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Viewpoint

Virtual Reality in Clinical Practice and Research: Viewpoint on Novel Applications for Nursing

Hyojin Son¹, RN, PhD; Alyson Ross¹, RN, PhD; Elizabeth Mendoza-Tirado¹, BA; Lena Jumin Lee¹, RN, PhD

Translational Biobehavioral and Health Disparities Branch, National Institutes of Health Clinical Center, Bethesda, MD, United States

Corresponding Author:

Hyojin Son, RN, PhD

Translational Biobehavioral and Health Disparities Branch

National Institutes of Health Clinical Center

10 Center Drive

Bethesda, MD, 20892

United States

Phone: 1 667 701 5768

Email: hyojin.son@nih.gov

Abstract

Virtual reality is a novel technology that provides users with an immersive experience in 3D virtual environments. The use of virtual reality is expanding in the medical and nursing settings to support treatment and promote wellness. Nursing has primarily used virtual reality for nursing education, but nurses might incorporate this technology into clinical practice to enhance treatment experience of patients and caregivers. Thus, it is important for nurses to understand what virtual reality and its features are, how this technology has been used in the health care field, and what future efforts are needed in practice and research for this technology to benefit nursing. In this article, we provide a brief orientation to virtual reality, describe the current application of this technology in multiple clinical scenarios, and present implications for future clinical practice and research in nursing.

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KEYWORDS

virtual reality; health care; application; nursing

Introduction

Virtual reality (VR) is a type of extended reality technology that is increasingly being used in health care, from assisting medical staff in practicing new techniques to supporting treatment procedures and wellness activities [1-4]. In nursing, VR technology has been primarily used in nursing education, such as simulation-based skills training and distance learning [3]. Although there is growing evidence that VR can be used in more innovative ways, such as improving troublesome physical and psychological symptoms [5,6], many nurses in clinical practice and research may be unfamiliar with novel applications of VR technology. In this article, we provide a brief orientation to VR, describe the current application of this technology in health care, and present implications for clinical practice and future research in nursing.

A Brief Look at Virtual Reality

VR is defined as “an artificial world made up of computer-generated images and sounds and is influenced by the actions of an individual who is experiencing that world”

[7]. The technology stimulates a user’s multiple senses, enabling the user to interact with realistic 3D virtual environments [5,8]. VR is different from augmented reality, which is another type of extended reality technology; while augmented reality superimposes digital data onto the real world, VR shuts out the real world and provides interaction with the simulated virtual world [9]. Simulated virtual worlds can be delivered in a nonimmersive or immersive manner. Nonimmersive VR implements the virtual environment by projecting it onto a large display or wall screen (eg, Powerwall screens and cave automatic virtual environments), while immersive VR commonly applies a head-mounted display to provide full immersion and interaction with the virtual environment [10].

VR technology has become more immersive, affordable, and portable due to the ubiquity of mobile high-performance computing and the availability of various software programs [8]. VR is being used in various fields such as education, business, medical and military training, treatment of mental health and traumatic disorders, and entertainment [4]. In particular, the use of VR has increased for recreational purposes during the COVID-19 pandemic, with users reporting its positive impact on physical activity and mental well-being [4]. In recent

years, VR technology has also been recognized for its value of application for health-related purposes, including symptom improvement and pain management in diverse populations [5,11]. As VR continues to advance, we expect more active use of the technology in health care practice and research.

Virtual Reality in Health Care

Features of VR have gained attention in the health care field, and in particular, this technology has been actively used in education and training for students and staff in medical professions. In medical education, VR has been often used for surgical and physical examination skills training, acquisition of anatomical knowledge, and building empathy for patients with neurodegenerative diseases [1]. Although VR has a comparatively short history in nursing, VR has been mainly used for nursing education purposes to optimize nursing students and nurses' acquisition of practical skills and theoretical knowledge. Some examples include urinary catheterization practice, basic life support training, and communication practice with patients having virtual dementia [3]. Most participants who experienced VR in medical and nursing education indicated that VR-based trainings were motivating and helpful in acquiring knowledge and skills [1,3]. With the high demand for contactless learning due to the recent COVID-19 pandemic, the application of VR to health care education has never been more prominent.

The application of VR is not limited to these education or training purposes but is increasingly being used for therapeutic purposes as well. Several major therapeutic purposes of VR use include distraction from pain or uncomfortable medical procedures [2,11], relaxation and mindfulness for stress and symptom improvement [12-15], cognitive coping as psychotherapy [16,17], and rehabilitation of neuromotor functions [18]. VR has shown promising levels of effectiveness in various clinical scenarios.

Distraction

VR can be a method of distraction for overcoming uncomfortable medical procedures or as a nonpharmaceutical therapy for pain management. Current regimens in pain management, including surgical treatment, physical rehabilitation, or implantable drug-delivery systems, can be costly and ineffective [19]. Furthermore, opioids prescribed for pain control may lead to dependency and misuse [19]. Studies reporting positive results of VR interventions for pain management suggest that nurses working in a variety of care settings could use VR as an alternative therapy for pain relief [11]. In a randomized controlled study with 120 adults hospitalized in orthopedics or internal medicine with a pain score of at least 3 out of 10, those using multiple options of VR experience (eg, meditation, game, and nature experience) through a headset showed significant reductions in pain after 48 and 72 hours compared with those watching a television channel on health and wellness [8]. Importantly, the effect of this VR intervention was more pronounced in patients with severe baseline pain (pain score 7 out of 10) [8]. VR can also assist patients in coping with uncomfortable and even painful medical procedures [2]. Piskorz et al [20] found that 36 children whose attentions were distracted by playing or watching VR

games during blood sampling reported significantly lower pain and stress than 21 children who did not experience VR.

Relaxation and Mindfulness

VR can be an effective and feasible relaxation tool for individuals suffering from stress and psychological symptoms [5]. One experimental study assessed the effects of a VR intervention that provided relaxing videos of nature along with guided meditation and muscle relaxation to 49 individuals with depression, anxiety, or bipolar disorder [14]. This study revealed the beneficial effects of the VR intervention in improving mood and decreasing symptoms of depression and anxiety [14]. Kamińska et al [12] tested a 15-minute nature-based relaxation training program that comprised forest scenery and birdsong to relieve workplace stress in 28 office workers. The participants experienced significant improvements in perceived stress and mood [12]. Nurses are subject to workplace stress and symptoms such as anxiety and depression, and the recent pandemic has further aggravated the problem [21]. As a result, some hospitals have implemented VR experiences for frontline health care workers, explaining that VR may help them detach from stressful work environments and feel relaxed [22].

