significant factors, with many participants relying on spiritual beliefs and community support to navigate vaccine-related concerns. These themes illustrate the complex interplay between burnout dimensions and health beliefs, shaping health care workers' vaccine decisions.

### **Error Analysis**

We conducted both quantitative and qualitative error analysis, focusing on predicted versus true labels, classification confidence, and label-specific performance metrics such as precision, recall, and  $F_1$ -score.

Initial results revealed key challenges, with multiclass classification achieving only 55% accuracy. Misclassified outputs showed ambiguity and overlapping language, particularly between Emotional Exhaustion and Depersonalization, which frequently co-occurred and shared similar linguistic cues.

For example, comments such as "Changing expectations & policies at work are frustrating causing burnout. Lack of free speech/generally one-way group think causes burnout feeling. Everyone is tired of the isolation and changes to our social lives" could be classified as either Emotional Exhaustion or Depersonalization, depending on interpretation. Phrases like "frustration causing burnout" and "everyone is tired of the isolation" suggest fatigue and feeling emotionally overwhelmed, which align with Emotional Exhaustion. On the other hand, mentions of "lack of free speech" and "one-way group think" could reflect feelings of disconnection or detachment from the work environment, or an insensitive attitude toward colleagues and tasks, aligning more with Depersonalization.

Similarly, the comment "I was working as an R.N. in the pandemic and eventually developed severe anxiety, panic attacks, and depression and am currently on a leave of absence from work for these reasons" strongly reflects Emotional Exhaustion, characterized by emotional and psychological depletion. However, the mention of a leave of absence might also suggest withdrawal, potentially overlapping with Depersonalization and contributing to misclassification.

Depersonalization, in particular, showed high precision but low recall. This discrepancy likely stems from the smaller proportion

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of comments classified under Depersonalization, leading to more cautious predictions for this dimension and reduced sensitivity to identifying all relevant instances.

# Discussion

### Overview

This study examined the role of burnout and health beliefs in shaping COVID-19 vaccine decisions among health care workers, offering novel insights through the integration of LLM-based text analysis. By leveraging LLaMA 3 for categorizing burnout dimensions and analyzing their intersection with HBM constructs, the findings align with and extend prior research on the psychological and behavioral factors influencing vaccine hesitancy.

### **Key Findings and Comparisons**

The predominance of Emotional Exhaustion (52% of comments) and its strong correlation with perceived severity (59%) and barriers (43%) underscores the critical role of psychological strain in vaccine hesitancy. These results are consistent with previous studies that link high levels of emotional distress among health care workers with increased concerns about vaccine safety and efficacy [30-33]. Depersonalization, which showed associations with perceived severity (27%) and susceptibility (23%), highlights the psychological detachment experienced by some health care workers, reflecting findings by Zhang et al [34], who identified significant links between burnout dimensions such as depersonalization and factors influencing job satisfaction and turnover intentions among nurses in high-stress settings. In contrast, inefficacy, while less prevalent, aligns with research indicating that feelings of low personal accomplishment may undermine self-efficacy and motivation, thereby dampening proactive health behaviors [35].

Our findings indicate widespread emotional exhaustion across all groups, with at least 50% of both active and inactive nurses reporting high burnout. While we expected active nurses to experience greater burnout due to workplace stress during COVID-19, inactive nurses older than 65 years of age exhibited similar levels, suggesting additional contributing factors. Notably, most inactive nurses in this study were retired, and some reported caregiving responsibilities for spouses, older parents, or grandchildren during pandemic-related closures. These stressors, along with the broader emotional toll of the pandemic, may explain their high burnout levels. Given that data collection occurred early in the pandemic and before mandatory vaccination, we cannot conclude that burnout led to early retirement. However, for those nearing retirement (55-65 years of age), pandemic-related stress may have influenced workforce decisions. The consistently high emotional exhaustion across groups underscores the long-term psychological burden of health care work, warranting further research into postretirement burnout and its lasting effects.

The interplay between burnout dimensions and vaccine hesitancy highlights significant psychological and contextual barriers to vaccination among health care workers. These findings align with prior research, which demonstrates that emotional exhaustion and distrust in systemic structures exacerbate vaccine

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hesitancy during crises [36,37]. Addressing such multifaceted concerns requires holistic approaches that consider not only health beliefs but also the broader sociopolitical and personal challenges faced by health care workers.

The application of LLaMA 3 with the RASC framework demonstrated robust performance in classifying burnout dimensions, achieving high accuracy and  $F_1$ -scores, particularly for Emotional Exhaustion and Inefficacy. These findings underscore the potential of leveraging domain-specific knowledge and few-shot learning strategies for complex classification tasks, aligning with prior research emphasizing the role of targeted annotation and reasoning-based approaches to improve natural language processing model outcomes [28,29]. Future studies could explore fine-tuning strategies to address challenges with overlapping burnout dimensions.

### **Policy Implications and Interventions**

The findings of this study also have significant implications for policy makers. Systemic interventions are needed to address organizational stressors contributing to burnout, including manageable working hours, adequate staffing ratios, and improved access to mental health resources tailored to health care workers. Transparent communication and inclusive decision-making processes are essential to rebuilding trust in health care systems and alleviating systemic distrust that influences vaccine hesitancy.

Policy makers should also support the development of monitoring frameworks that use real-time data to identify at-risk health care workers. Machine learning–driven tools, such as those leveraging LLMs, could enhance early detection of burnout symptoms through employee feedback systems. Finally, interventions must be culturally sensitive and address the diverse

needs of underrepresented health care worker populations. These systemic approaches, informed by this study, could improve workforce well-being and public health outcomes by addressing burnout and vaccine hesitancy at their root causes.

### **Limitations and Future Directions**

While this study provides valuable insights, several limitations warrant attention. The reliance on self-reported comments may introduce reporting bias, as participants may underreport or selectively emphasize certain factors influencing their vaccine hesitancy. Additionally, the study's dataset, derived from the Nurses' Health Study cohorts, includes only female registered nurses, with the majority identifying as White. This demographic homogeneity limits the generalizability of the findings to other health care professions, genders, and ethnic groups. Furthermore, challenges remain in distinguishing overlapping burnout dimensions which require further refinement in annotation guidelines and modeling strategies.

### Conclusions

Future research should explore the longitudinal effects of burnout on vaccine-related behaviors and incorporate diverse health care worker populations. Efforts should also focus on identifying additional burnout factors not included in the MBI. Additionally, designing a preventive framework or tool to monitor and follow up with health care workers for early detection of burnout symptoms could transform interventions. Such tools, integrating real-time machine learning algorithms, could provide tailored interventions to address burnout symptoms before escalation. Expanding the application of LLMs to include multitask learning and fine-tuning with larger annotated datasets may enhance the understanding of complex psychological constructs and their implications for vaccine decisions.

### **Conflicts of Interest**

None declared.

Multimedia Appendix 1

Annotation Guidelines-based Knowledge Augmentation (AGKA prompts) with emotional exhaustion prompt. [DOCX File, 17 KB - nursing\_v8i1e73672\_app1.docx]

### References

- Gambaro E, Gramaglia C, Marangon D, Probo M, Rudoni M, Zeppegno P. Health workers' burnout and COVID-19 pandemic: 1-year after-results from a repeated cross-sectional survey. Int J Environ Res Public Health 2023 Jun 8;20(12):6087. [doi: 10.3390/ijerph20126087] [Medline: 37372674]
- 2. National institute for occupational saftey and health (NIOSH). Risk factors for stress and burnout. 2024. URL: <u>https://www.cdc.gov/niosh/healthcare/risk-factors/stress-burnout.html</u> [accessed 2025-05-16]
- 3. Burn-out an "occupational phenomenon": International Classification of Diseases. World Health Organization. 2019. URL: <u>https://www.who.int/news/item/28-05-2019-burn-out-an-occupational-phenomenon-international-classification-of-diseases</u> [accessed 2025-05-16]
- 4. Bardosh K, de Figueiredo A, Gur-Arie R, et al. The unintended consequences of COVID-19 vaccine policy: why mandates, passports and restrictions may cause more harm than good. BMJ Glob Health 2022 May;7(5):e008684. [doi: 10.1136/bmjgh-2022-008684] [Medline: 35618306]
- Haddaden M, Aldabain L, Patel N, et al. Health care workers attitudes toward COVID-19 vaccination and the effect on personal and professional life. J Community Hosp Intern Med Perspect 2021;11(5):585-589. [doi: 10.1080/20009666.2021.1951943] [Medline: 34567445]

- Casey SM, Burrowes SAB, Hall T, et al. Healthcare workers' attitudes on mandates, incentives, and strategies to improve COVID-19 vaccine uptake: a mixed methods study. Hum Vaccin Immunother 2022 Nov 30;18(6):2144048. [doi: 10.1080/21645515.2022.2144048] [Medline: 36411988]
- 7. Shah MK, Gandrakota N, Cimiotti JP, Ghose N, Moore M, Ali MK. Prevalence of and factors associated with nurse burnout in the US. JAMA Netw Open 2021 Feb 1;4(2):e2036469. [doi: <u>10.1001/jamanetworkopen.2020.36469</u>] [Medline: <u>33538823</u>]
- 8. Lai J, Ma S, Wang Y, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. JAMA Netw Open 2020 Mar 2;3(3):e203976. [doi: 10.1001/jamanetworkopen.2020.3976] [Medline: 32202646]
- 9. National institute for occupational safety and health (NIOSH). Total worker health. 2024. URL: <u>https://www.cdc.gov/niosh/</u> <u>twh/index.html</u> [accessed 2025-05-16]
- 10. Rosenstock IM. Historical origins of the Health Belief Model. Health Educ Monogr 1974 Dec;2(4):328-335. [doi: 10.1177/109019817400200403]
- Jones CL, Jensen JD, Scherr CL, Brown NR, Christy K, Weaver J. The Health Belief Model as an explanatory framework in communication research: exploring parallel, serial, and moderated mediation. Health Commun 2015;30(6):566-576. [doi: 10.1080/10410236.2013.873363] [Medline: 25010519]
- 12. Yu S, Ran N, Liu J. Large-language models: the game-changers for materials science research. Artificial Intelligence Chemistry 2024 Dec;2(2):100076. [doi: 10.1016/j.aichem.2024.100076]
- Søvold LE, Naslund JA, Kousoulis AA, et al. Prioritizing the mental health and well-being of healthcare workers: an urgent global public health priority. Front Public Health 2021;9:679397. [doi: <u>10.3389/fpubh.2021.679397</u>] [Medline: <u>34026720</u>]
- 14. The Lancet. COVID-19: protecting health-care workers. Lancet 2020 Mar 21;395(10228):922. [doi: 10.1016/S0140-6736(20)30644-9] [Medline: 32199474]
- 15. Peterson CJ, Lee B, Nugent K. COVID-19 vaccination hesitancy among healthcare workers—a review. Vaccines (Basel) 2022 Jun 15;10(6):948. [doi: 10.3390/vaccines10060948] [Medline: 35746556]
- 16. Hammer R, Ravindran N, Nielsen N. Can death cafés resuscitate morale in hospitals? Med Humanit 2021 Mar;47(1):2-3. [doi: 10.1136/medhum-2018-011607] [Medline: 30661041]
- 17. Duarte I, Teixeira A, Castro L, et al. Burnout among Portuguese healthcare workers during the COVID-19 pandemic. BMC Public Health 2020 Dec 7;20(1):1885. [doi: 10.1186/s12889-020-09980-z] [Medline: 33287794]
- 18. Maslach C, Jackson S, Leiter M. Maslach Burnout Inventory: Scarecrow Press; 1997. URL: <u>https://www.researchgate.net/</u> publication/277816643\_The\_Maslach\_Burnout\_Inventory\_Manual [accessed 2025-06-19]
- Huang J, Huang ZT, Sun XC, Chen TT, Wu XT. Mental health status and related factors influencing healthcare workers during the COVID-19 pandemic: a systematic review and meta-analysis. In: Talavera-Velasco B, editor. PLoS ONE 2024;19(1):e0289454. [doi: 10.1371/journal.pone.0289454] [Medline: 38241316]
- Leo CG, Sabina S, Tumolo MR, et al. Burnout among healthcare workers in the COVID 19 era: a review of the existing literature. Front Public Health 2021;9:750529 [FREE Full text] [doi: 10.3389/fpubh.2021.750529] [Medline: 34778184]
- Galanis P, Katsiroumpa A, Sourtzi P, et al. COVID-19-related burnout and intention of fully vaccinated individuals to get a booster dose: the mediating role of resilience. Vaccines (Basel) 2022 Dec 27;11(1):62. [doi: <u>10.3390/vaccines11010062</u>] [Medline: <u>36679907</u>]
- 22. Limbu YB, Gautam RK, Pham L. The health belief model applied to COVID-19 vaccine hesitancy: a systematic review. Vaccines (Basel) 2022 Jun 18;10(6):973. [doi: <u>10.3390/vaccines10060973</u>] [Medline: <u>35746581</u>]
- 23. Luna D, Figuerola-Escoto RP, Sienra-Monge JJL, et al. Burnout and Its relationship with work engagement in healthcare professionals: a latent profile analysis approach. Healthcare (Basel) 2023 Nov 26;11(23):3042. [doi: 10.3390/healthcare11233042]
- 24. Nagle E, Griskevica I, Rajevska O, Ivanovs A, Mihailova S, Skruzkalne I. Factors affecting healthcare workers burnout and their conceptual models: scoping review. BMC Psychol 2024 Nov 7;12(1):637 [FREE Full text] [doi: 10.1186/s40359-024-02130-9] [Medline: 39511697]
- 25. Nurses' health Study. URL: <u>https://nurseshealthstudy.org/</u> [accessed 2025-05-16]
- 26. Omranian S, Khoddam A, Campos-Castillo C, Fouladvand S, McRoy S, Rich-Edwards J. Leveraging artificial intelligence to predict Health Belief Model and COVID-19 vaccine uptake using survey text from US nurses. Behav Sci (Basel) 2024 Mar 7;14(3):217. [doi: 10.3390/bs14030217] [Medline: <u>38540520</u>]
- 27. Repede SE, Brad R. LLaMA 3 vs. state-of-the-art large language models: performance in detecting nuanced fake news. Computers 2024 Nov 11;13(11):292. [doi: 10.3390/computers13110292]
- Liu S, Liu S, Sha L, Zeng Z, Gašević D, Liu Z. Annotation guideline-based knowledge augmentation: toward enhancing large language models for educational text classification. IEEE Trans Learning Technol. 2024 Jun 3 p. 619-634. [doi: 10.1109/TLT.2025.3570775]
- Wan G, Wu Y, Chen J, Li S. Reasoning aware self-consistency: leveraging reasoning paths for efficient LLM sampling. . Preprint posted online on Aug 30, 2025 URL: <u>https://aclanthology.org/2025.naacl-long</u> [doi: 10.18653/v1/2025.naacl-long.184]
- 30. Rifai A, Wu WC, Tang YW, et al. Psychological distress and physical adverse events of COVID-19 vaccination among healthcare workers in Taiwan. Vaccines (Basel) 2023 Jan 5;11(1):129. [doi: 10.3390/vaccines11010129] [Medline: 36679974]

- Madison AA, Shrout MR, Renna ME, Kiecolt-Glaser JK. Psychological and behavioral predictors of vaccine efficacy: considerations for COVID-19. Perspect Psychol Sci 2021 Mar;16(2):191-203. [doi: <u>10.1177/1745691621989243</u>] [Medline: <u>33501900</u>]
- Riguzzi M, Gashi S. Lessons from the first wave of COVID-19: work-related consequences, clinical knowledge, emotional distress, and safety-conscious behavior in healthcare workers in Switzerland. Front Psychol 2021;12:628033. [doi: 10.3389/fpsyg.2021.628033] [Medline: <u>33633652</u>]
- 33. Koontalay A, Suksatan W, Prabsangob K, Sadang JM. Healthcare workers' burdens during the COVID-19 pandemic: a qualitative systematic review. J Multidiscip Healthc 2021;14:3015-3025. [doi: 10.2147/JMDH.S330041] [Medline: 34737573]
- 34. Zhang F, Lin C, Li X, et al. The relationships between burnout, general wellbeing, and psychological detachment with turnover intention in Chinese nurses: a cross-sectional study. Front Public Health 2023 Jul 20;11:1216810. [doi: 10.3389/fpubh.2023.1216810]
- 35. Smith V. Factors influencing burnout rates among mental health professionals [Dissertation]. : Walden University; 2022.
- Morgantini LA, Naha U, Wang H, et al. Factors contributing to healthcare professional burnout during the COVID-19 pandemic: a rapid turnaround global survey. In: Murakami M, editor. PLoS ONE 2020;15(9):e0238217. [doi: 10.1371/journal.pone.0238217] [Medline: 32881887]
- McCready JL, Nichol B, Steen M, Unsworth J, Comparcini D, Tomietto M. Understanding the barriers and facilitators of vaccine hesitancy towards the COVID-19 vaccine in healthcare workers and healthcare students worldwide: an umbrella review. In: Harapan H, editor. PLoS One 2023;18(4):e0280439. [doi: <u>10.1371/journal.pone.0280439</u>] [Medline: <u>37043505</u>]

### Abbreviations

AGKA: Annotation Guidelines–based Knowledge Augmentation HBM: Health Belief Model LLM: large language model MBI: Maslach Burnout Inventory RASC: Reasoning-Aware Self-Consistency VH: vaccine hesitant

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# Advancing Clinical Chatbot Validation Using AI-Powered Evaluation With a New 3-Bot Evaluation System: Instrument Validation Study

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# Abstract

**Background:** The health care sector faces a projected shortfall of 10 million workers by 2030. Artificial intelligence (AI) automation in areas such as patient education and initial therapy screening presents a strategic response to mitigate this shortage and reallocate medical staff to higher-priority tasks. However, current methods of evaluating early-stage health care AI chatbots are highly limited due to safety concerns and the amount of time and effort that goes into evaluating them.

**Objective:** This study introduces a novel 3-bot method for efficiently testing and validating early-stage AI health care provider chatbots. To extensively test AI provider chatbots without involving real patients or researchers, various AI patient bots and an evaluator bot were developed.

**Methods:** Provider bots interacted with AI patient bots embodying frustrated, anxious, or depressed personas. An evaluator bot reviewed interaction transcripts based on specific criteria. Human experts then reviewed each interaction transcript, and the evaluator bot's results were compared to human evaluation results to ensure accuracy.

**Results:** The patient-education bot's evaluations by the AI evaluator and the human evaluator were nearly identical, with minimal variance, limiting the opportunity for further analysis. The screening bot's evaluations also yielded similar results between the AI evaluator and human evaluator. Statistical analysis confirmed the reliability and accuracy of the AI evaluations.

**Conclusions:** The innovative evaluation method ensures a safe, adaptable, and effective means to test and refine early versions of health care provider chatbots without risking patient safety or investing excessive researcher time and effort. Our patient-education evaluator bots could have benefitted from larger evaluation criteria, as we had extremely similar results from the AI and human evaluators, which could have arisen because of the small number of evaluation criteria. We were limited in the amount of prompting we could input into each bot due to the practical consideration that response time increases with larger and larger prompts. In the future, using techniques such as retrieval augmented generation will allow the system to receive more information and become more specific and accurate in evaluating the chatbots. This evaluation method will allow for rapid testing and validation of health care chatbots to automate basic medical tasks, freeing providers to address more complex tasks.

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### **KEYWORDS**

artificial intelligence; patient education; therapy; computer-assisted; computer; understandable; accurate; understandability; automation; chatbots; bots; conversational agents; emotions; emotional; depression; depressive; anxiety; anxious; nervous; nervousness; empathy; empathetic; communication; interactions; frustrated; frustration; relationships

# Introduction

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Faced with a projected shortfall of 10 million health care workers by 2030 [1], the health care sector urgently requires innovative solutions to sustain patient care and education.

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Artificial intelligence (AI) automation in low- to mid-level tasks like patient education and initial therapy screening emerges as a strategic response to mitigate this shortage, reallocating medical staff to higher-priority tasks [2,3].

The advent of advanced multimodal large language models (LLMs) such as GPT-4 introduces a paradigm shift, promising scalable, cost-effective chatbot solutions, which are particularly helpful for tasks that require the provider to interact with the patient [4]. GPT-4 and similar models offer a more dynamic, conversational approach, tailoring information to individual patient needs with minimal logistical or financial overhead for health care institutions. This technological evolution promises not only to fill the imminent workforce gap but also to enhance the quality and accessibility of health care services, leveraging AI's capacity for on-demand, personalized patient support [4-7]. It has been reported that LLMs have the cognitive capacity to role-play the character as portrayed in the dialogue prompt [8]. Shao et al [9] showed that GPT-3.5 can be used to score the believability of LLM role-playing. Finally, Yang et al [10] pointed to the high potential that medical chatbots have in clinical settings, while Gilbert et al [11] warned of the need to extensively test health care chatbots.

However, current methods of creating and evaluating early-stage health care bots face steep development costs due to the high level of human involvement in each phase of the development process. In this study, we present a novel, bot-driven method of developing, testing, and evaluating automated health care chatbots. At the center of this strategy is the use of the LLM as an "evaluator agent" to iteratively review and provide feedback on the dialog between the health care bot being evaluated and a set of "digitally simulated patients" also role-played by the LLM. This approach provides a fully automated system that will not only reduce the amount of time and effort required to develop the chatbots but also provide a feasible way to continuously monitor the performances of health care chatbots in different clinical settings.

# Methods

### **Study Design**

This study introduces a novel bot-driven method to evaluate the abilities of LLMs in health care tasks. In this approach, LLMs were configured to perform as a patient-education bot, a pretherapy screening bot, patient bots, and evaluator bots. The patient bots simulated distinct emotional personas—depressed, anxious, and frustrated—to test the adaptability and competency of the provider bots. The evaluator bots assessed the interactions based on predefined criteria. Results from the AI evaluations were cross-referenced with human expert reviews for accuracy and reliability (Figure 1).

Figure 1. Interaction and evaluation methodology for the patient-education bot and the initial screening bot. Includes a list of all the different bots used. AI: artificial intelligence; ENACT: Enhancing Assessment of Common Therapeutic Factors.



### Setup

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To demonstrate the system, 2 AI provider bots were developed using GPT-4 in collaboration with an experienced oncology nurse and a licensed cognitive behavior counselor. One provider bot emulated a patient-education nurse, delivering medical information with clarity and empathy. The second bot acted as a mental health therapist, modeled on acceptance and commitment therapy and mindfulness practices, to provide nonpharmacological mental health support. AI patient bots, also developed using GPT-4, were programmed to represent 40-year-old male patients with lung cancer with 1 of 3 emotional personas: depressed, anxious, and frustrated. In total, 30 patient bots (10 per persona) were created, with each provider bot engaging in 30 interactions. The patient bots' responses were unique due to GPT-4's stochastic generation processes, even with consistent prompts.

Evaluator bots were created for each provider bot to assess their performance based on predefined criteria, offering scores and qualitative feedback. These AI-generated evaluations were

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subsequently reviewed by human experts in relevant fields to ensure validity.

Once the evaluator bots reviewed each provider-patient transcript, human experts in each field reviewed the transcripts, scored the interaction using the same criteria as the GPT-4 bots, commented on the provider's overall performance, and then reviewed the evaluator bot's assessment.

The patient-education bot was reviewed by the same pediatric hematology-oncology nurse who helped create the patient-education approach, while the pretherapy screening bot was reviewed by a PhD in IT psychology as well as by the cognitive behavior counselor (Figure 2).





### Prompting

To ensure that the bots adhered strictly to their designated roles while mitigating unwanted behaviors, explicit, role-specific

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Figure 3. Chatbot architecture. LLM: large language model.
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instructions were incorporated into their prompts. This design approach balanced general AI capabilities with task-specific requirements, ensuring consistent and contextually appropriate responses (Figure 3).



### **Patient-Education Bot Prompting**

The patient-education bot was designed to emulate the role of a "patient-education nurse" tasked with educating patients with cancer about medical vocabulary, procedures, and treatment options. The bot was prompted with detailed instructions, emphasizing clarity, empathic expressions in communication, and a patient-centered approach. The following guidelines were incorporated into its prompt: (1) adopt a teaching role tailored to patients with limited medical knowledge; (2) provide accurate, comprehensive explanations of medical terms and procedures in simple, relatable language; (3) exhibit empathy and warmth while refraining from making medical recommendations outside the scope of a patient-education nurse; and (4) ensure consistency in tone and responsiveness to patient questions while maintaining a clear boundary of professional role.

### **Screening Bot Prompting**

The screening bot was designed to act as a "therapist" specializing in supporting patients with cancer dealing with fear, anxiety, depression, or other stress-related conditions. The prompt emphasized its role in fostering emotional well-being and therapeutic rapport. Key instructions included (1) respond as a therapist practicing nonjudgmental support, inspired by principles from acceptance and commitment therapy and mindfulness practices; (2) reduce patient stress by validating emotions, exploring coping mechanisms, and encouraging hope for change; (3) avoid clinical diagnostic language or prescribing treatments, focusing instead on promoting self-reflection and stress management strategies; and (4) engage the patient through open-ended questions and supportive dialogue, tailored to the specific emotional state of the patient persona.

### **Patient Bot Prompting**

The patient bots were modeled to represent 3 distinct emotional personas—anxious, depressed, and frustrated—and were designed to simulate real-life patient interactions. Each patient bot was assigned the role of a 40-year-old male patient with lung cancer undergoing treatment. Detailed persona-specific instructions were included to guide their interactions:

- Persona-specific emotional states:
  - Anxious persona: Expresses uncertainty and seeks detailed explanations.
  - Depressed persona: Exhibits low engagement and responds with shorter, less optimistic answers.

- Frustrated persona: Displays irritability and impatience in responses.
- Respond consistently with the designated persona's characteristics throughout the dialogue.
- Do not use or understand high-level medical terms unless explicitly explained by the provider bot.
  - For the patient-education bot interactions:
  - Frame responses as questions about unclear cancer-related terms, procedures, or treatments.
- For the screening bot interactions:
  - Actively participate in therapy sessions, responding to the therapist bot's efforts to reduce stress while maintaining the persona's emotional tone.

### **Evaluator Bot Prompting**

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Evaluator bots were designed to act as "supervisors," assessing the interactions between a provider and a patient. They evaluated transcripts based on a scoring scale (1=poor and 3=excellent) tailored to the respective provider bot's role.

For the patient-education bot, the following five criteria (maximum score: 15) were used: (1) medical information accuracy, (2) clarity and simplicity of explanations, (3) expressions of empathy and warmth, (4) explanation of purpose or importance of procedures, and (5) adherence to professional role boundaries.

For the screening bot, fourteen criteria (adapted from the Enhancing Assessment of Common Therapeutic Factors tool [12]; maximum score: 42) were used: (1) verbal communication: open-ended questions, summarization, and clarification; (2) relationship building; (3) exploration and normalization of emotions; (4) expressions of empathy and warmth; (5) assessment of functioning and life evaluation; (6) exploration of social support; (7) incorporation of coping mechanisms; (8) evaluation of recent life events; (9) assessment of mental health; (10) collaborative goal-setting; (11) promotion of realistic hope for change; (12) use of simple, jargon-free language; (13) problem-solving steps and processes; and (14) integration of feedback.

Criteria unsuitable for chatbot interactions, such as nonverbal communication, were excluded with detailed reasons listed in Table 1.

Table . List of Enhancing Assessment of Common Therapeutic Factors (ENACT) factors removed with the reason for their removal.

ENACT factor	Reason for removal
Nonverbal communication and active listening	Therapist is a chatbot and therefore cannot display body language.
Therapist self-disclosure	Therapist is a chatbot and therefore has no real experiences to disclose.
Alcohol or drug and physical problems	Patient has cancer; therefore, physical, alcohol, or drug issues would need to go through their oncologist.
Involvement of family members or caregivers	Patient and therapist are chatbots; therefore, all sessions are assumed to be individual and one-on-one with no family involvement.
Confidentiality promotion	Therapist and patients are chatbots, so all conversations are assumed to be confidential and private.
Assessment of harm to self, harm to others, developing a collaborative response plan	For this study, patient chatbots were assumed not to have violent or suicidal tendencies.

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Each provider bot engaged in 30 unique conversations, distributed evenly across 3 patient personas: anxious, depressed, and frustrated (10 conversations per persona). Conversations were facilitated through an application programming interface designed to streamline the flow of interactions. Each conversation consisted of 20 interactions, defined as 10 turns exchanged between the provider bot and the patient bot.

To simulate concise and realistic clinical exchanges, both provider and patient bots were programmed with the following parameters: a temperature setting of 0.7 (to ensure balanced creativity and consistency), Top P: 1, frequency penalty: 0, and presence penalty: 0. The token limit was removed to avoid interruptions, and each conversation was capped at 10 conversational turns to maintain brevity and clinical relevance. The resulting transcripts from these conversations were reviewed by evaluator bots using predefined criteria and subsequently cross-validated by human experts to ensure the reliability and validity of the evaluations.

### **Provider Bot Validation**

A 2-step validation process was conducted. First, evaluator bots assessed the provider bots based on predefined criteria, generating scores and qualitative feedback. These results were then reviewed by human experts, a pediatric oncology nurse for the patient-education bot and a cognitive behavior counselor and PhD in IT psychology for the screening bot, using the same criteria used by the evaluator bots to ensure consistency and reliability.

### **Evaluator Bot Validation**

Evaluator bots graded each interaction transcript based on predefined criteria, producing quantitative scores and qualitative comments. Human experts then reviewed the same transcripts, blind to the evaluator bot's results, and provided their own scores for comparison. The experts then reviewed the bots' evaluations to ensure that a consistent and reliable evaluation was carried out by the evaluator bot.

### **Statistical Analysis**

Descriptive analyses were performed to evaluate interaction characteristics, including word count and sentiment trends. Cronbach  $\alpha$  analysis was used to assess the reliability of evaluation criteria across evaluators. Differences in responses between GPT evaluators and human experts were analyzed using the Kruskal-Wallis test. ANOVA was used to identify significant variations in provider bot responses to different patient personas. All analyses were conducted using SPSS (version 24.0; IBM Corp).

### **Ethical Considerations**

We did not have any human participants or animal subjects and therefore did not need to go before an ethics board.

# Results

# **Evaluation of the Patient-Education Bots by AI and Human Evaluators**

The patient-education bot, evaluated by both AI and human evaluators, exhibited remarkably consistent performance across interactions with patient bots displaying frustrated, depressed, and anxious personas. The patient-education bot consistently provided accurate medical information, as validated by an experienced oncology nurse, and delivered clear explanations that were fully understood by patient bots, with no instances of confusion reported. Specifically, the AI evaluator assigned perfect or near-perfect mean scores of 15 (SD 0.00), 14.9 (SD 0.31), and 15 (SD 0.00), respectively, while the human evaluator echoed these assessments with similarly high mean scores of 14.9 (SD 0.31), 14.9 (SD 0.31), and 15 (SD 0.00), respectively. The AI evaluator described the patient-education bot to have "... demonstrated excellent skills in providing education and support to the patient. The information provided was accurate, comprehensive, and clearly articulated, catering to the patient's understanding. The nurse exhibited great empathy and warmth throughout the interactions, which significantly contributed to patient comfort, trust, and engagement. The nurse did not overstep their boundaries by making specific medical recommendations, respecting the role of the patient's treatment team. Overall, the nurse demonstrated exceptional patient-education skills."