VR has the potential to increase mindfulness, focusing one's attention on the present moment with an accepting and nonjudgmental attitude [23]. Developing mindfulness can reduce stress and improve symptoms, but mindfulness can be difficult to practice due to environmental and personal distractions [23]. VR may address these difficulties by providing an immersive virtual environment that supports the user to focus on the present moment. Seabrook et al [13] found that a VR mindfulness app that delivered a 15-minute program of a peaceful forest scenery video with a guided mindfulness voice-over significantly increased mindfulness and positive emotions in 37 adults. The participants reported a strong sense of being in the virtual forest while using the program [13]. Studies examining VR use to enhance relaxation and mindfulness have often involved healthy populations [13,15,23], yet increasing levels of mindfulness using VR may be beneficial to patients with a variety of physical and mental conditions.

Cognitive Coping

The potential of VR-based therapy is gaining attention as a way to develop cognitive coping skills in individuals with psychiatric disorders such as posttraumatic stress disorder (PTSD) and depressive disorder. Peskin et al [16] tested 12 weekly 90-minute VR exposure therapy sessions in 25 adults with PTSD following the September 11 attacks. The participants described their trauma in detail while being exposed to VR scenarios simulating the attacks and reported significant decreases in PTSD, which in turn led to decreased depressive symptoms [16]. Another experimental study assessed the effects of up to 16 sessions of VR-based cognitive behavioral therapy (CBT) in 15 adult patients diagnosed with generalized social anxiety disorder [17]. The participants were exposed to behaviors and sounds of digital humans in virtual environments that simulated places that might trigger anxiety for these individuals, such as crowded cafés or supermarkets. This study indicated that VR-based CBT can be effective in improving social anxiety and depressive symptoms [17]. These studies suggest that VR may be a useful adjunct to

psychotherapy to safely expose individuals to their traumatic triggers in a carefully controlled environment, enabling them to establish healthy cognitive coping skills over time.

Rehabilitation

In recent years, VR has shown its potential as an assistive technology to aid the rehabilitation of patients with impaired neuromotor functions. Although VR cannot replace conventional physical or occupational therapies, it can promote the effectiveness of rehabilitation by providing task-oriented and multisensory training within an individualized safe virtual environment [18]. Mekbib et al [24] developed a VR-based rehabilitation system and validated its therapeutic potential in 23 recent patients who had stroke. The system provided upper extremity training in an immersive virtual environment and was effective in recovering upper extremity motor function when combined with conventional occupational therapy [24]. Regularity and repetition are essential in rehabilitation training for individuals with neurological disorders; however, motivation and adherence often decrease over time [18]. VR combined with traditional rehabilitation training may improve motivation and training outcomes. Winter et al [25] demonstrated that VR-based treadmill training improved motivation and gait rehabilitation in 36 healthy participants and 14 patients with multiple sclerosis or stroke. VR-assisted therapy is also promising for rehabilitation of children with neuromotor impairments. In the study by Bortone et al [26], VR games were introduced to 8 children with cerebral palsy or developmental coordination disorder through immersive virtual environments and wearable haptic devices, improving the children's functionality of upper extremity.

Future Implications for Practice and Research in Nursing

As VR technology becomes more popular and diverse in contents, the application of VR is expanding beyond education and training to support treatments or therapies and to promote wellness. Nurses can incorporate VR into clinical practice to improve treatment experience of patients and caregivers. Nurses may introduce relaxing VR experiences to reduce stress and anxiety in patients undergoing uncomfortable and painful procedures or surgeries [27]. VR can be a supportive medium to alleviate distress of patients undergoing intense treatments, such as chemotherapy [28]. Entertaining elements of VR can be effective in relieving pain and promoting psychological well-being in hospitalized patients, especially pediatric patients who tend to be more interested in gaming technology [29]. For patients with impaired cognitive or neuromotor functions, VR-based programs may stimulate their interests and motivate them to engage in long-term therapy sessions or rehabilitation [17,25].

For caregivers as well as patients, VR could also be useful for coping with stress and improving symptoms. While caring for individuals with acute or chronic conditions, caregivers often experience high levels of stress and associated multiple symptoms (eg, fatigue, sleep disturbance, depression, anxiety, and impaired cognition) due to the burden of caregiving tasks

and changes in their circumstances [30]. Caregivers tend to be reluctant to leave the patient to practice their own health-promoting activities [31], but limited resources are available that enable caregivers to cope with stress without leaving the side of the patient. Through a VR platform, caregivers could briefly escape their real circumstances by exploring peaceful nature scenes or practicing mindfulness, which may lead to stress reduction and symptom improvement.

Although VR is a promising technology that can be used in diverse care settings, the realities we face in our practice and research may differ from our expectations. While some patients and caregivers are interested in and willing to use VR, others may be skeptical about the technology [8]. They may think that using VR takes away therapeutic encounters with care providers, and those with less affinity for technology may be somewhat averse to trying VR [32]. As such, the acceptance of VR depends on each person's characteristics and perception and attitudes toward VR use [32]. More evidence should be generated regarding factors closely associated with VR acceptance. To optimize the opportunities VR can provide in health care, nurses need to first become familiar with the technology so that they can introduce and educate patients and caregivers about VR-based programs. It is important to create an environment that supports nurses to be competent in using digital health technologies, including VR [33]. Efforts also should be made to evaluate and improve user-friendliness and usefulness of VR-based programs perceived by various users [34].

As for research, more large-scale, long-term studies are needed to rigorously evaluate the effects of VR interventions on mood, cognitive function, as well as physical and psychological symptoms across different age groups and clinical populations. Expanding scientific research of physiological markers (eg, pulse rate, cortisol, cytokines, and genomic DNA) or neuroscientific measures (eg, real time functional magnetic resonance imaging) will also contribute to understanding the impact of VR interventions [35,36]. In addition, research on VR use in care settings should be practical, examining not just whether the interventions are effective, but also whether they are feasible for nurses to use in their practice and satisfactory to subjects [37]. Another important consideration when it comes to VR research is designing the research based on theoretical knowledge. Designing VR research referring to well-validated theories helps develop interventions that reflect the characteristics and needs of the target population; however, existing VR studies have rarely discussed theoretical components [34]. Further efforts are encouraged to develop and perform clinically meaningful and methodologically robust theory-based VR research.

When introducing VR to real subjects, especially patients, we should always keep in mind that we need to ensure their safety from any potential side effects. Nausea and dizziness caused by simulation sickness have been reported as common side effects associated with VR experiences [38]. VR-related side effects could lead to physical risks or injuries in those who are sensitive to motion sickness or individuals with impaired functions [39]. To prevent these potential side effects, it is recommended that VR interventions be applied for a limited period of time in a quiet and safe place to individuals who do

not have restrictions on using the technology [37]. Nurses and other staff members also need to assess any physical discomfort associated with wearing VR devices, especially a bulky head-mounted display [37].