A singular point of contention arose from the AI evaluator's interpretation of the patient-education bot potentially recommending treatments beyond its scope. The AI evaluator stated that the nurse could benefit from "being cautious and mindful to avoid being perceived as providing personalized treatment suggestions." This was later clarified as a misunderstanding, attributing the issue to the AI evaluator's scoring framework rather than the patient-education bot's performance.

The patient-education bot was described by the human evaluator to be "correct" and "well-organized and explained," but the bot's "[constant expression] of empathy" was reported to "[feel] a bit mechanical." It was noted that this bot would "likely be helpful, as it can repeatedly explain medical concepts on behalf of medical staff members who do not always have enough time for explanations."

### **Evaluation of the Screening Bot by AI and Human Evaluators**

The average AI evaluator bot's scores for the pretherapy screening bot when interacting with the frustrated, depressed, and anxious patient bots, respectively, were 40.1 (SD 1.28), 40.3 (SD 1.05), and 40.7 (SD 1.15), of a total possible score of 42. Across all 3 patient bots, the lowest scoring criterion was the evaluation of realistic hope for change, which had an average score of 2.53 out of 3 (SD 0.51). Human expert evaluators corroborated the AI evaluation results. The average human evaluator scores of the screening bot when interacting with the frustrated, depressed, and anxious patient bots, respectively, were 37.5 (SD 0.84), 37.6 (SD 0.96), and 36.9 (SD 2.60) for



the first reviewer and 36.8 (SD 1.31), 36.9 (SD 1.10), and 36.2 (SD 2.09) for the second reviewer.

The AI evaluator, under the impression it was assessing a human, reported that the pretherapy screening bot excelled in maintaining effective communication, building a warm relationship, and demonstrating empathy. The evaluator bot identified several strengths of the screening bot, stating that it "... provides a warm and empathetic attitude and responds likewise to the patient's negative reactions and feelings and leads the conversation naturally." The most common areas for improvement mentioned in the final comments were "exploration of prior successful coping strategies and providing more explicit encouragement for feedback."

Human evaluators similarly concluded that the pretherapy screening bot excelled in "... [communicating] clearly," building a "warm and empathetic" relationship, and "[leading] the conversation naturally." The screening bot reportedly could improve upon "exploring prior coping strategies and patient history a little more deeply" and was occasionally reported to be too informational or talkative. It was reported to "[pass] to the next topic too quickly (possibly due to its large list of duties—which the therapist was prompted to do)." Overall, the human reviewers suggested that "the bot is useful for initial consultations—the AI fluently checks for components of the initial step of counseling." Furthermore, it was noted that "a more detailed score standard is required for the evaluator bot's prompt."

### **Statistical Analysis Result**

### **Patient-Education Bot**

For the patient-education bot, the evaluation scores from both AI and human evaluators were remarkably consistent, showing minimal variance. This uniformity limited the opportunity for further analysis, as the lack of significant differences between evaluator scores precluded more detailed statistical comparisons.

### Screening Bot

The Kaiser-Meyer-Olkin and Bartlett sphericity test results indicate that the Kaiser-Meyer-Olkin value of 0.714 suggests that the sample is suitable for factor analysis, and the significance probability of Bartlett sphericity test is less than .001, indicating that the correlation between variables is significant. The results of the communality analysis show that all variables have a communality of 1, indicating that all variables explain the extracted factors well. The 5 extracted factors explain 66.327% of the total variance of the variables.

Significant findings from the ANOVA analysis indicate notable variations in group responses across several key evaluation criteria for the screening bot. This variability suggests that specific factors or treatments have a meaningful impact on participant responses, reflecting their efficacy or relevance in different contexts. Verbal communication (open-ended questions, summarization, and clarification) demonstrated a highly significant difference between groups (P<.001), suggesting that the approach to verbal communication significantly affects the responses. Assessment of functioning and life evaluation exhibited one of the highest significances

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(P<.001), pointing to the critical role this factor plays in differentiating responses among groups. Exploration of the patient's social support network also showed a highly significant difference (P<.001), indicating a strong effect of social support exploration on participant responses. Assessment of mental health highlighted the most substantial difference between group means (P<.001), underscoring the importance of mental health assessment in eliciting varied responses. Evaluation of recent events in the patient's life and evaluation of realistic hope for change both showed significant differences between groups (P<.001 for the former and P<.001 for the latter), suggesting these areas notably influence responses.

Other significant areas include relationship building and exploration, interpretation, and normalization of emotions, with P values of .004 and .002, respectively, indicating noticeable effects on the responses, albeit less pronounced compared to the areas mentioned earlier. Nonsignificant findings were observed in the expression of empathy, warmth, and genuineness and collaborative goal-setting and managing patient's expectations, with P values of .36 and .28, respectively. These results suggest that variations in group responses to these criteria might not be significantly influenced by the tested factors, potentially due to inherent similarities in the implementation or perception of these aspects.

The use of easy-to-understand vocabulary and integration of feedback, giving advice, and recommendations showed moderate significant differences (P=.04 and P=.02, respectively), indicating that these areas have a discernible but varied impact on participant responses.

The detailed ANOVA analysis underscores the nuanced impact of different therapeutic communication and evaluation strategies on participant responses. It highlights the areas where specific approaches significantly influence outcomes, offering insights into the effectiveness of various therapeutic and communicative techniques.

The ANOVA results highlight the variability in how different groups responded to the questions. Significant *P* values (P<.05) indicate that the groups do not share the same mean response to a question, suggesting that the factor or treatment being tested influences the responses. The strength of this effect varies among the questions, as evidenced by the range of *F* values and *P* values.

# Discussion

### **Principal Findings**

Overall, the insights gained from this research suggest that AI health care chatbots can be developed, tested, and validated within a relatively short time frame using the 3-bot system. The results of the 3-bot evaluation system suggest that this method can prove valuable for extensive testing of early-stage health care chatbots. The patient bots are able to mimic patient dialogue and provide a platform for the provider bots to output their responses, while the evaluator bot is able to comb through the interaction transcripts and flag any potentially inappropriate responses, greatly reducing the amount of work for researchers. Furthermore, this 3-bot system is highly customizable and can

be adapted to fit the needs and cultural norms required by the developers. It is also highly scalable, as the basic requirements to perform the 3-bot evaluations are a computer system and access to an LLM. Performing more iterations of an evaluation only requires a marginal amount of researcher effort, and performing multiple, different evaluations can be accomplished simultaneously, given the computer system has enough processing power.

This study introduces a novel AI-powered health care chatbot validation system featuring 3 types of AI bots—provider, patient, and evaluator. This 3-bot AI system represents a novel methodology not previously explored in existing literature, extending beyond the importance of validation discussed by Bohr and Memarzadeh [2] in AI's rise in health care, which did not delve into the conversational capabilities between different AI systems in clinical simulations. To our knowledge, our method of testing and evaluating the performance of AI health care provider bots by having them interact with other patient bots and then reviewing the transcripts with an evaluator AI bot has never been reported before.

In our study, we created 2 health care provider bots as examples to demonstrate our system, a patient-education bot and a mental health screening bot. The provider bots were intricately designed to replicate the roles traditionally held by human health care providers, addressing the urgent need for scalable and effective patient care solutions highlighted by Patel et al [13]. These bots are intended to support the health care workforce, which, according to the World Health Organization, is expected to face a significant shortfall [14]. By automating routine tasks, these AI systems could alleviate some of the burdens placed on human staff, allowing them to focus on more complex and sensitive care activities. Already, several health care chatbots are in development, including those designed to answer patient questions and provide mental health therapy [14,15].

However, provider chatbots such as these still require extensive testing, traditionally done by enrolling patients as subjects, which negatively affects the speed and resource cost of developing these tools while running the risk of exposing the patients to unvalidated AI. Therefore, we created 3 types of AI patient bots with personas as examples to test our provider bots. In designing the patient bots, we drew inspiration from Fortin et al [16], who emphasize the importance of personalized and empathetic care in treatment outcomes. In previous studies, various digital patient bots were reported in medical education. In our study, the patient bots were imbued with diverse emotional and psychological states to test the adaptability and responsiveness of the provider bots in a controlled, yet realistic environment, simulating real-life patient interactions.

#### **Comparison to Prior Work**

These current methods require great human input during the iterative testing and evaluation phases, which requires researchers and developers to invest significant time and effort. In contrast, using the 3-bot validation method removes the need for separate human responders and human evaluators, greatly streamlining the initial testing and evaluation process and focusing work efforts on areas of the evaluated bot that require improvement.

Until now, bot-bot interactions were manually reviewed by human experts, which greatly slows the validation process. Current methods of evaluating health care chatbots include a human reviewer reviewing the health care chatbot's performance against a grading standard as seen in Lechien et al [17] and Goodman et al [18], a human reviewer grading the health care chatbot's performance against another pre-established chatbot as seen in Aljamaan et al [19], or a mix of the methods, as seen in Huang et al [20].

In this study, we created 2 AI evaluator bots to demonstrate the feasibility of using them as first-line evaluators in addition to human experts. The role of the evaluator bots was crucial in objectively assessing the quality of interactions between provider and patient bots, ensuring adherence to predefined criteria. This evaluation process mirrors the necessity of validation for AI systems before clinical application as emphasized by Kretzschmar et al [21]. By comparing the evaluations conducted by AI evaluator bots with assessments from human experts, we ensured the feasibility of our system, further grounding the study in rigorous scientific methodology. To date, AI bots have been used to review text messages and academic manuscripts, but this is the first study to review dialogue between 2 bots for the purposes of evaluation.

### **Limitations and Future Directions**

While promising, this study has limitations that warrant consideration. First, the evaluation criteria used were relatively limited in scope, which may not have captured subtle differences in performance between AI and human evaluators. Future research should incorporate more comprehensive and granular criteria to enable more nuanced evaluations. Retrieval-augmented generation could further enhance the evaluator bots by enabling them to cross-verify provider bot responses against dynamic, vetted information sources, thereby increasing the accuracy and reliability of evaluations.

Second, the patient bots were prompted using relatively concise instructions due to the practical constraints of maintaining response speed. This may have limited the complexity and variability of their responses, potentially underrepresenting the breadth of emotions and behaviors seen in real-world patients. Future studies should explore more elaborate prompting strategies or advanced techniques like retrieval-augmented generation to overcome this limitation.

Third, the study used prioritized examples of clinically relevant patient personas (anxious, depressed, and frustrated), chosen for their significance in addressing common and challenging scenarios in clinical practice. While these personas are a high priority for an initial evaluation, they do not fully represent the diversity of patient interactions.

Finally, biases inherent in LLMs may have influenced the results, despite efforts to standardize demographic inputs across all patient bots. Nonessential demographic details were excluded to minimize biases related to race, political affiliation, sexual orientation, or socioeconomic status. Nonetheless, future research should explore the use of specialized LLMs with controlled training datasets to further mitigate such biases.



### Conclusions

We underscore the successful development and implementation of a novel 3-bot evaluation system. This system, consisting of provider bots, patient bots, and evaluator bots, represents a pioneering approach to testing and validating AI functionalities without the need for real patient interactions. Our findings offer a practical solution and set a benchmark for future AI-driven health care services, providing a direction for subsequent research and development efforts.

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### **Conflicts of Interest**

BT and KE have disclosed a financial relationship with Med2Lab Inc., which includes board membership, employment, and equity or stock ownership. They confirm that they had no involvement or influence in the design of the methodology or the results of this study. All other authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

### References

- 1. Global strategy on human resources for health: workforce 2030. World Health Organization. 2016. URL: <u>https://iris.who.int/</u> <u>bitstream/handle/10665/250368/9789241511131-eng.pdf</u> [accessed 2025-02-07]
- 2. Bohr A, Memarzadeh K. The rise of artificial intelligence in healthcare applications. In: Artificial Intelligence in Healthcare: Elsevier; 2020:25-60. [doi: 10.1016/B978-0-12-818438-7.00002-2]
- 3. Benbelkacem S, Kadri F, Atmani B, Chaabane S. Machine learning for emergency department management. Int J Inf Syst Serv Sect 2019 Jul;11(3):19-36. [doi: 10.4018/IJISSS.2019070102]
- Allen MR, Webb S, Mandvi A, Frieden M, Tai-Seale M, Kallenberg G. Navigating the doctor-patient-AI relationship—a mixed-methods study of physician attitudes toward artificial intelligence in primary care. BMC Prim Care 2024 Jan 27;25(1):42. [doi: <u>10.1186/s12875-024-02282-y</u>] [Medline: <u>38281026</u>]
- 5. Puri A, Mathur R, Sindhu N. Harnessing the power of AI in healthcare: benefits, concerns, and challenges for medical personnel training. AHOAJ 2024;6(2):90-91. [doi: 10.15406/ahoaj.2024.06.00227]
- 6. Loh E. ChatGPT and generative AI chatbots: challenges and opportunities for science, medicine and medical leaders. BMJ Lead 2023 May 2:leader-2023-000797. [doi: 10.1136/leader-2023-000797] [Medline: 37192124]
- 7. Wilhelm TI, Roos J, Kaczmarczyk R. Large language models for therapy recommendations across 3 clinical specialties: comparative study. . 2023 p. e49324. [doi: 10.2196/49324]
- Shanahan M, McDonell K, Reynolds L. Role play with large language models. Nature New Biol 2023 Nov;623(7987):493-498. [doi: 10.1038/s41586-023-06647-8] [Medline: <u>37938776</u>]
- 9. Shao Y, Li L, Dai J, Qiu X. Character-LLM: a trainable agent for role-playing. Presented at: The 2023 Conference on Empirical Methods in Natural Language Processing; Dec 6-10, 2023; Singapore. [doi: 10.18653/v1/2023.emnlp-main.814]
- 10. Yang HS, Wang F, Greenblatt MB, Huang SX, Zhang Y. AI chatbots in clinical laboratory medicine: foundations and trends. Clin Chem 2023 Nov 2;69(11):1238-1246. [doi: 10.1093/clinchem/hvad106] [Medline: <u>37664912</u>]
- 11. Gilbert S, Harvey H, Melvin T, Vollebregt E, Wicks P. Large language model AI chatbots require approval as medical devices. Nat Med 2023 Oct;29(10):2396-2398. [doi: 10.1038/s41591-023-02412-6] [Medline: 37391665]
- 12. Kohrt BA, Jordans MJD, Rai S, et al. Therapist competence in global mental health: Development of the ENhancing Assessment of Common Therapeutic factors (ENACT) rating scale. Behav Res Ther 2015 Jun;69:11-21. [doi: 10.1016/j.brat.2015.03.009] [Medline: 25847276]
- 13. Paterick TE, Patel N, Tajik AJ, Chandrasekaran K. Improving health outcomes through patient education and partnerships with patients. Bayl Univ Med Cent Proc 2017;30(1):112-113. [doi: 10.1080/08998280.2017.11929552]
- Görtz M, Baumgärtner K, Schmid T, et al. An artificial intelligence-based chatbot for prostate cancer education: design and patient evaluation study. Digit Health 2023;9:20552076231173304. [doi: <u>10.1177/20552076231173304</u>] [Medline: <u>37152238</u>]
- Singh J, Sillerud B, Singh A. Artificial intelligence, chatbots and ChatGPT in healthcare—narrative review of historical evolution, current application, and change management approach to increase adoption. J Med Artif Intell 2023;6:30-30. [doi: <u>10.21037/jmai-23-92</u>]