We should assess cost-effectiveness as well as efficacy and safety in order to leverage VR technology in clinical practice. VR is a high-cost technology that requires software development and equipment [34]. Implementing VR-based programs without considering cost-effectiveness within the already expensive US health care system could increase care costs and worsen health

disparities caused by an individual's ability to pay for such novel programs [40]. People with lower education and income levels may lag in getting information on treatments using VR technology as they tend to have limited eHealth literacy and poor access to health resources [41]. Care should be taken to ensure that all individuals have equitable access to participation in VR-based treatments and interventions.

Textbox 1 summarizes recommendations when incorporating VR into nursing practice and research.

Textbox 1. Summary of recommendations for use of virtual reality in clinical practice and research.

- Research recommendations
 - Investigate factors associated with virtual reality acceptance
 - Assess user-friendliness and usefulness of virtual reality interventions
 - Evaluate the effectiveness of virtual reality interventions in a variety of populations (eg, pediatric patients and caregivers)
 - Establish virtual reality interventions based on theoretical components
 - Conduct long-term studies with large samples
 - Use physiological and neuroscientific measures as well as self-reported measures
 - Assess nurses' perception whether virtual reality interventions are feasible in practice
 - Collect data regarding the optimal frequency, duration, and timing of use for virtual reality interventions
- Implications for clinical practice
 - Create an environment that supports nurses becoming familiar with virtual reality
 - Ensure participant safety from potential virtual reality-related adverse effects or discomfort
 - Assess cost-effectiveness of virtual reality in the current health care system
 - Establish evidence-based guidelines for implementing virtual reality interventions

Conclusions

With care recipient needs and care environments becoming more complex, VR technology may provide opportunities to improve clinical practice and research. Beyond health care staff and students' education and training, evidence in the literature supports VR use in pain management, distraction from difficult medical procedures and treatments, relaxation and mindfulness, CBT, and rehabilitation. Future studies are encouraged to evaluate how the impact of VR use differs across age groups

and populations and explore which VR interventions are appropriate for each group and population. Evidence-based practice guidelines for implementing VR in care settings should be established through active research and quality improvement activities. Nurses need to be equipped with up-to-date information on VR use in health care, including trends and prospects, and interact with experts in relevant fields. We cannot stop the flow of novel technologies into health care. The use of such technologies should be optimized in a way that supports the current health care delivery.

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Conflicts of Interest

None declared.

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Abbreviations

- CBT:** cognitive behavioral therapy
- PTSD:** posttraumatic stress disorder
- VR:** virtual reality

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Review

Technology-Supported Guidance Models Stimulating the Development of Critical Thinking in Clinical Practice: Mixed Methods Systematic Review

Jaroslav Zlamal¹, MHP; Edith Roth Gjevjon¹, PhD; Mariann Fossum², PhD; Marianne Trygg Solberg³, PhD; Simen A Steindal^{3,4}, PhD; Camilla Strandell-Laine^{1,5}, PhD; Marie Hamilton Larsen³, PhD; Andréa Aparecida Gonçalves Nes¹, PhD

¹Department of Bachelor Education in Nursing, Lovisenberg Diaconal University College, Oslo, Norway

²Department of Health and Nursing Sciences, University of Agder, Kristiansand, Norway

³Department of Postgraduate Studies, Lovisenberg Diaconal University College, Oslo, Norway

⁴Faculty of Health Studies, VID Specialized University, Oslo, Norway

⁵Faculty of Health and Welfare, Novia University of Applied Sciences, Åbo, Finland

Corresponding Author:

Jaroslav Zlamal, MHP

Department of Bachelor Education in Nursing

Lovisenberg Diaconal University College

Lovisenberggt. 15b

Oslo, 0456

Norway

Phone: 47 95963522

Email: Jaroslav.Zlamal@ldh.no

Abstract

Background: Nursing education has increasingly focused on critical thinking among nursing students, as critical thinking is a desired outcome of nursing education. Particular attention is given to the potential of technological tools in guiding nursing students to stimulate the development of critical thinking; however, the general landscape, facilitators, and challenges of these guidance models remain unexplored, and no previous mixed methods systematic review on the subject has been identified.

Objective: This study aims to synthesize existing evidence on technology-supported guidance models used in nursing education to stimulate the development of critical thinking in nursing students in clinical practice.

Methods: This mixed methods systematic review adopted a convergent, integrated design to facilitate thematic synthesis. This study followed the guidelines of the *Joanna Briggs Institute Manual for Evidence Synthesis*.

Results: We identified 3 analytical themes: *learning processes implemented to stimulate critical thinking*, *organization of the learning process to stimulate critical thinking*, and *factors influencing the perception of the learning process*. We also identified 4 guidance models, all based on facilitator or preceptorship models using tailored instructional or learning strategies and one or several technological tools that were either generic or custom-made for specific outcomes. The main facilitators of these technology-supported guidance models were nurse educators or nurse preceptors, and the main challenges in using technology-supported guidance models were the stress associated with technical difficulties or increased cognitive load.

Conclusions: Although we were able to identify 4 technology-supported guidance models, our results indicate a research gap regarding the use of these models in nursing education, with the specific aim of stimulating the development of critical thinking. Both nurse preceptors and nurse educators play a crucial role in the development of critical thinking among nursing students, and technology is essential for such development. However, technology-supported guidance models should be supervised to mitigate the associated stress.

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KEYWORDS

critical thinking; guidance models; technology; nursing education; clinical practice

Introduction

Background

The increasing complexity of modern health care demands not only a new kind of thinking among nurses but also a complex set of skills and competencies [1]. Although earlier nursing education focused on building knowledge [2], modern nursing education to teach highly professional nurses needs to shift its focus to nurses' ability to combine various skills and competencies that demand critical thinking [3].

Critical thinking can be understood as a manifestation of a set of dynamic skills that are purposeful and self-regulatory [4]. A critically thinking nurse is creative, flexible, and open-minded [5] and is able to question established assumptions [6]. To acquire a deeper understanding of a situation, a critically thinking nurse considers its context [7] and exhibits the ability to think logically, seek information, and transform knowledge into actions [8]. Hence, critically thinking nurses are highly skilled professionals [7]. Despite the importance of critical thinking in nursing practice, concerns have been raised as to whether newly graduated nurses possess the necessary level of critical thinking skills [9-11]; therefore, the means by which nursing students become critical thinkers has become a recurring topic in nursing education [12].

Traditionally, clinical practice during nursing education has been an important learning context in becoming a highly skilled professional nurse and, as such, also a critical thinker. In European countries, learning has mostly been facilitated through a guidance model in which registered nurses as nurse preceptors provide continuing guidance and nurse educators maintain oversight of the learning process [13]. A guidance model is a distinct way of organizing clinical practice for nursing students, involving predefined tasks, procedures, and guidelines. According to these models, nursing students are guided in clinical practice to achieve learning outcomes [14].

The introduction of technological tools has transformed nursing education in many ways and facilitated flexible new approaches in the education of nursing students [15]. Previous research has questioned whether technology can be used to facilitate the development of critical thinking [16]. The use of tailored technological tools in nursing education seems still to be somewhat limited [17], but earlier research has shown that mobile-based learning may support the development of knowledge and nursing students' skills both outside and within clinical practice [18]. Technology-supported guidance models draw on the principle of integrating technological tools into guidance models and the use of technological tools to increase knowledge and improve attitudes and learning outcomes [19].

Previous systematic reviews have focused on the effectiveness and obstacles of teaching strategies in the development of critical thinking, with or without the use of technology, but not in the context of clinical learning and guidance [20-24]. Other systematic reviews have focused on the use of mobile

technology in nursing education but without an explicit focus on critical thinking or clinical learning and guidance [18,25,26].

In these reviews, some of the strategies identified to support the development of critical thinking were problem-based learning, concept mapping, simulation, narrative pedagogy, critical reading and writing, videotaped vignettes, web-based animated pedagogical agents, reflective writing, grand round strategies, videodisc systems, and evidence-based courses [20-24].

The identified obstacles and challenges in supporting the development of critical thinking include learning and educational culture, language barriers, lack of a common understanding of the term *critical thinking*, educators' beliefs and knowledge, and attitudes about critical thinking [23].

No previous systematic review has combined the focus on critical thinking and its development with the use of technology as part of a guidance model in the context of clinical practice. For this purpose, we selected a mixed methods systematic review. A traditional systematic review would provide us with findings that could answer, for example, the effect of interventions; however, adding qualitative data to a systematic review and conducting a mixed methods systematic review enables us to explore a body of literature on both qualitative and quantitative approaches. This provides us with the possibility of examining research gaps and answering multiple research questions. As such, a mixed methods approach may increase the impact and use [27].

Objectives

This review aimed to synthesize existing evidence on a range of guidance models supported by technology and enhance nursing students' critical thinking during clinical practice.

Research Questions

The research questions are as follows:

1. Which technology-supported guidance models are used to stimulate the development of critical thinking in the context of clinical practice in nursing education?
2. What are the challenges and facilitators of such technology-supported guidance models?

Methods

Design

This mixed methods systematic review adopted a convergent integrated design following the guidelines outlined in the *Joanna Briggs Institute (JBI) Manual for Evidence Synthesis* [28]. The review is reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 checklist [29], as described in [Multimedia Appendix 1](#). Deviations from the published protocol [30] are summarized in [Multimedia Appendix 2](#) [31-35].

Ethics Approval

This study is exempt from institutional review board evaluation [28].

Eligibility Criteria

The eligibility criteria are elaborated in [Textbox 1](#).

Textbox 1. Inclusion and exclusion criteria [30].

<p>Inclusion criteria</p> <ul style="list-style-type: none"> • Study population: preregistration nursing students or undergraduate nursing students • Phenomenon of interest: technological tools used in clinical practice, technology-assisted guidance models, technology-supported guidance models, guidance models, mentoring, tutoring, preceptorship in clinical practice, or clinical educational models • Context: clinical practice in hospitals, nursing homes, community health care, or other health care institutions and settings • Type of study: qualitative, quantitative, and mixed methods studies using experimental, quasi-experimental, or nonexperimental design published in peer-reviewed journals • Type of outcome: critical thinking, clinical decision-making, analytical thinking, creative thinking, problem solving, reflective thinking, diagnostic reasoning, and clinical judgment <p>Exclusion criteria</p> <ul style="list-style-type: none"> • Study population: nursing students studying at the master's or graduate level; postregistration nursing students; student paramedics; students of midwifery, physiotherapy, or occupational therapy; medical students; and dental students • Phenomenon of interest: technology-assisted guidance models; clinical educational models; guidance models; mentoring, tutoring, or preceptorship outside clinical practice in clinical laboratories or as a preparation for clinical practice; and simulation or technology use in conjunction with simulation • Context: outside clinical practice, such as in classes for preparation for clinical practice, simulation sessions, and training in a clinical laboratory • Type of study: any type of systematic or nonsystematic review, non-peer-reviewed articles, conference proceedings, comments or opinion articles, official guidelines, national nursing curriculums, editorials, abstracts, and doctoral theses • Type of outcome: all outcomes other than those mentioned in the inclusion criteria
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Main Outcome

As previously published in the study protocol of this mixed methods systematic review [30], the primary outcome is critical thinking according to the definition of Facione [4], as well as synonyms of the term *critical thinking* as outlined in [Textbox 1](#).

Search Strategy

The review team chose the initial terms suitable for building a search strategy. Using Medical Subject Headings, CINAHL headings, and subject terms, a research librarian (Fredrik Solvang Pettersen), the first author (JZ), and the last author (AAGN) constructed a search strategy for MEDLINE and CINAHL. The search strategy was tested in MEDLINE and CINAHL, peer reviewed by a second research librarian (Mia Ølnes), and then further used in CINAHL, Cochrane Trials, Embase, ERIC, MEDLINE, PsycINFO, and Web of Science. The search strategy has been previously published [30] and is presented in [Multimedia Appendix 3](#). In addition, the first (JZ) and last author (AAGN) conducted forward and backward citation searches. It was not feasible to conduct searches of the gray literature because of the lack of an accepted standard method to conduct such searches [36].

Database searches were performed on October 21, 2020. Database searches were updated on December 3, 2021.

Data Management

Rayyan (Rayyan Systems Inc) [37] used a web-based tool to facilitate the screening process. We used the Paperpile

(Paperpile, LLC) [31] web-based tool for record storage and management.

Selection Process

On the basis of the inclusion and exclusion criteria, titles and abstracts were screened independently by pairs of authors [38] (AAGN and JZ, ERG and MF, MHL and CSL, and SAS and MTS). The first author uploaded the full-text articles to the Notion (Notion Labs, Inc) [39] web-based tool, enabling other authors to access them. The pairs of authors (AAGN and JZ, ERG and MF, MHL and CS-L, and SAS and MTS) then independently assessed the full-text articles and included or excluded them based on the eligibility criteria. We encountered uncertainty regarding the selection of some of the full-text articles, which were discussed with the team in question and the first and last authors. The final decision was made through consensus.

Assessment of Methodological Quality

We appraised the methodological quality of the included studies using the JBI Critical Appraisal Tool checklist for qualitative research [40] and quasi-experimental studies [41]. For mixed methods studies, we used the Mixed Methods Appraisal Tool [42]. This process was conducted independently by the pairs of authors (AAGN and JZ, ERG and MF, MHL and CS-L, and SAS and MTS). We included all studies in the data extraction and synthesis, regardless of the results of the assessment of methodological quality.

Data Extraction and Data Items

Using the standardized JBI Mixed Methods Data Extraction Form and using a convergent integrated method [28], the pairs of authors (AAGN and JZ, ERG and MF, MHL and CS-L, and SAS and MTS) extracted data from the included studies. We included data on the country of origin, year of publication, population, phenomenon of interest, type of study, methods, context, period, outcomes, percentages, averages, significant and nonsignificant results, and themes and subthemes [28].