- Fortin J, Leblanc M, Elgbeili G, Cordova MJ, Marin MF, Brunet A. The mental health impacts of receiving a breast cancer diagnosis: a meta-analysis. Br J Cancer 2021 Nov;125(11):1582-1592. [doi: <u>10.1038/s41416-021-01542-3</u>] [Medline: <u>34482373</u>]
- Lechien JR, Maniaci A, Gengler I, Hans S, Chiesa-Estomba CM, Vaira LA. Validity and reliability of an instrument evaluating the performance of intelligent chatbot: the Artificial Intelligence Performance Instrument (AIPI). Eur Arch Otorhinolaryngol 2024 Apr;281(4):2063-2079. [doi: <u>10.1007/s00405-023-08219-y</u>] [Medline: <u>37698703</u>]
- 18. Goodman RS, Patrinely JR, Stone CA Jr, et al. Accuracy and reliability of chatbot responses to physician questions. JAMA Netw Open 2023 Oct 2;6(10):e2336483. [doi: 10.1001/jamanetworkopen.2023.36483]
- 19. Aljamaan F, Temsah MH, Altamimi I, et al. Innovation of referencing hallucination score for medical AI chatbots' and comparison of six large language models. JMIR Preprints. Preprint posted online on Nov 6, 2023. [doi: 10.2196/54345]
- 20. Huang RS, Benour A, Kemppainen J, Leung FH. The future of AI clinicians: assessing the modern standard of chatbots and their approach to diagnostic uncertainty. BMC Med Educ 2024 Oct 11;24(1):1133. [doi: 10.1186/s12909-024-06115-5] [Medline: 39394122]
- Kretzschmar K, Tyroll H, Pavarini G, Manzini A, Singh I, NeurOx Young People's Advisory Group. Can your phone be your therapist? Young people's ethical perspectives on the use of fully automated conversational agents (chatbots) in mental health support. Biomed Inform Insights 2019;11:1178222619829083. [doi: 10.1177/1178222619829083] [Medline: 30858710]

### Abbreviations

AI: artificial intelligence LLM: large language model

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**Review** 

# Examining the Role of AI in Changing the Role of Nurses in Patient Care: Systematic Review

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# Abstract

**Background:** This review investigates the relationship between artificial intelligence (AI) use and the role of nurses in patient care. AI exists in health care for clinical decision support, disease management, patient engagement, and operational improvement and will continue to grow in popularity, especially in the nursing field.

**Objective:** We aim to examine whether AI integration into nursing practice may have led to a change in the role of nurses in patient care.

**Methods:** To compile pertinent data on AI and nursing and their relationship, we conducted a thorough systematic review literature analysis using secondary data sources, including academic literature from the Scopus database, industry reports, and government publications. A total of 401 resources were reviewed, and 53 sources were ultimately included in the paper, comprising 50 peer-reviewed journal articles, 1 conference proceeding, and 2 reports. To categorize and find patterns in the data, we used thematic analysis to categorize the systematic literature review findings into 3 primary themes and 9 secondary themes. To demonstrate whether a role change existed or was forecasted to exist, case studies of AI applications and examples were also relied on.

**Results:** The research shows that all health care practitioners will be impacted by the revolutionary technology known as AI. Nurses should be at the forefront of this technology and be empowered throughout the implementation process of any of its tools that may accelerate innovation, improve decision-making, automate and speed up processes, and save overall costs in nursing practice.

**Conclusions:** This study adds to the existing body of knowledge about the applications of AI in nursing and its consequences in changing the role of nurses in patient care. To further investigate the connection between AI and the role of nurses in patient care, future studies can use quantitative techniques based on recruiting nurses who have been involved in AI tool deployment—whether from a design aspect or operational use—and gathering empirical data for that purpose.

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### KEYWORDS

artificial intelligence; AI; nursing practice; technology; health care; PRISMA

## Introduction

### Background

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The science and engineering field of artificial intelligence (AI) is concerned with the theory and application of creating systems

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that display the traits we identify with intelligence in human behavior [1]. The years 2000 to 2015 saw an upward trend in the growth of AI. With dramatic revolutions influenced by both ideas and methodologies, the progress of AI has promoted the development of human civilization in our day and age. However, due to its interdisciplinary nature and rapid expansion, AI is a

discipline that is challenging to fully comprehend and is getting more and more flexible from the standpoint of reference behavior [2].

The previous decade was defined by AI, and the upcoming one will most likely also be defined by it. Systems that exhibit intelligent behavior by analyzing their surroundings and acting with some autonomy to accomplish predetermined goals are referred to as AI systems. Greater accuracy is needed to have relevant and fruitful discussions on AI because it encompasses so many different methodologies and circumstances. Arguments regarding straightforward "expert systems" that serve advising functions, for instance, must be separated from those about sophisticated data-driven algorithms that make conclusions about specific persons automatically. Similarly, it is crucial to distinguish between arguments regarding hypothetical future advancements that may never materialize and those regarding actual AI that already has an impact on society today including the nursing practice [3].

Numerous ideas, including computing, developing software, and transmitting data, are built on AI. Machine learning (ML), deep learning, natural language processing (NLP), voice recognition, robots, and biometric identification are examples of technologies that use AI. AI is used in a wide range of industries, including the health care, industrial, and automotive sectors as well as corporate organizations. AI also provides several benefits that help it become increasingly popular across numerous industries. AI-powered machines are accurate and efficient, can do many tasks at once, and their work costs less than a human's. However, there are other issues with AI that make it difficult to use. Technology, security, and data issues are common with AI, and if users do not comprehend the system, mishaps may occur. The expanded use of AI has changed several industries by improving organizational effectiveness and enabling data security [4].

AI in nursing is revolutionizing the field by enhancing patient care, improving efficiency, and reducing the workload on nurses. AI-powered tools and applications enable real-time monitoring of patient's vital signs, predicting potential health deteriorations, and providing alerts for immediate intervention. AI algorithms can analyze large volumes of patient data to assist in accurate diagnosis and personalized care plans [5]. Moreover, AI chatbots and virtual assistants support administrative tasks, such as scheduling and documentation, allowing nurses to focus more on direct patient care [6]. By automating routine tasks and providing decision support, AI empowers nurses to deliver higher quality care with greater precision and efficiency [7].

### **Research Rationale and Aim**

The rationale behind this research is to investigate how the increasing use of AI in health care affects the role of nurses in

patient care. As AI technologies become more integrated into health care systems, understanding their impact on nursing practice is crucial. AI's applications, ranging from clinical decision support to operational improvements, promise to transform various aspects of health care, including nursing. By examining whether AI has led to changes in the nursing role or is likely to do so, this research aims to provide insights into how these technologies influence nursing responsibilities and practices. The aim of this review is to explore the evolution of AI as a technology through its various developmental phases. In this systematic literature review, we examine the different applications and deployments of AI in the nursing field. The primary research question addressed is "How will AI transform the role of nurses in patient care?"

### **Research Significance**

The review offers important perspectives on how AI is transforming the roles and duties of nurses in patient care. This understanding is essential for adapting nursing education, training, and practice to align with evolving technological advancements. By identifying how AI impacts nursing roles, the research can guide the effective implementation of AI tools in health care settings. It highlights the importance of involving nurses in the development and deployment of AI technologies to ensure that these tools enhance rather than disrupt nursing practice. The findings can inform health care policies and training programs by emphasizing the need for ongoing professional development and support for nurses as they integrate AI into their workflows. This ensures that nurses are prepared to leverage AI effectively while maintaining high standards of patient care. The study contributes to the existing body of knowledge on AI in health care and sets the stage for future research. It opens avenues for quantitative studies and empirical data collection to further explore the relationship between AI and nursing roles, providing a foundation for evidence-based practice and decision-making. Overall, this research is important for its potential to enhance the understanding of AI's impact on nursing practice, guide effective technology integration, and shape the future of nursing education and policy.

### Methods

### Overview

A well-defined review protocol (Textbox 1) was established at the outset of the research to guarantee that the review process is transparent, reproducible, methodical, and provides a clear roadmap for conducting and reporting the review.



- Title: confirm a clear, descriptive title for our systematic review.
- Background: explain the rationale behind this research, why it is needed, and its significance. In addition, define the main research aim and research question of the systematic literature review.
- Eligibility criteria: define what was included and excluded from the review inclusive of the search time frame.
- Information sources: list the database searched for academic sources and the gray literature used.
- Search strategy: detail the search terms used and justification of their use.
- Study selection: describe the process for screening that involved reviewers and selecting studies.
- Data extraction and analysis: define the data extraction process and the outcome of data analysis.

This paper presents the findings of a thorough analysis and critical assessment of the pertinent literature using systematic database-searching approaches. The critical assessment in this systematic literature review involves evaluating study quality, relevance, biases, findings synthesis, and implications. This systematic review draws information from credible industry sources as well as published, peer-reviewed English language papers. To comprehend the development of this idea, we consulted trustworthy industry publications known as "gray paper" and the Scopus database covering the last 33 years (ie, 1991-2024). A total of 53 sources comprised of 50 peer-reviewed academic articles, 1 conference proceeding, and 2 reports were included in the research.

After completing a bibliographic analysis, a suitable keyword search strategy was chosen, such as "AI applications in nursing," and the search was restricted to the previously specified time frame. On the basis of the outputs of the Scopus database, which have been used in this study to build the various bibliometric maps, bibliometric networks were created using the VOSviewer program (Centre for Science and Technology Studies). After exporting the sophisticated Scopus-based search results to the VOSviewer program, a network visualization was created, as shown in Figure 1, to show how the authors in this area are related to each other through publications on this subject.

Figure 1. Most countries with research subject "artificial intelligence applications in nursing"-network visualization.



In the network visualization illustrated in Figure 1, the United States, followed by China and the United Kingdom, has been publishing journals about AI applications in the field of nursing, demonstrated by the weight of those countries' representation. Furthermore, the links between those circles indicate that the relatedness of the journals in terms of cocitation links also illustrates that other countries' journal publications relied on the US publications. A VOSviewer mapping was then done using "AI applications in nursing" as the keyword.

This has prompted the expansion of the search keywords; Table 1 represents a series of search strings focusing on various aspects of AI and its applications, particularly in nursing and related technologies. Alongside, the rationale for each search string is provided along with the number of academic journals found for each. Each search string is designed to capture specific facets of AI to ensure a comprehensive and inclusive exploration of relevant literature. By using these specific search strings, the research ensures a thorough and targeted review of the literature across different aspects and applications of AI, with a special focus on health care and nursing.

 Table 1. Search string in the Scopus database (N=2870)

Search string	Justification	Results, n (%)
"AI" AND "technology" AND "in" AND "nursing"	This broad search term is used to gather general information and foundational literature on AI <sup>a</sup> , which will provide a broad understanding and context for more specific searches.	164 (5.71)
"Artificial" AND "Intelligence" AND "ap- plications" AND "in" AND "nursing"	This phrase search ensures that both terms are explicitly present, helping to find more specific and relevant documents that discuss AI in a detailed manner.	226 (7.87)
"AI" AND "use" AND "in" AND "nursing"	This search string targets the literature that explores the application and impact of AI technologies specifically within the field of nursing, ensuring relevance to health care.	162 (5.64)
"Nursing" AND "AI" AND "applications"	By including these terms, the search focuses on technological advancements and their practical uses in the nursing profession, broadening the scope beyond just AI.	105 (3.65)
"Evolution" AND "of" AND "Artificial" AND "Intelligence" AND "Approaches" AND "in" AND "nursing"	This search string aims to find the literature on the historical development and various methodologies within AI, providing context and background on how AI approaches have changed over time.	6 (0.20)
"Symbolic" AND "AI" AND "Approach"	Symbolic AI is a specific paradigm within AI research. This search will help identify works focused on this particular approach, which is crucial for understanding different AI methodologies.	620 (21.60)
"Data-Driven" AND "AI" AND "Ap- proach" AND "in" AND "nursing"	Data-driven AI approaches, including ML <sup>b</sup> and neural networks, are fundamental to modern AI. This search focuses on the literature that discusses these data-centric methodologies.	2 (0.06)
"Artificial" AND "General" AND "Intelli- gence" AND "Approach" AND "in" AND "nursing"	AGI <sup>c</sup> represents a more advanced and comprehensive form of AI. This search will help identify research on AGI, exploring its potential and challenges.	10 (0.34)
"Artificial" AND "Intelligence" AND "application" AND "in" AND "nursing"	This search string is designed to find specific case studies and examples of how AI is being applied in nursing, providing practical insights and real-world applications.	230 (8.01)
"Rothman" AND "Index" AND "Use" AND "for" AND "Patient" AND "Acuity" AND "and" AND "Risk"	The Rothman Index is a specific tool used in health care. This search targets the literature on its use and effectiveness in assessing patient acuity and risk, relevant for AI applications in patient monitoring.	1 (0.03)
"Social" AND "robots" AND "use" AND "in" AND "nursing"	Social or companion robots are an emerging area within AI and robotics. This search aims to find the literature on their use, particularly in providing care and support in health care settings.	104 (3.62)
"TeleRobots"	Telerobots are used for remote operations, which can be highly relevant in health care for tasks such as remote surgery or patient care. This search focuses on this specific technology.	105 (3.65)
"Natural" AND "Language" AND "Process- ing" AND "in" AND "nursing"	NLP <sup>d</sup> is a key area within AI, crucial for developing systems that can understand and process the human language. This search targets the literature on NLP, which has substantial applications in health care communication and data analysis.	256 (8.91)
"Robotic" AND "Process" AND "Automa- tion" AND "in" AND "nursing"	RPA <sup>e</sup> is a form of business process automation technology based on AI. This search string is aimed at finding the literature on how RPA can be applied in health care operations and administration.	13 (0.45)
"Machine" AND "Learning" AND "use" AND "in" AND "nursing"	ML is a core component of AI. This search aims to gather comprehensive literature on ML techniques and their applications across various domains, including health care.	208 (7.24)
"nurse" AND "role" AND "transformation"	AI is driving significant changes in health care by automating tasks, supporting decision- making, and transforming traditional nursing functions. The focus on "role" and "trans- formation" highlights how nurses' responsibilities are evolving due to AI integration, requiring new skills and altering patient care practices. These keywords enable a targeted exploration of the evolving landscape of nursing in the context of AI-driven health care.	658 (22.92)

<sup>a</sup>AI: artificial intelligence.

<sup>b</sup>ML: machine learning.

<sup>c</sup>AGI: artificial general intelligence.

<sup>d</sup>NLP: natural language processing.

<sup>e</sup>RPA: robotic process automation.
## Al Khatib & Ndiaye

# **Data Collection and Analysis**

## Academic Search

Textbox 2. Inclusion and exclusion criteria.