Thematic Synthesis

We adopted a thematic synthesis approach, which Thomas and Harden [43] regarded as founded upon thematic analysis [43]. The first author (JZ) uploaded the extracted textual data to the MAXQDA tool (VERBI GmbH) for further analysis [32], read the textual data, and used color marking to identify the data or concepts present. Quantitative data were transformed to qualitative data through the process of qualitzation of data, qualitzing the data through textual descriptions of the quantitative data [28]. Following this process, the first author (JZ) conducted line-by-line textual coding, in which, text was segmented and initial codes were developed [43,44]. At this stage, textual data were not related to the research questions. Subsequently, the first author (JZ) reread the textual data, assigned codes, and reviewed them in relation to the research questions. At this stage of the synthesis process, the codes were combined and reduced and a codebook with code definitions was created. The first (JZ) and last (AAGN) authors then individually coded the text segments and jointly reviewed the results, looking for discrepancies or necessary adjustments. The

codes were then further reduced and combined. Through this process, we developed descriptive themes that were closely related to the original text segments [43]. In the next step of the synthesis process, we developed analytical themes to generate new insights [43]. In total, 110 text segments were coded with 80 initial codes and subcodes, with their descriptions. The final number of codes was 14.

The completed codebook and text segments were sent to all the coauthors (ERG, MF, MHL, CS-L, SAS, and MTS), who also individually coded the text segments with the provided codebook. On the basis of this coding, the intercoder reliability was calculated [38] using the DataTab (DATAtab e.U.) [45] statistical tool, which yielded a Fleiss κ of 0.25 on individual codes, indicating fair agreement (0.21-0.40) [46]. After this process, we identified the need for further interpretation, abstraction, and combination of codes and themes. The first (JZ) and last (AAGN) authors conducted a final review of themes and codes relative to the original text segments and further combined and reduced the descriptive and analytical themes. A new intercoder reliability was calculated, which yielded a Cohen κ of 0.49 on individual codes, indicating moderate agreement (0.41-0.60) [47]. With regard to the descriptive themes, Cohen κ was 0.54, also indicating moderate agreement (0.41-0.60) [47]. On the analytical themes, Cohen κ was 0.62, indicating substantial agreement (0.61-0.80) among the coders [47]. The final results comprised 7 descriptive themes and 3 analytical themes. Table 1 provides a detailed overview of the results of intercoder reliability calculations. An example of the coding process is presented in Table 2.

Table 1. Fleis κ and Cohen κ of individual codes, descriptive themes, and analytical themes.

	On individual codes (intercoder reliability among all authors)	On individual codes (intercoder reliability between the first and last authors)	On descriptive themes (intercoder reliability between the first and last authors)	On analytical themes (intercoder reliability between the first and last authors)	Asymptomatic SE	95% CI
Fleiss κ	0.25	N/A ^a	N/A	N/A	0.02	0.21-0.29
Cohen κ	N/A	0.49	N/A	N/A	0.06	0.37-0.61
Cohen κ	N/A	N/A	0.54	N/A	0.07	0.40-0.68
Cohen κ	N/A	N/A	N/A	0.62	0.07	0.48-0.76

^aN/A: not applicable.

Table 2. Example of the coding process.

Analytical themes	Descriptive themes	Code (identifier)	Text segment
Learning processes implemented to stimulate critical thinking	Learning	Learning activities (LA)	The students explained the procedures and nursing skills they had learnt.
Organization of the learning process to stimulate critical thinking	Help and support	Mentoring (ME)	The lecturers avoided teaching the students on the forum and instead tried to give the students possibilities to solve the problems themselves. Giving support to think, compare, and reflect the students' nursing actions.
Factors influencing the perception of the learning process	Technological tools	Advantages of technological tools (ATT)	[The] student and instructor said that they greatly benefited from the use of the mobile e-based system for clinical practicums.

Results

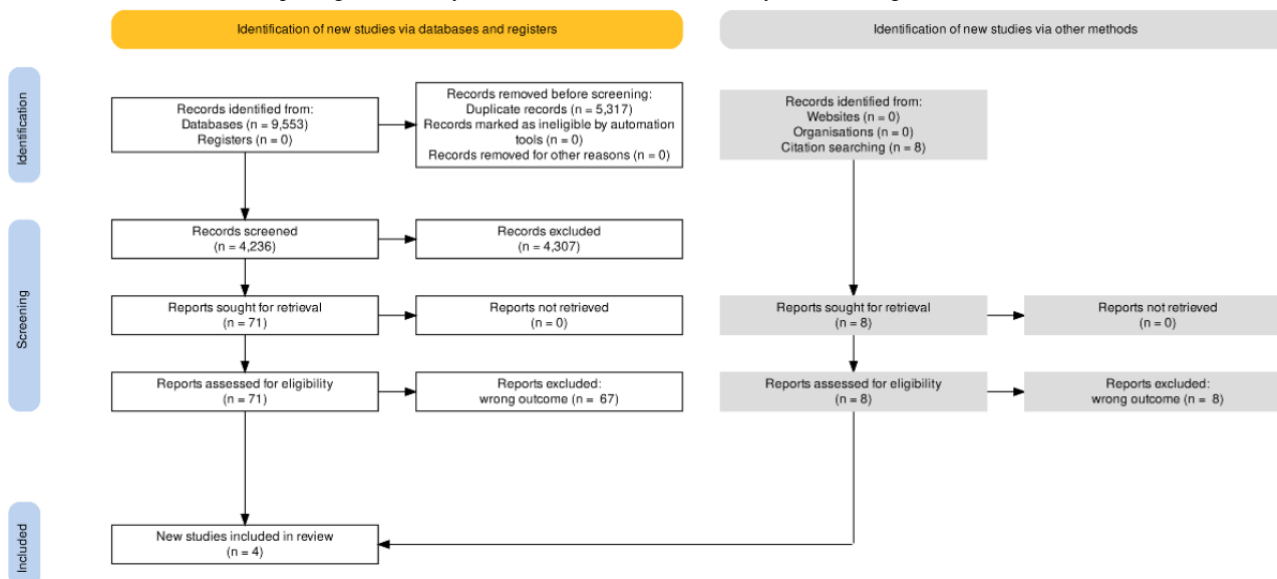
Search and Selection Process

We identified 9553 records, of which, after removing 5317 (55.66%) duplicates, we screened the titles and abstracts of 4236 (44.34%) records. A total of 1.68% (17/9553) of reports were assessed for eligibility, and 0.04% (4/9553) of studies were included.

We identified 8 records through forward and backward citation searches. We retrieved these records and accessed them for eligibility; however, none were eligible for inclusion. We did not contact any other researchers in this field.

Figure 1 provides a detailed overview of the selection process and the reasons for exclusion.

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.



Study Characteristics and Methodological Quality

The studies included in this review (N=4) were conducted in Taiwan (n=3, 75%) [48-50] and Finland (n=1, 25%) [51]. Their sample sizes ranged from 8 to 64 [48-51], and their participants were undergraduate nursing students in clinical practice in community health practice (n=64), psychiatric nursing (n=18), and surgical theaters (n=25) [48-51].

All the studies (N=4) used the organized guidance of nursing students in a procedural setup, but the guidance models were poorly described in all the articles, which lacked detailed descriptions of both guidance procedures and student follow-up and cooperation between nurse preceptors and nurse educators [48-51].

The technological tools used in the studies included web-based discussion forums (1/4, 25%), mobile devices (1/4, 25%), e-portfolio systems (1/4, 25%), and e-book systems (1/4, 25%).

A description of the theoretical framework was provided in 2 studies [49,51].

Lai and Wu [48] measured critical thinking among participants using an author to develop a competency scale that included critical thinking and was a student- and instructor-assessed scale. Wu et al [50] also evaluated critical thinking on a scale that authors called “The seven dimensions of learning effectiveness.” No information was provided regarding the characteristics of the scales or the scoring methods.

All included studies (N=4) either lacked information, such as a description of the design and methods, or provided an unclear statistical analysis or unclear interpretation of the results [48-51]. Multimedia Appendix 4 [48-51] provides a detailed overview of the characteristics of the studies. The assessment of methodological quality is provided in Multimedia Appendix 5-8.

Results Related to the Research Questions

Overview

To answer the research questions, the results were organized on the basis of the analytical themes presented in Table 3: *learning processes implemented to stimulate critical thinking, organization of the learning process to stimulate critical thinking, and factors influencing the perception of the learning process.*

The first research question aimed to identify technology-supported guidance models used to stimulate the development of critical thinking in the context of clinical practice in nursing education. All participants in the selected studies [48-51] received guidance during clinical practice through lecturers, nurse preceptors, or both, and the guidance was supported by technological tools. Table 4 provides a detailed overview of the organization of guidance and the technological tools used to support guidance.

Table 3. Comprehensive overview of analytical themes, descriptive themes, codes, and their definitions.

Analytical and descriptive themes	Code (identifier)	Code definition	Study
Learning processes implemented to stimulate critical thinking			
Teaching	Instructional strategies (IS)	A teacher's overall approach that facilitates the learning process and includes various teaching activities, strategies, styles, and training; includes time allocated for learning	[49,51]
Learning			
	Learning activities (LA)	Activities targeted toward the learning process that involve technology and learning from one's own and others' experiences, discussions, or reflections	[49,51]
	Learning results (LR)	The effect of diverse approaches and guidance on the process of learning	[49-51]
	Learning strategy (LS)	Approaches that facilitate diverse learning styles without the use of technology	[49,51]
	Learning motivation (LM)	The motivation to learn; a personal drive to learn and acquire knowledge	[50,51]
Professional knowledge	Knowledge construction (KC)	The process of evaluating, adding, explaining, transforming, and summarizing information, including self-awareness of what one does not know as well as reflection, self-judgment, self-observation, and consciousness of one's own needs	[48,49,51]
Professional skills	Competence (C)	The set of skills and abilities by which one connects theoretical knowledge with practice and understands context; includes both acquired and improved competence	[48,50,51]
Organization of the learning process to stimulate critical thinking			
Technological tools	Use of technological tools (UTT)	Various uses of diverse technological tools to showcase one's work, write daily journals, submit assignments, search for answers, complete daily tasks, access necessary information, and assess learning; technological tools serving as cognitive tools; use of discussion forums	[49,51]
Help and support			
	Mentoring (ME)	The process of giving students the opportunity to solve problems and of providing support for thinking and reflecting on their actions	[51]
	Supervision (SUP)	The process of continuous supervision	[51]
	Peer support (PSU)	Sharing learned knowledge, creating dialogue and conversation, and understanding and encouraging one another	[51]
Factors influencing the perception of the learning process			
Technological tools			
	Technical problems (TP)	Technical problems that make the use of technological tools challenging	[48]
	Advantages of technological tools (ATT)	Positive experiences of using technological tools and descriptions of their advantages	[48-50]
	Stress (ST)	Stress in relation to learning or using technological tools	[48,50]

Table 4. Organization of guidance and technological tools used in guidance.

Study	Organization of guidance	Technological tools used in guidance
Mettiäinen and Vähämaa [51]	Supervision organized in a web-based discussion forum in which guidance was provided by nurse educators with additional attention to peer support	An online discussion forum on the Moodle platform (a learning management system)
Lai and Wu [48]	A clinical e-portfolio system supervised by nurse educators	An e-portfolio system running on mobile netbooks
Lai and Yen [49]	Guidance provided by nurse educators, both with and without the use of technological tools	A mobile voice recording app, various evaluation apps, videos, mobile devices, and a web-based learning platform
Wu et al [50]	An e-book system in conjunction with guidance from nurse preceptors and nurse educators	A web-based e-book system

Learning Processes Implemented to Stimulate Critical Thinking and Organization of the Learning Process to Stimulate Critical Thinking

With regard to our primary outcome of critical thinking, the results showed that critical thinking was described in diverse terms in the selected studies. Mettiäinen and Vähämaa [51] refer directly not only to the term critical thinking but also to reflective thinking, whereas Wu et al [50] refer to both critical and creative thinking and problem solving. Lai and Wu [48] and Lai and Yen [49] also use the term critical thinking.

Technological tools were not used on their own but jointly with varied instructional and learning strategies and activities to stimulate the development of critical thinking. Among such strategies were discussion [51], demonstration [49], dividing students into groups to tailor learning, compulsory participation and preparation of students for activities, giving students space and time to learn, and supporting students through their learning while motivating them to share their experiences [51].

Other strategies include checking factual information against theory [51], viewing one another's assignments [48], comparing diverse learning strategies, posting and reading comments in a web-based environment [51], and observing patients' states [49]. During these activities, improvements in the ability to reflect [49,51] and improved theoretical knowledge and practical skills were observed [48]. Students also experienced improved self-satisfaction and became aware of their own feelings, learning needs, and areas where their skills needed improvement [48,50,51].

To support the development of critical thinking, lecturers supported students in various ways, such as by providing feedback [50] and giving time and opportunities for students to find their own solutions [51]. The lecturers avoided teaching the students and gave them opportunities to solve problems themselves. The lecturers also provided comments and feedback and supported the students' thinking, reflection, and discussion. The lecturers followed the students' discussions and provided active and continuous supervision [51]. The students also found support from their peers, with whom they could share knowledge, feelings, conversations, encouragement, and understanding [51].

Lai and Wu [48] measured critical thinking as a part of competency among participants, as assessed by instructors and showed increased scores from 2.7 at week 1 to 4.3 at week 3 ($P < .001$). Wu et al [50] did not provide any results for critical thinking in their evaluation of "The seven dimensions of learning effectiveness."