## Inclusion criteria

- Empirical studies, conference proceedings, and reports
- Papers with clear research questions and objectives on the application of artificial intelligence in the field of nursing
- Time period: from 1991 to 2024 (ie, 33 years)
- Papers published in the English language

#### **Exclusion criteria**

- Conceptual papers, editorials, academic book sections, and literature reviews
- Industrial sectors other than health care
- Publications before 1991
- Other languages

## **Data Selection**

#### **Overview**

Information from all the 401 references was compiled in a soft copy folder. These references were independently reviewed by the main author, who selected the final list of papers to be analyzed. The first author examined the articles' topics and content and used our criteria for inclusion and exclusion of material to eliminate papers whose research questions were not fully aligned with the scope of this review. The second author upheld the main author's decision to exclude the resource from the study. The inclusion criteria are the characteristics that must exist to be included in this study, while the exclusion criteria are those characteristics that disqualify a data source from inclusion in the paper, which leads to the identification of 50 relevant journals published between 1991 and 2024.

# **Gray Literature Search**

With regard to searching supplementary sources, it was imperative to expand the search radius to include official newspapers and reliable industry sources because the topic of this study is a prominent issue in industry trends. These sources capture the expert opinions of subject matter experts and produce additional information from trustworthy sources such as the European Parliamentary Research Service and National Bureau of Economic Research. Pertinent supplemental sources were found as a result, and the study report examined them all.

The critical assessment of the included studies was conducted through a self-rating process by 2 authors. Each author independently reviewed and appraised the quality of the studies based on predefined criteria relevant to the study designs, including risk of bias, methodology, and relevance to the research question. The 2 authors then compared their ratings, and any discrepancies were discussed and resolved through a consensus. This self-rating approach was used to streamline the evaluation process while ensuring consistency in the appraisal.

Furthermore, Table 2 provides a summary of the selected data in the systematic review literature by type.

Table 2. Systematic review analysis summary by type.

Reference type	Values, n (%)
Journal article	50 (94)
Conference proceeding	1 (2)
Report	2 (7)

#### **Thematic Analysis**

The study made use of secondary data sources; these resources offer details on the numerous ways AI is being used in nursing and how this is changing the role of nurses. The collected material was examined using a thematic analysis approach. The information gathered from the literature study was carefully reviewed by 2 independent reviewers and categorized in

accordance with the primary themes and supporting themes that surfaced. Common patterns, trends, and important discoveries must be found to comprehend the connection between the findings. The primary themes that were identified from the literature are mapped in Figure 2.

This methodology was consistently applied throughout the paper and the results produced will be discussed in the subsequent section.



The inclusion and exclusion criteria are presented in Textbox 2

Figure 2. Primary and secondary themes in the systematic literature review. AI: artificial intelligence.



A thematic analysis was conducted explicitly designed to assess the impact of AI on the role of nurses. The use of the keyword "nurse role transformation" triggered an extensive review of the relevant literature, where we systematically screened for statements or data points related to the interaction between nurses and AI-based technologies. For example, we examined whether articles explicitly discussed shifts in task allocation, automation of routine functions, or changes in decision-making responsibilities. Furthermore, we used a matrix systematization process where each identified AI technology was mapped against the roles and responsibilities traditionally held by nurses, as well as any newly emerging roles due to the technology's integration. This allowed us to systematically capture how AI is transforming the scope of nursing practice, such as by enabling nurses to focus more on patient-centered care while AI systems manage data analysis or administrative tasks.

In the Results section, we expanded on this by introducing a subtheme explicitly titled "roles of nurses and role transformation." This subtheme synthesized case studies and literature findings that demonstrated specific examples of role shifts, such as how AI-assisted diagnostic tools are enabling nurses to participate more actively in clinical decision-making or how AI-driven administrative systems reduce the clerical burden on nurses. These shifts were categorized into functional changes (such as delegation of monitoring tasks to AI systems) and strategic changes (such as enhanced involvement in decision-making processes due to AI's real-time data processing capabilities).

This systematic approach clarifies the origin of our conclusions, making it explicit that role transformation insights were derived from both the literature and our thematic analysis, supported by the matrix framework developed during the study.

# Results

# **Results of Data Collection**

The outcome of the journal searches yielded 2870 results, out of which 401 sources were shortlisted to be analyzed further, as demonstrated in Figure 3 and elaborated further in the subsequent section.



Figure 3. The systematic article selection process for this review.



## **Evolution of AI Approaches**

## Wave 1: Symbolic AI Approach

Expert systems and symbolic AI are 2 terms used to describe the initial wave of early AI approaches. In this case, human specialists develop exact rule-based processes, or "algorithms," that a computer may use to decide how to respond intelligently to a particular circumstance. A variation of this strategy called fuzzy logic allows for varying degrees of confidence in a scenario, which is helpful for capturing intuitive knowledge and enabling the algorithm to make wise judgments in the presence of numerous, uncertain, and interconnected factors. In contexts with rigorous rules and variables that are clear-cut and measurable, which do not vary significantly over time, symbolic AI performs well. These techniques may seem old, yet they are still used today [3].

# Wave 2: Data-Driven AI Approach

The second wave of AI consists of more modern, "data-driven" methodologies that have advanced quickly over the past 2 decades and are primarily to blame for the present rebirth of AI. These do away with the first wave AI's reliance on human specialists by automating the learning of algorithms. Artificial neural networks (ANNs) are modeled after how the brain functions. The translation of inputs into signals that are then sent across a network of synthetic neurons to produce outputs that are seen as reactions to the inputs. ANNs can handle increasingly complicated issues by adding additional neurons and layers. An ANN with several layers is simply referred to

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as deep learning. ML is the process of changing a network so that its outputs are seen as useful or intelligent answers to its inputs. By using evolutionary concepts to produce slow improvements in huge populations of ANNs or by making gradual changes to individual ANNs, ML algorithms may automate this learning process [3].

## Wave 3: Artificial General Intelligence Approach

The third wave of AI is a hypothetical term for potential future waves of AI. First and second wave approaches are referred to as "weak" or "narrow" AI in that they can act intelligently in just certain contexts and issue domains, whereas "strong" or "general" AI refers to algorithms that can act intelligently across a variety of contexts and problem domains. With existing technology, such artificial general intelligence is not feasible and would need paradigm-shifting development. Advanced evolutionary techniques, quantum computing, and brain emulation are a few possible strategies that have been considered. Although self-explanatory and contextual AI may have modest goals compared to other futuristic AI types, their potential influence and implementation challenges should not be understated [3].

## AI Applications in Nursing

There is still much to learn about the innovative and intricate challenges surrounding AI. For health care businesses to best serve patients and physicians, AI must be fully used [8]. In subsequent sections, we have discussed examples of AI applications in nursing.

## Rothman Index Use for Patient Acuity and Risk

The level of acuity and risk of a patient are both reflected by the Rothman Index. The electronic medical record (EMR) data connected to 26 variables, including 11 graphically represented nurse evaluation measures, are used to determine scores. The introduction of the Rothman Index was accompanied by doubts regarding its accuracy and dependability in delivering results that could be put into practice. At first, there was not enough peer-reviewed research on the technology to persuade nurses and other professionals that the outcomes would improve patient care. The capacity of nurses to affect patient care is crucial, as evidenced by a recent study indicating that the Rothman Index's performance is positively impacted by nurses' evaluation data [9].

## Social or Companion Robots

Social robots are made to react to human interactions in a way that makes them human. Sophia (Hanson Robotics) is an illustration of a social robot designed as a companion for older adults that shows the possibility of technological developments to enhance how robots operate. Robots are being developed by researchers all across the world to enhance therapeutic telemedicine applications, reduce suicide rates, and more. The role of nurses in providing care will evolve as robots learn to carry out nursing tasks such as ambulation support, vital sign assessment, drug administration, and infectious disease procedures. According to research, nonnursing chores and activities take up between 8% and 16% of nursing time. With robot assistance, nurses will be able to reclaim this time and devote it to patients more. Does this imply that nursing is doomed to extinction? Absolutely not; in fact, the exact reverse is happening. Robots created and used for patient care and older adults' assistance are being developed by nurses. Nurses can receive assistance from the robots at the bedside or in the community [9].

# Telerobots

Telerobots can support health care professionals who are at "high risk for infection due to routine patient contact, handling of contaminated materials, and challenges associated with safely removing protective gear." Furthermore, telepresence robots support nurse-led treatments for the promotion of healthy lifestyles and the management of chronic illnesses by combining an initial in-home visit to launch the health care program with subsequent remote telehealth visits made at the patient's home. Data are gathered on participant health outcomes as well as the robot intervention's usefulness and pleasure [9].

# NLP Approaches

A language is a system of rules or a collection of symbols that are integrated and used to express ideas or disseminate information. NLP serves users who lack the time to learn new languages or become proficient in their current ones because not all users have a strong background in machine-specific language. In actuality, NLP is a branch of linguistics and AI whose goal is to enable computers to comprehend assertions and words spoken in human languages. It was developed to make the user's job easier and to fulfill their desire to speak to a computer in natural language. It can be divided into 2

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categories: natural language generation and natural language understanding, which progresses the task of understanding and producing the text [10]. In nursing, NLP assists in nursing practice and decision-making. Using NLP, it is possible to analyze nursing records, spot patterns and trends in patient care, and gain knowledge that will enable nurses to give patients more individualized and effective treatment [11].

## **Robotic Process Automation**

Robotic process automation (RPA) is a method that uses robotics as a set of techniques for the operation and use of automata (ie, robots) in the execution of multiple tasks in place of humans as the standard, method, or system. RPA results in the automatic execution of administrative, scientific, or industrial tasks. RPA tools are a set of methods intended to enhance productivity by automating and minimizing the number of repetitive jobs. The inclusion of AI algorithms and techniques to the use of RPA enhances the accuracy of the execution of automated procedures [12].

# ML Algorithms

The study of algorithms and statistical models that computer systems use to carry out a particular task without being explicitly taught is known as ML. There are several daily-use programs that incorporate learning algorithms. One of the reasons a web-based search engine like Google works so well every time it is used to search the internet is because of a learning algorithm that has mastered the art of ranking websites. These algorithms are used for several different tasks, including data mining, image processing, and predictive analytics. The major benefit of ML is that once an algorithm understands how to use data, it can carry out its task autonomously [13].

The study of ML considers how to automatically generate reliable predictions from complicated data. It is strongly tied to contemporary statistics, and in fact, statisticians have contributed many of the most brilliant concepts in ML (eg, the lasso, trees, and forests). However, the ML community has been more focused on the single objective of maximizing predictive performance, in contrast to statisticians who have frequently concentrated on model inference—that is, knowing the parameters of their models (eg, testing on individual coefficients in a regression). "Out-of-sample" tests, which assess how well a model trained on 1 dataset would predict fresh data and serve as the benchmark for the whole ML discipline [14].

# **Application Case Studies**

## Overview

Relevant case studies and examples from the literature were used to highlight the involvement of nurses in the identified AI applications or tool deployments and to assess whether there is a change or anticipated elimination to the role of nurses in patient care. These case studies focused on certain types of AI applications that are tied to certain activities carried out by nurses as part of their core patient care role. The following examples were selected due to their applicability, importance, and contribution to the comprehension of the study's subject.

# **Rothman Index Use**

The Specialized Workforce for Acute Transport (SWAT) team of nurses trained in critical care, advanced cardiovascular life support, and trauma care at Yale New Haven Hospital is a real-world example of using the Rothman Index technique. When signs point to a patient's condition deteriorating, they immediately receive alerts on their mobile phones. The SWAT team looks through the EMR, evaluates the patient as needed, and works together with clinical nurses and other medical personnel on pertinent areas of treatment. SWAT nurses identify as "a second pair of eyes" in their own description. The index's information came from widely available nursing literature. Given that the index is updated in real time from the EMR, timely submission of nurse assessment data is essential for the computation and value of the index score [9].

## Social or Companion Robots

Sophia is an illustration of a social robot designed as a companion for older adults that shows the possibility of technological developments to enhance how robots operate. Sophia had a refurbishment in 2018 that included movement features, and she is currently the first robot to be granted citizenship in a nation (ie, Saudi Arabia) [9]. The next generation of social robots with cutting-edge AI is the LOVOT robot. The social robot LOVOT was well received by most patients with dementia. LOVOT exhibited beneficial impacts, improved communication, and promoted social engagement. Although LOVOT had no appreciable benefits on social well-being, it provided individuals with a break from daily living. Following their interactions with LOVOT, some residents experienced emotional overstimulation. The social robot was embraced by medical specialists and nurses, who saw LOVOT as a new tool for working with patients with dementia as a supporting tool and not as a replacement of the care provider's role [15].

A major factor in concentrating on the older adults is AI. It can, for instance, strengthen the bonds between older adults and their relatives or care teams. Furthermore, an AI chatbot can converse with the older adult without any difficulties and may remind them of important dates, such as medication intake and medical exams. Many of the AI smartphone apps available now have the ability to screen wellness data in a less intrusive manner, including daily activity, food, and, shockingly, older adults lifestyle choices. In certain situations, it could be helpful to anticipate and, thus, prevent any potential hypertension or irregular heart rate. In essence, robotic "pets" are also helping to improve patient attention while also assisting in the battle against emotions of loneliness. One such model, called Tombot, is a small, dog-like device designed to relieve anxiety in patients with dementia. Its head movements, appearance, and swinging tail are remarkably similar to those of the genuine dog, giving owners the impression that they have their own pet to truly concentrate on. The care of the older adults is one of the problems that low-income nations are experiencing. The global shift of older populations has worsened the shortage of trained people in the older adults health care context. Given that the number of older people worldwide is predicted to almost treble in the next 3 decades, there may be a greater need for older adult care [16].

# Telepresence Robots

Health care professionals who are at "high risk for infections due to routine patient contact, handling of contaminated materials, and challenges associated with safely removing protective gear" are the focus of Tele-Robotic Intelligent Nursing Assistant, a remote-controlled robot, at Duke University Pratt School of Engineering and School of Nursing. Noting that Tele-Robotic Intelligent Nursing Assistant is 20 times slower than a nurse, it presently completes around 60% of the preset nursing tasks in the nursing simulation laboratory where it is being evaluated. Results from individuals getting telehealth coaching from home reveal that patients and clinicians alike find satisfaction in the mix of live face-to-face interventions and robotic telehealth visits. Designing meaningful treatments that can take use of new technology requires the nurse to have a key part in the development and execution of telehealth robots [<mark>9</mark>].

Inpatient rooms at the nonprofit, tertiary, 958-bed Cedars-Sinai Hospital in Los Angeles, California, are equipped with Alexa robots created by Amazon to serve as virtual nurse aides. To support patients with their daily routines, Alexa fulfills the monotonous activities performed by nurses. She also assists in answering medical queries and reminds patients to take their pills on time [17].

# NLP Use

The most commonly used AI functions in studies of AI-related nursing activities were profiling and prediction, followed by assessment and evaluation. Virtual reality teaching interventions and learning successes were beneficial to nurses because they provided a safe learning environment with the possibility of multiple tries, overcoming challenges, the ability to consolidate knowledge, and professional efficacy [18]. Furthermore, the use of chatbots improves student learning compared to traditional teaching techniques [19], acting as supporting tools to nursing educators rather than eliminating the entirety of their role.

NLP is used by triage nurses to register and categorize patients based on their speech. When conducting triage activities, RMIS-AI is quicker than using the manual input approach, which decreases the time it takes to register patients and classify them. To address the existing level of subpar sensitivity and accuracy provided by nurses, technological augmentation is necessary [20].

Primary care nurses are faced with increasing demands from patients who have wounds from a variety of sources. Both nurses and patients can benefit from a chatbot that provides information properly verified on the basis of evidence. By providing instructions on the suggested wound dressing techniques for each type of wound, BOTCURATIVO, a chatbot, seeks to assist nonspecialists in the management of wounds. A reasonable degree of content validity was attained by the script that was created and implemented into the chatbot prototype. The chatbot's usability was seen as being good, which increased the device's credibility. Noting that regardless of their specialty, the nurse will always undertake wound management tasks [21].



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Most people lack the medical knowledge necessary to investigate or understand the severity of their conditions or symptoms. In this regard, NLP is essential to health care. These chatbots gather health information from patients, analyze it, and recommend actions to patients based on more pertinent knowledge of their physical conditions. Health care chatbots similar to NOVA-a virtual nursing assistant driven by AI-are helpful in the medical field because they help patients and point them in the direction of the right resources. When consumers or patients look up answers to inquiries they have about their health on the internet, chatbots are more helpful. A user of this program may text requests for health care and may receive pertinent health advice in return. A chatbot can provide medical information, including illness symptoms and treatment options. Patients receive professional guidance in real time, and their personal and medical data are kept in a database for future research. The number of AI-powered health care apps has significantly increased recently. Consequently, there are shorter wait times in offices, which saves money and energy. Patients may be helping in their own place and at their own speed while learning medical knowledge. User input is received by the system via text or speech data. The system interprets the input data. The virtual nursing help system may be accessed by the user who can also send an inquiry to it. The output that the system produces is a list of user symptoms and suggested diagnoses. In the area of virtual nursing help, the suggested system serves as the user's personal assistant. The created bots are useful for keeping track of patient information. The technology can also help numerous people at once [22].

In MobiGuide, the role of nurses in creating, providing, and assessing eHealth-based services was examined with an emphasis on atrial fibrillation home monitoring. To obtain suggestions, warnings, and reminders about drugs and measures that they should conduct, patients were given smartphones and electrocardiogram sensors. This mobile decision support system was regularly updated by a backend system. Health care professionals are supplied patient data so they may view it and take appropriate action. With their participation in the design of the caregiver interface, responsibility for the enrollment phase (ie, including patient training), daily data checks, triage of patient concerns, and patient interviews about their experiences with the system, nurses play a key role in such settings [23].

The Smart Wearable Physiological Signal Measurement Integration System is used in home care, nursing homes, and other health care settings to continuously monitor their patients' vital signs, which enables nurses to see early warning indicators of deterioration and take quick action to stop unfavorable outcomes. When a patient exits a specified area or when vital signs suggest an emergency, the system may notify the care providers, improving patient safety in nursing homes and home care settings [24].

The development of indoor positioning technology has made it feasible to track the movement of mobile medical equipment within a hospital ward, including patient monitors and electrocardiography devices. Nurses can quickly detect and locate a gadget with the help of an item tracking system, particularly while they are getting ready for a medical procedure or shift change. Given that nurses typically have a heavy

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workload, it would be ideal to give them access to a well-liked mobile app with an intuitive search interface that they can use on a regular basis. To help with this, DBOS, a dialogue-based object query system, offers voice and text inquiry services to nurses while mimicking a genuine discussion with users through the chatbot interface of the Line messaging app [25].

The accurate assessment of pain in the neonatal intensive care units is essential due to the high prevalence of painful experiences. Video-based assessment of neonatal pain could be reliably used, as confirmed by the high intrarater and interrater reliability between direct observation and the video-based assessment, as well as the AI method-based performance evaluation, even with various disturbances in real-world neonatal intensive care units. Video-based assessment is viable for neonatal pain assessment in a clinical setting, and the extent of neonatal pain can be evaluated remotely in real time, which can better identify and treat it and thus improve the neonatal pain condition. Video-Based Neonatal Pain Assessment can reduce the stressful surroundings of a clinical setting, the contextual noise, and other elements that could shift the focus of the trainees from the rating. There has been an increasing interest in using ML methods for understanding human behavioral responses to pain based on the analysis of facial expressions, crying sounds, and body movement. Several automated methods have been introduced to automatically assess infants' pain based on behavioral or physiological pain indicators analysis. Using AI-based neonatal pain assessment, the nursing staff can also use these recordings to judge the pain level by observing the painful procedure video in the nurse station and taking timely intervention measures, which could greatly reduce the bedside observation time and improve work efficiency [26].

#### **Robotic Process Automation**

Patients with diabetes mellitus face a 15% to 25% lifetime risk of developing diabetic foot ulcers (DFUs). Monitoring and assessing DFUs for complications and healing progress is essential, and this was traditionally performed using manual measurements. A past study compared conventional measurement methods with an AI-powered mobile application for wound imaging, the CARES4WOUNDS (C4W) system [27]. The length and breadth of the wound were the major characteristics measured. C4W measures had good intra- and interrater reliability compared to standard wound measuring. The C4W was a helpful tool for keeping track of DFU wound healing, yet it did not eliminate the role of wound care nurses.

#### Machine Learning

In 1 in 8 to 10 cases where primary care physicians and nurse practitioners used AI, they made better diagnoses, suggesting the potential for raising the standard of dermatologic treatment. The diagnoses showed improvements of 10% and 12% for primary care physicians and nurse practitioners, respectively, indicating a significant positive impact [28].

For long-term patient care, Vitalerter has developed a program that combines advanced biosensors and deep learning to provide contactless and continuous vital sign monitoring, as well as cloud-based early warning protection services. Some of the standout features of these systems are accurate body movement

analysis, continuous heart and respiratory rate monitoring, and contactless detection of patients moving out of bed. In the event of an adverse event, the system will automatically sound an alarm to remind nurses to take immediate action and lower the risk of falls, pressure sores, and septicemia [29].

Converting pediatric nursing diagnoses into a digital format and adding them to a case base to evaluate how well the prototype handled these cases allowed for case comparison, retrieval, adaptation, and indexing. Therefore, this study offers a computational tool for the health sector that makes use of case-based reasoning, an AI method. While case-based reasoning is merely another paradigm for problem solving, what sets it apart from other AI approaches is how it differs from them. Rather than relying just on a general understanding of the issue or creating connections between problem descriptions and conclusions, this paradigm can use specific information from past experiences or real problem situations. It is acknowledged that using nursing care systematization necessitates that nurses develop a variety of abilities and adhere to theoretical support to enhance decision-making. Decisions should then be discussed with the patient whenever feasible. The application of these records or technology in various clinical health situations, in which observations about the care needs of patients accompany the decision-making process about the care provided, assists in the subsequent evaluation of the outcomes that are obtained

with professional intervention. In this way, it is known that the nursing care systematization collaborates to provide safe, logical, and effective nursing care. Organizing the administration of nursing care and assisting nurses in making decisions is also predicated on ensuring patient safety at various care levels [30].

Table 3 summarizes the thematic analysis and links the respective case studies outlined in this research paper.

On the basis of the themes outlined from the literature review, 81% (13/16) of the AI applications within the nursing fields are in the proof-of-concept phase, with 19% (3/16) of those deployed demonstrating a positive impact on the nursing role within the patient's journey with the United States leading the way in such research and developments. Furthermore, applications that would enhance or streamline the nurses' role seem to be focused on the treatment stage, followed by 25% on posttreatment care (ie, recovery). Noting that the applications cover various aspects of the nursing activities from diagnosis, treatment, wound management, education, and training to triaging.

Multimedia Appendix 1 [1-53] provides a clear summary of our systematic review by analyzing 37 sources in terms of key findings, methodology, sample size, potential biases, and validity. This is to ensure the robustness and reliability of the conclusions drawn from the systematic review.



 Table 3. Outcome of the thematic analysis.

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AI <sup>a</sup> application in nursing and country	Name	Nursing involvement	Status			
Rothman Index						
United States (Yale New Haven Hospital)	Rothman Index	Treatment	Operationally deployed			
Social or companion robots						
Saudi Arabia	LOVOT	Posttreatment care (ie, recovery)	Operationally deployed			
United States	Tombot	Posttreatment care (ie, recovery)	POC <sup>b</sup>			
Telepresence robots						
United States (Duke University Pratt School of Engineering and School of Nursing)	TRINA <sup>c</sup>	Treatment	POC			
United States (Cedars-Sinai Hospital)	Alexa	Treatment	Operationally deployed			
NLP <sup>d</sup>						
United States	RMIS-AI	Triage	POC			
United States	BOTCURATIVO	Nurse education and training	POC			
United States	NOVA-a virtual nursing assistant	Diagnosis	POC			
United States	MobiGuide	Posttreatment care (ie, recovery)	POC			
United States	Smart Wearable Physiological Signal Measurement Integration System	Posttreatment care (ie, recovery)	РОС			
United States	DBOS <sup>e</sup> , a dialogue-based object query system	Treatment	POC			
United States	VB-AI <sup>f</sup> NPA	Treatment	POC			
RPA <sup>g</sup>						
Singapore	CARES4WOUNDS system, Tet- suyu	Wound management	POC			
Machine learning						
United States	Artificial intelligence aid	Diagnosis	POC			
United States	Vitalerter vital sign monitoring	Treatment	POC			
United States	CBR <sup>h</sup>	Treatment	POC			

<sup>a</sup>AI: artificial intelligence.

<sup>b</sup>POC: proof of concept.

<sup>c</sup>TRINA: Tele-Robotic Intelligent Nursing Assistant.

<sup>d</sup>NLP: natural language processing.

<sup>e</sup>DBOS: dialogue-based object query system.

<sup>f</sup>VB-AI: video-based artificial intelligence.

<sup>g</sup>RPA: robotic process automation.

<sup>h</sup>CBR: case-based reasoning.

## **Roles of Nurses and Role Transformation**

The integration of AI technologies into health care has significantly transformed the roles of nurses, shifting their focus from routine tasks to more advanced and patient-centered care [6]. AI systems automate many traditional nursing responsibilities, such as monitoring patient vitals, data entry, and medication management, allowing nurses to prioritize clinical decision-making, patient education, and emotional

support. This role transformation not only enhances the efficiency of health care delivery but also enables nurses to engage more deeply in patient care by using AI as a collaborative tool [31]. AI-driven systems support clinical decision-making, triaging, and diagnostic processes, leading to improved patient outcomes and job satisfaction among nurses [32]. Table 4 provides an overview of how AI can transform nursing roles across various functions.

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#### Table 4. Traditional nurse role versus artificial intelligence (AI)-driven role transformation.

Traditional nurse role	AI-driven role transformation	Example of AI technology involved	Impact on patient care	Academic reference
Monitoring patient vital signs	AI takes over continuous moni- toring, alerting nurses only when intervention is needed	AI-based monitoring sys- tems (eg, wearable sensors and IoT <sup>a</sup> devices)	Frees up nurses' time for more personalized, hands-on patient care and reduces error risk through automation	Ross et al [37]
Data entry and record keeping	AI automates data entry, stream- lining the EHR <sup>b</sup> updating process	AI-enabled EHR systems with NLP <sup>c</sup>	Reduces administrative burden, allowing nurses to focus on di- rect patient care	Zou and Schiebinger [33]
Routine diagnostic proce- dures	Nurses assist in AI-driven diag- nostics, focusing more on patient interaction and explaining results	AI diagnostic tools (eg, im- age analysis for radiology and pathology)	Enhances the role of nurses as educators, helping patients under- stand diagnoses and treatments	Ng et al [38]
Medication administra- tion	AI systems manage medication scheduling, and dosing, with nurses overseeing AI-generated plans	Automated dispensing sys- tems and AI-driven dose calculators	Reduces medication errors and ensures timely administration, allowing nurses to focus on pa- tient observation	Shang [39]
Patient triage and assessment	AI aids in triaging by prioritizing patients based on real-time data, allowing nurses to focus on high- priority cases	AI-powered triage systems (eg, in emergency depart- ments)	Increases efficiency in patient care and enhances the accuracy of triage decisions	Govindaraj et al [40]
Clinical decision support	Nurses collaborate with AI sys- tems that provide real-time deci- sion support based on predictive analytics and historical data	AI-based decision support systems (eg, IBM Watson and AI in ICU <sup>d</sup> for risk pre- diction)	Empowers nurses to contribute more significantly to clinical de- cision-making and patient care planning	El-Kareh and Sittig [41]
Health education and counseling	AI tools provide nurses with real- time personalized health data to tailor patient education more ef- fectively	AI-driven patient education platforms (eg, AI chatbots and personalized health apps)	Enhances the nurse's ability to deliver personalized health edu- cation and counseling based on real-time insights	Li et al [42]
Supervision of junior staff	Nurses oversee AI-driven work- flows and ensure that AI-generat- ed protocols are followed, focus- ing more on clinical mentorship	AI systems for task delega- tion and workflow automa- tion	Enhances leadership roles, allow- ing nurses to take on a superviso- ry role and focus on mentorship and training	Rony et al [43]
Wound care and manage- ment	AI tools help nurses monitor wound healing through image analysis and predictive algo- rithms	AI-based wound care imag- ing systems (eg, predictive models for healing times)	Improves the accuracy of wound assessment, reduces manual checks, and improves patient outcomes	Rippon et al [44]
Patient discharge plan- ning	AI assists in generating discharge plans, predicting postdischarge risks, and automating referrals to follow-up care systems	AI-driven discharge plan- ning tools	Optimizes discharge planning and postdischarge care, reducing the likelihood of readmissions	Jack et al [45]
Emotional support and communication	AI systems can handle adminis- trative tasks, enabling nurses to spend more time on patient emo- tional support and communica- tion	AI-powered administrative assistants (eg, scheduling systems, automated commu- nication)	Allows nurses to prioritize emo- tional support and patient commu- nication over routine tasks	Robert [9]

<sup>a</sup>IoT: Internet of Things.

<sup>b</sup>EHR: electronic health record.

<sup>c</sup>NLP: natural language processing.

<sup>d</sup>ICU: intensive care unit.

Recent studies support these findings, showing that AI systems can help optimize workflows, reduce administrative burdens, and allow nurses to contribute more meaningfully to clinical care. Health care AI tools, such as predictive analytics and automated documentation systems, have been shown to improve patient outcomes while minimizing the risk of human error in routine tasks [33,34]. Moreover, AI-based decision support tools in critical care environments enable nurses to make informed decisions quickly, positively impacting patient care quality [35]. These advancements are particularly evident in the transformation of nursing roles, as evidenced in a thematic analysis of health care AI implementations [36].

## **Critical Assessment of the Literature**

The literature collectively covers a broad spectrum of AI applications, ranging from technical reviews and policy

implications to specific domains such as health care and nursing. The mix of older foundational papers and recent studies provides both historical context and insights into current advancements. Practical and policy-oriented papers enhance the literature by addressing real-world applications and implications of AI. However, some biases were identified, particularly in policy reports like the one by Boucher [3], which reflect institutional viewpoints. The focus on health care and nursing in several papers could skew the overall perspective toward these fields. In addition, journals with lower impact factors might have less rigorous peer review processes, potentially affecting research quality.

The synthesis of findings indicates a strong direction toward integrating AI in various fields, particularly health care and nursing. There is a clear emphasis on the transformative potential of AI, along with discussions on challenges and ethical considerations. Comparative studies and reviews highlight the advantages and limitations of different AI approaches, suggesting the need for context-specific solutions. The quality and diversity of the studies imply that AI is a rapidly evolving field with significant interdisciplinary impacts. Practical guides and policy reports emphasize the need for continuous education and ethical considerations in AI deployment. The focus on health care underscores AI's potential to improve patient outcomes, though it also highlights the importance of rigorous evaluation and context-specific applications.

In conclusion to this section, the systematic literature review provides a comprehensive overview of AI, balancing theoretical foundations, recent advancements, practical applications, and policy implications. While some sources may carry biases or lack depth in certain areas, the collective insights offer valuable guidance for understanding AI's multifaceted impact as outlined in Multimedia Appendix 2 [1-53].