Factors Influencing the Perception of the Learning Process

The second research question aimed to identify the challenges and facilitators of technology-supported guidance models. In the included studies, we found that some guidance models used custom-made technological tools (such as bespoke software) that were created or adapted for the context [48,50,51], whereas others used mobile devices in a more generic way [49]. In addition, some guidance models used only one technological tool, whereas others incorporated several technological tools

simultaneously, as noted in Table 4. All the technological tools described in the chosen studies at least partially required access to the internet to work for their intended purpose [48-51]. Some technological tools required that users connect to the internet at home [51], whereas others used the available internet access in clinical practice [48-50].

The students deemed technological tools to be beneficial facilitators of learning in clinical practice [48]. These tools facilitate reflection and decision-making [50]; serve as additional learning resources [48]; facilitate discussions [50,51]; and improve competencies, patient care, and interactions with instructors [48]. Technological tools also gave students opportunities to showcase their own work [50], achieve clinical practice objectives [50], write daily reflective journals, and take notes of important information [49]. They also facilitated patient assessment, writing and submitting assignments, summarizing information, and recording instructors' demonstrations [50]. The students who used technological tools in clinical practice scored better on evaluation instruments than their counterparts who did not use the tools [50].

However, technology-supported guidance models were also associated with stress, which was identified in relation to the challenges or mental load of students in a technology-supported guidance model. Some students experienced an increased mental load related to spending more energy and mental resources on tasks in clinical practice than those who did not receive guidance involving technology [50]. Other students experienced stress related to technical challenges that hindered the use of technological tools, such as setting up a wireless internet connection in clinical practice [48].

Discussion

Principal Findings

This review synthesizes the existing evidence on a range of guidance models supported by technology to enhance nursing students' critical thinking during clinical practice. However, of the 71 reports assessed for eligibility, only 4 (6%) were eligible for inclusion, which may point to a research gap. The topic of technology-supported guidance models in conjunction with critical thinking and in the context of nursing students' clinical practice appears to be an underresearched area.

In all the included studies, guidance and technological tools were set up and organized within a guidance model, a framework with an organized, predefined set of procedures [14]. We identified diverse types of technology-supported guidance models in which nurse preceptors, nurse educators, or both provided guidance with the support of one or more technological tools. Although none of the studies offered detailed descriptions of the guidance model, all the guidance models we identified were either preceptor and facilitator or preceptor based [52]. The facilitation- or preceptor-based guidance model, in which nursing students, nurse preceptors, and nurse educators cooperate in the guidance process, is common in European countries. The main advantage of this approach is the provision of mutual support and exchange of knowledge, which ensures that nursing students develop the necessary competencies and

achieve learning outcomes [53]. However, the degree of cooperation may vary, and cooperation may be challenging [53,54].

We also found that the guidance of nursing students in these technology-supported guidance models occurs in 2 distinct ways. In one instance, guidance was provided by a nurse preceptor in clinical practice without access to or the use of technological tools, whereas guidance was simultaneously provided by nurse educators with the support of such tools. However, if the common guidance models are facilitation- or preceptor-based [53], nurse educators and nurse preceptors do not have access to or use the same technological tools, which may exacerbate division and result in less cooperation and support. In other instances, guidance with access to and support from the same technological tools was provided by both nurse preceptors and nurse educators.

We found that only half of technology-supported guidance models were based on a theoretical framework [49,51]. If we regard such models as interventions, it is necessary to base the intervention on a theoretical framework that can provide understanding and important insights on how a guidance model works and creates change [55].

This systematic review also found that technology-supported guidance models include diverse instructional and learning strategies, including reflection, discussion, and demonstration. Thus, our results confirm the findings of previous research, which showcase a plethora of approaches to support the development of critical thinking [20-24].

Regardless of the approach to critical thinking, it is regarded as something that can be learned [12]. Our findings identified learning activities targeted at critical thinking, such as comparing and contrasting, observational learning, discussion in an e-environment (ie, a discussion forum), and project-based learning. According to Krishna et al [56], students can gain a deeper understanding and develop critical thinking by comparing different concepts or processes; with regard to observational learning, it is assumed that observation contributes to learning through behavior change [57]. Wang et al [58] and Puig et al [59] pointed out that technological tools, such as e-environments, bring advantages that enhance the learning of critical thinking skills, as students in an e-learning environment can easily discuss, collaborate, or practice diverse skills. As Lee et al [21] noted, there is no universal agreement on the most suitable approach to developing critical thinking. However, this diversity of approaches may reflect that critical thinking is a multidimensional concept; as such, the development of critical thinking can be approached in various ways [12].

In our findings, the students perceived technological tools as essential to clinical practice; they might be used for many purposes, such as a knowledge database, sharing of experiences, or as knowledge or communication tools [48-51]. Contrary to our results, Lee et al [25] found no evidence that technological tools, such as mobile technology, support the development of knowledge or skills.

We identified nurse educators as the main facilitators of technology-supported guidance models. Nurse educators have

facilitated these guidance models by supporting students in various ways, such as allowing time for students to find their own solutions [51] and providing situational feedback [48,50]. Nurse educators also avoided teaching the students and gave them opportunities to solve problems themselves. Nurse educators provided comments and feedback and supported students in thinking, reflection, and discussion.

Nurse educators also followed the discussions and provided active and continuous supervision [51]. These findings on the contributions of nurse educators have been confirmed in previous research [53,54] and point to the fact that technological tools in guidance models cannot be introduced on their own but require oversight, as well as support and mentoring by nurse educators, and peers may be a valuable addition in facilitating technology-supported guidance models. Students perceive their peers as facilitators who provide support by sharing knowledge and feelings, engaging in conversation and encouraging and understanding one another [49,51]. The positive influence of peer support and interaction has also been confirmed in previous research [60]. Anderson and Soden [60] pointed out that peer interaction is important for developing critical thinking skills.

In line with previous research [61], we identified the need for infrastructure, such as internet or Wi-Fi access, for technological tools to work properly [48]. Previous research has shown that simply setting up a technological tool, such as an e-learning environment, is not sufficient to support the development of critical thinking; resources, careful planning, and implementation are also required [59]. Our results indicate that technological tools were set up by educational institutions [48-51] and supervised mostly by lecturers [48,49,51] and that students were provided with regular feedback [48-51].

Our findings also show that technological tools are to varying degrees customized for the context in which they are used [48-51]. Students have called for bespoke technological tools [17]; however, as O'Connor and Andrews [17,61] found, most technological tools, such as mobile apps used in nursing education, are generic and not customized for the specific needs of nursing students. This may be particularly relevant if the aim of technological tools is to stimulate the development of critical thinking. However, if customized technological tools are used, they must be developed collaboratively with nursing students to ensure that their functionality addresses the specific context of nursing education and clinical practice [17].