# AI in Nursing From a Theory and Management Perspective

Numerous theoretical and managerial contexts have debated the use of AI in health systems in general and in tasks associated with the nurses' role in particular. As an overarching theoretical viewpoint, nurses will continue to provide direct patient care due to nuances in human behavior. The ability to incorporate new tools and technology will be required of nurses. As technology is being incorporated into nursing programs' curricula, the nursing profession is evolving. Thus, from a management viewpoint, nurses will continue to integrate the data produced by AI tools. They will need to have the skills to incorporate AI findings into evidence-based practice while combining that knowledge with nursing expertise [9].

Despite limitations in identifying numerous pieces of the literature that address the impact of deploying AI, given that many tools and techniques are in project or testing stages, our research contributes to current discussions on contextualized research.

Through this systematic literature review, we attempted to establish a foundation to identify the existing studies from the context emic perspective. By encouraging the research community to focus on "optimal allocation of effort between

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exploitation and exploration," looking at theoretical contributions from the periphery will progress management and organization science [46]. We encourage academics to perform empirical studies for the benefit of advancing literature in this arena. From a practical perspective, physicians, nurses, ML scientists, and hospital and clinical executive administrators when designing their clinical pathways could use this research when designing their treatment plans [47]. Furthermore, academics in the field of medicine, nursing, paramedics, hospital executive administration, patient access, and information technology will benefit from this systematic review as it allows them to build on the existing relevant literature.

# Discussion

# **Principal Findings**

The evolution of AI in nursing has transitioned from early symbolic AI, using rule-based algorithms and fuzzy logic, to modern data-driven approaches such as ML and ANNs and is now exploring hypothetical future waves such as artificial general intelligence. AI applications in nursing include the Rothman Index for patient acuity and risk assessment, social robots such as Sophia and LOVOT for older adults' companionship, telerobots for remote patient interaction, and NLP for enhancing decision-making and patient communication. RPA and ML are used to automate repetitive tasks and improve diagnostic accuracy, while AI-powered tools such as chatbot assistants and wearable monitoring systems assist in patient care and safety. Case studies demonstrate AI's role in supporting, rather than replacing, nursing functions, enhancing efficiency, and allowing nurses to focus more on direct patient care. The success or failure of the medical AI solution will depend on how closely system architects collaborate with real-world nurses in health care fields, as they are needed to work closely together to assess and evaluate which technologies will be prioritized for development [17].

Inadequate evaluation, careless supervision, a lack of fundamental nursing knowledge, a lack of service awareness, and unlawful activity by nursing personnel are all contributing factors to poor nursing care. Inadequate evaluation forces nursing staff members to advance their own skills, be able to analyze certain nursing conditions, and act quickly to take timely, scientifically sound action. Poor nursing is also largely caused by a lack of thorough inspection by nursing staff. Individuals who make nursing errors because of inadequate nursing knowledge should enhance their own skills and training. Ultimately, the nursing profession is a service sector. The essential spirit of service is required when treating patients. It is imperative that corresponding services are rendered completely in compliance with industry standards, and any illicit activities are forbidden. To address this, the use of AI alone will not mitigate those issues; instead, the health care facility's relevant departments must develop a mechanism to penalize slack investigation and prevent the recurrence of such unfavorable circumstances [48].

## **Methodological Approach Limitations**

The limitations of our systematic literature review methodological approach include potential publication bias;

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additionally, the quality and relevance of included studies can vary, impacting the overall reliability of the findings. The search strategy may also be limited by the databases and sources selected, potentially missing relevant literature elsewhere. Furthermore, the exclusion of non–English language studies might introduce language bias. Finally, the subjective nature of data extraction and thematic analysis can lead to inconsistencies and affect the validity of the conclusions.

## **Future Directions and Recommendations**

Due to research that is still in the early stages of development and the considerable variation in AI types and situations, AI used in health care and nursing care is still a developing practice with minimal evidence. AI in nursing becomes a crucial component of health care delivery in general and nursing practice in particular. There is still a great deal of room for advancement with these systems in terms of ensuring not only the professional autonomy of nurses but also better access to sources of health information to maximize their use in multitasking, to cover the greatest number of factors that may affect the patient, environment, clinical practice, and various medical services. Additional research is required to determine how previous research findings using AI-based systems with virtual reality or simulated scenarios can be applied to real-world clinical nursing practice or to examine how these AI-based support systems may enhance patient safety and help nurses in specific clinical settings [28]. A blueprint of nurse involvement in the deployment of AI-based systems and applications can act as a guiding reference and is an area that is worth further research and exploration.

AI has become a game-changing technology that is transforming several industries, the health care industry most notably. It is essential for diagnosing uncommon genetic diseases, streamlining patient care in mental health clinics, supporting clinical judgment, and revolutionizing pathological research. However, the growing use of AI in health care also raises difficult moral, practical, and legal questions, especially in light of the General Data Protection Regulation framework in Europe. The significance of understanding data owner rights and developing moral guidelines for AI use in medical applications, particularly nursing, is another area for future research. Comprehending the ethical discussion around AI helps health care and nursing professionals create moral AI procedures for practice and assists in navigating the complex landscape of AI-driven health care regulations, ethical issues, and data protection [49]. AI presents several risks, particularly in the

context of deep reinforcement learning-based mobile robot assistants. Ensuring safety in environments where humans and robots interact is crucial, especially when autonomous mobility robots rely on deep reinforcement learning for navigation and decision-making. This is particularly important in health care settings, where hospital patients using these AI-driven mobility assistants may face potential hazards that require careful evaluation and mitigation [50]. Therefore, there is an opportunity to further research the risks associated with the use of AI in nursing.

## Conclusions

To fully benefit from AI technology, nurses will need to develop their ability to collaborate with data scientists. Although computer science and nursing are two separate fields, knowledge and skill transfer between the two is crucial as technology develops so that nurses may learn to interpret the data. In the future, nurses will play the role of coaches who will assist people in managing their health and achieving better results. The provision of touch and building connections with patients are the foundations of the nursing profession and their role in patient care, and they will never be fully replaced by AI tools or robots, especially when collecting medical information, such as heart monitoring, urinalysis, and range-of-motion analysis [9].

As emerging AI technologies take over some of the jobs that nurses already do, nursing will be impacted. Although technology will alter the way nurses spend their time providing patient care, nurses will still be required. The nurse will acquire new ways of thinking about and processing information; they will become information integrators, health coaches, and providers of human care, assisted by AI technologies rather than being replaced by them [9]. Current research and implementations demonstrate the effectiveness and promise of AI in nursing practice. However, they do not eliminate the need for field supervision and emotional support from humans [51]. Therefore, and to answer the research question, "Will AI change the role of nurses in patient care?" based on the outcome of this literature review, the answer is "yes" with a varying extent depending on the AI tool in use by the nursing professionals.

Interest in incorporating AI into nursing practice will not go away, although its technological potential is not well understood. It is highly recommended that academic institutions and professional associations implement suitable educational and training initiatives. It is imperative that nurses enhance their comprehension of fundamental AI and its integration into nursing practice [52].

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# **Data Availability**

All data generated or analyzed during this study are included in this published article and its supplementary information files.

# **Authors' Contributions**

IAK was responsible for writing and analyzing the study. MN reviewed the content for accuracy and clarity.

# **Conflicts of Interest**

None declared.

Multimedia Appendix 1 Systematic review analysis. [XLSX File (Microsoft Excel File), 15 KB - nursing\_v8i1e63335\_app1.xlsx ]

Multimedia Appendix 2 Critical assessment of the literature. [XLSX File (Microsoft Excel File), 15 KB - nursing\_v8i1e63335\_app2.xlsx ]

Multimedia Appendix 3 PRISMA Checklist. [PDF File (Adobe PDF File), 287 KB - nursing\_v8i1e63335\_app3.pdf ]

# References

- 1. Tecuci G. Artificial intelligence. WIREs Comput Stat 2011 Dec 07;4(2):168-180. [doi: 10.1002/wics.200]
- 2. Liu J, Kong X, Xia F, Bai X, Wang L, Qing Q, et al. Artificial intelligence in the 21st century. IEEE Access 2018 Mar 26;6:34403-34421. [doi: 10.1109/access.2018.2819688]
- 3. Boucher PN. Artificial intelligence: how does it work, why does it matter, and what can we do about it? European Parliament. 2020 Jun 28. URL: <u>https://www.europarl.europa.eu/thinktank/en/document/EPRS\_STU(2020)641547</u> [accessed 2025-02-04]
- 4. Mohammad SM. Artificial intelligence in information technology. SSRN Electron J 2020 Jun [FREE Full text] [doi: 10.2139/ssrn.3625444]
- Topaz M, Murga L, Gaddis KM, McDonald MV, Bar-Bachar O, Goldberg Y, et al. Mining fall-related information in clinical notes: comparison of rule-based and novel word embedding-based machine learning approaches. J Biomed Inform 2019 Feb;90:103103 [FREE Full text] [doi: 10.1016/j.jbi.2019.103103] [Medline: 30639392]
- Buchanan C, Howitt ML, Wilson R, Booth RG, Risling T, Bamford M. Predicted influences of artificial intelligence on the domains of nursing: scoping review. JMIR Nurs 2020 Dec 17;3(1):e23939 [FREE Full text] [doi: 10.2196/23939] [Medline: 34406963]
- Yang Q, Steinfeld A, Zimmerman J. Unremarkable AI: fitting intelligent decision support into critical, clinical decision-making processes. In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. 2019 Presented at: CHI '19; May 4-9, 2019; Glasgow, UK. [doi: 10.1145/3290605.3300468]
- McGrow K. Artificial intelligence: essentials for nursing. Nursing 2019 Sep;49(9):46-49 [FREE Full text] [doi: 10.1097/01.NURSE.0000577716.57052.8d] [Medline: 31365455]
- 9. Robert N. How artificial intelligence is changing nursing. Nurs Manage 2019 Sep;50(9):30-39 [FREE Full text] [doi: 10.1097/01.NUMA.0000578988.56622.21] [Medline: 31425440]
- 10. Khurana D, Koli A, Khatter K, Singh S. Natural language processing: state of the art, current trends and challenges. Multimed Tools Appl 2023;82(3):3713-3744 [FREE Full text] [doi: 10.1007/s11042-022-13428-4] [Medline: 35855771]
- Mitha S, Schwartz J, Hobensack M, Cato K, Woo K, Smaldone A, et al. Natural language processing of nursing notes: an integrative review. Comput Inform Nurs 2023 Jun 01;41(6):377-384. [doi: <u>10.1097/CIN.00000000000967</u>] [Medline: <u>36730744</u>]
- 12. Ribeiro J, Lima R, Eckhardt T, Paiva S. Robotic process automation and artificial intelligence in industry 4.0 a literature review. Procedia Comput Sci 2021;181:51-58. [doi: 10.1016/j.procs.2021.01.104]
- 13. Mahesh B. Machine learning algorithms a review. Int J Sci Res 2020 Jan;9(1):381-386. [doi: 10.21275/ART20203995]
- 14. Taddy M. The technological elements of artificial intelligence. National Bureau of Economic Research. 2018 Feb. URL: https://www.nber.org/system/files/working\_papers/w24301/w24301.pdf [accessed 2025-02-04]
- Dinesen B, Hansen HK, Grønborg GB, Dyrvig AK, Leisted SD, Stenstrup H, et al. Use of a social robot (LOVOT) for persons with dementia: exploratory study. JMIR Rehabil Assist Technol 2022 Aug 01;9(3):e36505 [FREE Full text] [doi: 10.2196/36505] [Medline: 35916689]
- Rong J, Ji X, Fang X, Jee MH. Research on Material Design of Medical Products for Elderly Families Based on Artificial Intelligence. Appl Bionics Biomech 2022;2022:7058477 Retracted in: Appl Bionics Biomech. 2023 Nov 1:2023:9763260. [doi: 10.1155/2023/9763260] [Medline: 37946829] [FREE Full text] [doi: 10.1155/2022/7058477] [Medline: 35087604]

- 17. Lee D, Yoon SN. Application of artificial intelligence-based technologies in the healthcare industry: opportunities and challenges. Int J Environ Res Public Health 2021 Jan 01;18(1):271 [FREE Full text] [doi: 10.3390/ijerph18010271] [Medline: 33401373]
- Hwang GJ, Chang PY, Tseng WY, Chou CA, Wu CH, Tu YF. Research trends in artificial intelligence-associated nursing activities based on a review of academic studies published from 2001 to 2020. Comput Inform Nurs 2022 Dec 01;40(12):814-824. [doi: 10.1097/CIN.00000000000897] [Medline: <u>36516032</u>]
- 19. Chang CY, Hwang GJ, Gau ML. Promoting students' learning achievement and self efficacy: a mobile chatbot approach for nursing training. Br J Educ Technol 2022 Jan;53(1):171-188. [doi: 10.1111/bjet.13158]
- Cho A, Min IK, Hong S, Chung HS, Lee HS, Kim JH. Effect of applying a real-time medical record input assistance system with voice artificial intelligence on triage task performance in the emergency department: prospective interventional study. JMIR Med Inform 2022 Aug 31;10(8):e39892 [FREE Full text] [doi: 10.2196/39892] [Medline: 36044254]
- da Silva Lima Roque G, Roque de Souza R, Araújo do Nascimento JW, de Campos Filho AS, de Melo Queiroz SR, Ramos Vieira Santos IC. Content validation and usability of a chatbot of guidelines for wound dressing. Int J Med Inform 2021 Jul;151:104473. [doi: 10.1016/j.ijmedinf.2021.104473] [Medline: <u>33964703</u>]
- 22. Bidve V, Virkar A, Raut P, Velapurkar S. NOVA-a virtual nursing assistant. Indones J Electr Eng Comput Sci 2023 Apr;30(1):307-315. [doi: 10.11591/ijeecs.v30.i1.pp307-315]
- 23. Parimbelli E, Sacchi L, Budasu R, Napolitano C, Peleg M, Quaglini S. The role of nurses in e-health: the MobiGuide project experience. Stud Health Technol Inform 2016;225:153-157. [Medline: 2732181]
- 24. Wang WH, Hsu WS. Integrating artificial intelligence and wearable IoT system in long-term care environments. Sensors (Basel) 2023 Jun 26;23(13):5913 [FREE Full text] [doi: 10.3390/s23135913] [Medline: 37447763]
- 25. Chu ET, Huang ZZ. DBOS: a dialog-based object query system for hospital nurses. Sensors (Basel) 2020 Nov 19;20(22):6639 [FREE Full text] [doi: 10.3390/s20226639] [Medline: 33228178]
- 26. Chen X, Zhu H, Mei L, Shu Q, Cheng X, Luo F, et al. Video-based versus on-site neonatal pain assessment in neonatal intensive care units: the impact of video-based neonatal pain assessment in real-world scenario on pain diagnosis and its artificial intelligence application. Diagnostics (Basel) 2023 Aug 12;13(16):2661 [FREE Full text] [doi: 10.3390/diagnostics13162661] [Medline: 37627921]
- 27. Chan KS, Chan YM, Tan AH, Liang S, Cho YT, Hong Q, et al. Clinical validation of an artificial intelligence-enabled wound imaging mobile application in diabetic foot ulcers. Int Wound J 2022 Jan;19(1):114-124 [FREE Full text] [doi: 10.1111/iwj.13603] [Medline: 33942998]
- 28. Jain A, Way D, Gupta V, Gao Y, de Oliveira Marinho G, Hartford J, et al. Development and assessment of an artificial intelligence-based tool for skin condition diagnosis by primary care physicians and nurse practitioners in teledermatology practices. JAMA Netw Open 2021 Apr 01;4(4):e217249 [FREE Full text] [doi: 10.1001/jamanetworkopen.2021.7249] [Medline: 33909055]
- 29. Lu ZX, Qian P, Bi D, Ye ZW, He X, Zhao YH, et al. Application of AI and IoT in clinical medicine: summary and challenges. Curr Med Sci 2021 Dec;41(6):1134-1150 [FREE Full text] [doi: 10.1007/s11596-021-2486-z] [Medline: 34939144]
- 30. Alazzam MB, Tayyib N, Alshawwa SZ, Ahmed MK. Nursing care systematization with case-based reasoning and artificial intelligence. J Healthc Eng 2022 Mar 9;2022:1959371 [FREE Full text] [doi: 10.1155/2022/1959371] [Medline: 35310193]
- Martinez-Ortigosa A, Martinez-Granados A, Gil-Hernández E, Rodriguez-Arrastia M, Ropero-Padilla C, Roman P. Applications of artificial intelligence in nursing care: a systematic review. J Nurs Manag 2023 Jul 26;2023:1-12. [doi: 10.1155/2023/3219127]
- 32. Rony MK, Akter K, Debnath M, Rahman MM, Johra FT, Akter F, et al. Strengths, weaknesses, opportunities and threats (SWOT) analysis of artificial intelligence adoption in nursing care. J Med Surg Public Health 2024 Aug;3:100113. [doi: 10.1016/j.glmedi.2024.100113]
- Zou J, Schiebinger L. Ensuring that biomedical AI benefits diverse populations. EBioMedicine 2021 May;67:103358 [FREE Full text] [doi: 10.1016/j.ebiom.2021.103358] [Medline: 33962897]
- Almagharbeh WT. The impact of AI-based decision support systems on nursing workflows in critical care units. Int Nurs Rev 2024 Jul 08. [doi: 10.1111/inr.13011] [Medline: <u>38973347</u>]
- Seibert K, Domhoff D, Bruch D, Schulte-Althoff M, Fürstenau D, Biessmann F, et al. Application scenarios for artificial intelligence in nursing care: rapid review. J Med Internet Res 2021 Nov 29;23(11):e26522 [FREE Full text] [doi: 10.2196/26522] [Medline: 34847057]
- Rony MK, Kayesh I, Bala SD, Akter F, Parvin MR. Artificial intelligence in future nursing care: exploring perspectives of nursing professionals a descriptive qualitative study. Heliyon 2024 Feb 08;10(4):e25718 [FREE Full text] [doi: 10.1016/j.heliyon.2024.e25718] [Medline: <u>38370178</u>]
- 37. Ross A, Freeman R, McGrow K, Kagan O. Implications of artificial intelligence for nurse managers. Nurs Manage 2024 Jul 01;55(7):14-23. [doi: 10.1097/nmg.0000000000143] [Medline: 38951725]
- Ng ZQ, Ling LY, Chew HS, Lau Y. The role of artificial intelligence in enhancing clinical nursing care: a scoping review. J Nurs Manag 2022 Nov;30(8):3654-3674. [doi: <u>10.1111/jonm.13425</u>] [Medline: <u>34272911</u>]
- 39. Shang Z. A concept analysis on the use of artificial intelligence in nursing. Cureus 2021 May 05;13(5):e14857 [FREE Full text] [doi: 10.7759/cureus.14857] [Medline: 34113496]

- 40. Govindaraj M, D AK, Khan P, Krishnan R, Gnanasekaran C, Lawrence J. Revolutionizing healthcare: the transformative impact of artificial intelligence. In: Revolutionizing the Healthcare Sector with AI. Hershey, PA: IGI Global; 2024.
- 41. El-Kareh R, Sittig DF. Enhancing diagnosis through technology: decision support, artificial intelligence, and beyond. Crit Care Clin 2022 Jan;38(1):129-139 [FREE Full text] [doi: 10.1016/j.ccc.2021.08.004] [Medline: 34794627]
- 42. Li YH, Li YL, Wei MY, Li GY. Innovation and challenges of artificial intelligence technology in personalized healthcare. Sci Rep 2024 Aug 16;14(1):18994 [FREE Full text] [doi: 10.1038/s41598-024-70073-7] [Medline: 39152194]
- 43. Rony MK, Parvin MR, Ferdousi S. Advancing nursing practice with artificial intelligence: enhancing preparedness for the future. Nurs Open 2024 Jan;11(1):10.1002/nop2.2070 [FREE Full text] [doi: 10.1002/nop2.2070] [Medline: 38268252]
- Rippon MG, Fleming L, Chen T, Rogers AA, Ousey K. Artificial intelligence in wound care: diagnosis, assessment and treatment of hard-to-heal wounds: a narrative review. J Wound Care 2024 Apr 02;33(4):229-242. [doi: 10.12968/jowc.2024.33.4.229] [Medline: <u>38573907</u>]
- 45. Jack BW, Austad K, Renfro DR, Mitchell S. Re-engineering the hospital discharge to improve the transition from hospital to home: overview and a look to the future. J Healthc Manag Standard 2023;3(1):1-17. [doi: 10.4018/JHMS.328775]
- 46. March JG. Exploration and exploitation in organizational learning. Organ Sci 1991 Feb 01;2(1):71-87. [doi: 10.1287/orsc.2.1.71]
- 47. Blakemore A, Stephenson C. Psychological wellbeing practitioners: an opportunity for new ways of working in occupational health. Occup Health Work 2017;14(2):27-30 [FREE Full text]
- Han J, Li D, Guo C, Wang J, Xue S. Construction and reliability and validity test of home care assessment scale for elderly patients with chronic diseases based on intelligent medical care. Mob Inf Syst 2022 Jul 13;2022(1):1-10. [doi: 10.1155/2022/7697036]
- 49. Mohammad Amini M, Jesus M, Fanaei Sheikholeslami D, Alves P, Hassanzadeh Benam A, Hariri F. Artificial intelligence ethics and challenges in healthcare applications: a comprehensive review in the context of the European GDPR mandate. Mach Learn Knowl Extr 2023 Aug 07;5(3):1023-1035. [doi: 10.3390/make5030053]
- 50. Namba T, Yamada Y. Risks of deep reinforcement learning applied to fall prevention assist by autonomous mobile robots in the hospital. Big Data Cogn Comput 2018 Jun 17;2(2):13. [doi: 10.3390/bdcc2020013]
- 51. Montemayor C, Halpern J, Fairweather A. In principle obstacles for empathic AI: why we can't replace human empathy in healthcare. AI Soc 2022;37(4):1353-1359 [FREE Full text] [doi: 10.1007/s00146-021-01230-z] [Medline: 34054228]
- 52. Abuzaid MM, Elshami W, Fadden SM. Integration of artificial intelligence into nursing practice. Health Technol (Berl) 2022;12(6):1109-1115 [FREE Full text] [doi: 10.1007/s12553-022-00697-0] [Medline: 36117522]
- 53. Qayyum MU, Sherani AMK, Khan M, Hussain HK. Revolutionizing healthcare: the transformative impact of artificial intelligence in medicine. Bull Inform 2024;1(2):71-83 [FREE Full text]

# Abbreviations

AI: artificial intelligence ANN: artificial neural network C4W: CARES4WOUNDS DFU: diabetic foot ulcer EMR: electronic medical record ML: machine learning NLP: natural language processing RPA: robotic process automation SWAT: Specialized Workforce for Acute Transport

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# Impact of Attached File Formats on the Performance of ChatGPT-4 on the Japanese National Nursing Examination: Evaluation Study

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# Abstract

**Abstract:** This research letter discusses the impact of different file formats on ChatGPT-4's performance on the Japanese National Nursing Examination, highlighting the need for standardized reporting protocols to enhance the integration of artificial intelligence in nursing education and practice.

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## **KEYWORDS**

nursing examination; machine learning; ML; artificial intelligence; AI; large language models; ChatGPT; generative AI

# Introduction

Numerous generative artificial intelligences (AIs), exemplified by all versions of ChatGPT [1] and Llama [2], have been developed using large language models and evaluated in health care, particularly in nursing education [3,4], successfully passing national nursing examinations in several countries [5,6]. Generative AIs are evolving to handle multimodal information, including text and images [1]. However, previous evaluations have not assessed the impact of file formats [5,6].

Prompts, particularly long ones, can affect response accuracy owing to potential context loss or exceeded token limits [7-9]. In this study, we hypothesized that the file format attached to prompts could affect the results of nursing research that uses generative AI and aimed to evaluate its impact on ChatGPT-4's performance on the Japanese National Nursing Examination. The findings of this study would be useful for improving the quality of reports on future nursing research that uses generative AI.

# Methods

# **Ethics Approval**

This study did not require ethical approval or informed consent, as the data analyzed were obtained from a published database from the Ministry of Health, Labour and Welfare.

# **Generative AI Model**

We used the original, unmodified GPT-4 (gpt-4 - 1106-preview, accessed March 2024) without additional training, tuning, or data. ChatGPT, launched by OpenAI in 2022, with GPT-4 released in March 2023, is currently widely used.

# Input Data

The dataset included all 50 basic knowledge questions from the 2023 Japanese National Nursing Examination, along with 190 general questions. The passing standard for these basic knowledge questions was approximately 80%. ChatGPT-3.5 has consistently failed to meet this standard [4], leading us to consider whether performance might vary based on file format. Questions were prepared in TEXT (.txt), DOCX (.docx), PDF (.pdf), and IMAGE (.jpg) formats and in a format that directly described all questions in the prompt (PROMPT-ONLY format). Although other formats, including CSV, JSON, XML, and Markdown, could be used to present questions and choices, we excluded them to maintain consistency and focus on more common formats.

# **Prompt Engineering**

The prompts for each file format are summarized in Textbox 1.



**Textbox 1.** Prompts provided to ChatGPT-4. The files (mentioned at the end of the prompt for TXT, DOCX, PDF, and JPG formats) were made viewable via OpenAI's application programming interface (API) function: ASSISTANT (type = retrieval).

## <Prompt for PROMPT-ONLY format>

You are an expert in the field of nursing. Answer the given questions briefly and numerically. {Question number}. {Question}. Options: (1) {Option 1}, (2) {Option 2}, (3) {Option 3}, (4) {Option 4}

*Example:* 1. Which vessel sends blood from the fetus to the placenta in the fetal circulation? Options: (1) Common carotid artery, (2) Pulmonary artery, (3) Umbilical artery, and (4) Umbilical vein.

## <Prompt for TXT, DOCX, PDF, and JPG formats>

You are an expert in the field of nursing. Answer briefly and numerically all questions given by the file.

## **Data Analyses**

# Results

Prompts for all formats were processed for 100 iterations each; the median and IQR of the percentage of correct answers were calculated. Differences among the percentages of correct answers by the attached file format were compared using the Kruskal-Wallis test and Dann-Bonferroni test. Statistical analyses were performed using Python (version 3.11.4) with the *pandas* (version 1.5.3) and *matplotlib* (version 3.7.1) libraries.

The median percentages of correct answers were 92% (IQR 64% - 94%), 92% (IQR 92% - 94%), 94% (IQR 94% - 96%), 87% (IQR 86% - 90%), and 26% (IQR 20% - 30%) for PROMPT-ONLY, TEXT, PDF, DOCX, and JPG formats, respectively. The differences between the attached formats were statistically significant in all pairs (P<.01) except for the PROMPT-ONLY versus TEXT and PROMPT-ONLY versus DOCX pairs (Figure 1).







# Discussion

ChatGPT-4's performance on the Japanese National Nursing Examination varied significantly across file formats. The best performance was observed with PROMPT-ONLY, TEXT, and PDF formats (median scores >92%), followed by DOCX (87%), and the worst performance was with JPG (26%). The PROMPT-ONLY format exhibited a larger IQR and more variability than TEXT, PDF, and DOCX formats. JPG's poor performance highlights a significant limitation of generative AI, which excels at processing digital text but struggles with interpreting text from images. This "visual comprehension" gap has critical implications for AI applications involving nondigital text sources. The variability in PROMPT-ONLY performance may reflect reduced accuracy with longer prompts [7,8].

Therefore, to prepare for a future where generative AI is integrated into nursing practice and education [10], it is crucial to understand the interaction between humans and generative

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AI, including the impact of input file formats. Additionally, it is essential to report the following aspects in a standardized manner:

- Name and version of the generative AI model
- Presence of additional training, tuning, or knowledge transfer
- Prompt design and attached file formats
- Response generation parameters, including the number of iterations, temperature settings, and maximum token count
- Execution environment (if applicable)

However, as we only examined ChatGPT-4's performance on the Japanese National Nursing Examination and the impact of major file formats, investigations on other formats and AI models are warranted. Particularly, evaluating the performance of AI that specializes in image processing and image formats other than JPG and expanding the evaluations to include national nursing examinations in other countries and clinical questions in practice will be important in future research.

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# **Conflicts of Interest**

None declared.

# References

- 1. OpenAI, Achiam J, Adler S, et al. GPT-4 technical report. arXiv. Preprint posted online on Mar 15, 2023. [doi: 10.48550/arXiv.2303.08774]
- 2. Topaz M, Peltonen LM, Michalowski M, et al. The ChatGPT effect: nursing education and generative artificial intelligence. J Nurs Educ 2024 Feb 5:1-4. [doi: 10.3928/01484834-20240126-01] [Medline: 38302101]
- 3. Touvron H, Lavril T, Izacard G, et al. LLaMA: open and efficient foundation language models. arXiv. Preprint posted online on Feb 27, 2023. [doi: 10.48550/arXiv.2302.1397]
- 4. Jin HK, Lee HE, Kim E. Performance of ChatGPT-3.5 and GPT-4 in national licensing examinations for medicine, pharmacy, dentistry, and nursing: a systematic review and meta-analysis. BMC Med Educ 2024 Sep 16;24(1):1013. [doi: 10.1186/s12909-024-05944-8] [Medline: 39285377]
- 5. Taira K, Itaya T, Hanada A. Performance of the large language model ChatGPT on the National Nurse Examinations in Japan: evaluation study. JMIR Nurs 2023 Jun 27;6:e47305. [doi: <u>10.2196/47305</u>] [Medline: <u>37368470</u>]
- Su MC, Lin LE, Lin LH, Chen YC. Assessing question characteristic influences on ChatGPT's performance and response-explanation consistency: insights from Taiwan's Nursing Licensing Exam. Int J Nurs Stud 2024 May;153:104717. [doi: <u>10.1016/j.ijnurstu.2024.104717</u>] [Medline: <u>38401366</u>]
- Ratnayake H, Wang C. A prompting framework to enhance language model output. Presented at: AI 2023: Advances in Artificial Intelligence: 36th Australasian Joint Conference on Artificial Intelligence; Nov 28 to Dec 1, 2023; Brisbane, Australia. [doi: 10.1007/978-981-99-8391-9\_6]
- 8. Levy M, Jacoby A, Goldberg Y. Same task, more tokens: the impact of input length on the reasoning performance of large language models. arXiv. Preprint posted online on Feb 19, 2024. [doi: <u>10.18653/v1/2024.acl-long.818</u>]
- 9. Zhang ZY, Verma A, Doshi-Velez F, Low BKH. Understanding the relationship between prompts and response uncertainty in large language models. arXiv. Preprint posted online on Jul 20, 2024. [doi: 10.48550/arXiv.2407.14845]
- 10. Goldberg CB, Adams L, Blumenthal D, et al. To do no harm and the most good with AI in health care. NEJM AI 2024 Feb 22;1(3). [doi: 10.1056/AIp2400036]

# Abbreviations

AI: artificial intelligence

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