We observed that technology-supported guidance models can cause stress that can influence the development of critical thinking [48,50]. O'Connor and Andrews [61] pointed out that technological tools have many advantages, but some students may experience them negatively, causing stress. Upadhyaya [62] described the stress caused by technological tools as *technostress*, which in the worst case may negatively influence students' academic productivity.

Regarding the primary outcome, we found various usages of the term *critical thinking* and its synonyms, confirming earlier research. As Mundy and Denham [63] and Andreou et al [64] pointed out, there is no consistent agreement among educators or students in the understanding of critical thinking and the approaches that may support its development, which may pose

a challenge in implementing technology-supported guidance models.

Strengths and Limitations

This mixed method systematic review has several strengths. We conducted a comprehensive literature search and pairs of independent researchers appraised the quality of the resulting articles. We then conducted thematic synthesis with textual coding, with all authors coding the same texts, and the intercoder reliability was calculated to ensure the integrity of the results. Other strengths of this review include the inclusion of newer articles and the use of innovative contemporary technological tools in all included articles.

The primary outcome was critical thinking among nursing students in clinical practice. In line with our inclusion criteria and the definition of critical thinking according to Facione [4], we found that critical thinking was described directly by the concept of critical thinking, by the use of other synonymous concepts, or by a broader description.

All the included studies used some kind of intervention or technique to stimulate the development of critical thinking, although the aims of these interventions or techniques related to the development of critical thinking may be implied. Consequently, the included studies met the inclusion or exclusion criteria for this mixed methods review.

We followed the principles of thematic synthesis outlined by Thomas and Harden [43]. However, the researchers [43] did not use a traditional codebook in their approach to thematic synthesis; instead, they used a diagram of relationships among the descriptive themes, which was created by the EPPI Reviewer software [65]. As this study did not use EPPI Reviewer, we created a traditional codebook with code definitions to facilitate the coding process.

Thomas and Harden [43] did not outline a process for calculating intercoder reliability, but the authors of this study built a thematic synthesis on thematic analysis. Braun and Clarke [66] note that calculating intercoder reliability is an important step to ensure the quality and integrity of the coding process.

The initial result of the intercoder reliability calculation among all the authors indicated only fair agreement; however, that calculation clarified the need for further analysis, abstraction, and reduction of codes and themes, leading to a more robust coding process and result. The final intercoder reliability of analytical themes between the first and last authors indicates substantial agreement.

The main limitation of this systematic review is the quality of the included articles, all of which lacked detailed descriptions of technology-supported guidance models and research methods. However, we chose to include all studies in the synthesis, regardless of their methodological quality. One could argue that this decision weakened the final review, but our rationale was that the included studies uncovered a potential research gap,

pointing to areas that merit exploration in future research, with a focus on methodological rigor. We were also able to identify valuable experiences with technology-supported guidance models that could both inspire and strengthen future research and the design of guidance models.

We also used a search strategy that identified several studies in Chinese and Korean that were potentially relevant to the aim of the review, but which, because of the language barrier, had to be excluded. Thus, we may have missed eligible studies that were unavailable in English.

Regarding other limitations, we tried on the basis of earlier research to identify all possible synonyms of the term *critical thinking*, which were used in the literature search and screening process. However, because of the multidimensional nature of critical thinking, we may have missed some terms that authors used to describe critical thinking, which may have influenced the search strategy and, consequently, the identification of potential articles.

Conclusions

In nursing education, a few technology-supported guidance models that vary in setup and organization are used to stimulate the development of critical thinking in the context of clinical practice. The main characteristic of these models is the combination of instructional strategies with the active use of technological tools during guidance. The type of technological tools and how they are used in these guidance models vary across models. Thus, when using technology-supported guidance models, one should consider the underlying technological, instructional, and learning strategies incorporated in such models, as well as their suitability for intended use.

The main facilitators of these technology-supported guidance models are lecturers and nurse preceptors, who play an important role in nursing students' guidance and support the development of critical thinking.

Technological tools themselves can be the primary facilitators of these guidance models, enabling the development of critical thinking. However, technology-supported guidance models can also cause stress, which may negatively affect the development of critical thinking skills among nursing students.

We do not have sufficient data nor it is the aim of this mixed method review to conclude with which technology-supported guidance model is superior or inferior in relation to supporting the development of critical thinking.

The findings of this mixed methods systematic review are relevant to the future development of technology-supported guidance models that support the development of critical thinking among nursing students in clinical practice. However, because of the quality of the included studies, we recommend that our results be used only as inspiration for further research or in designing new technology-supported guidance models.

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Authors' Contributions

JZ was responsible for conceptualization, methodology, formal analysis, writing the original draft, writing the review and editing, visualization, and project administration. ERG and MF were responsible for writing the review and editing, formal analysis, and supervision. MTS, SAS, CSL, and MHL were responsible for writing the review and editing and formal analysis. AAGN was responsible for methodology, formal analysis, writing the review and editing, visualization, and supervision.

Conflicts of Interest

None declared.

Multimedia Appendix 1

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 checklist.

[PDF File (Adobe PDF File), 85 KB - [nursing_v5i1e37380_app1.pdf](#)]

Multimedia Appendix 2

Deviations from study protocol.

[PDF File (Adobe PDF File), 64 KB - [nursing_v5i1e37380_app2.pdf](#)]

Multimedia Appendix 3

Example of the MEDLINE search strategy applied to all databases in the search strategy.

[PDF File (Adobe PDF File), 112 KB - [nursing_v5i1e37380_app3.pdf](#)]

Multimedia Appendix 4

Study characteristics and methodological quality of the included studies.

[PDF File (Adobe PDF File), 158 KB - [nursing_v5i1e37380_app4.pdf](#)]

Multimedia Appendix 5

Joanna Briggs Institute checklist for qualitative research—article 1.

[PDF File (Adobe PDF File), 633 KB - [nursing_v5i1e37380_app5.pdf](#)]

Multimedia Appendix 6

Mixed Methods Appraisal Tool—article 2.

[PDF File (Adobe PDF File), 816 KB - [nursing_v5i1e37380_app6.pdf](#)]

Multimedia Appendix 7

Joanna Briggs Institute checklist for qualitative research—article 3.

[PDF File (Adobe PDF File), 1035 KB - [nursing_v5i1e37380_app7.pdf](#)]

Multimedia Appendix 8

Joanna Briggs Institute checklist for quasi-experimental studies—article 4.

[PDF File (Adobe PDF File), 1067 KB - [nursing_v5i1e37380_app8.pdf](#)]

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Abbreviations

JBI: Joanna Briggs Institute

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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Review

The Impact of Digital Health Transformation Driven by COVID-19 on Nursing Practice: Systematic Literature Review

Robab Abdolkhani^{1*}, PhD; Sacha Petersen^{1*}, PhD; Ruby Walter^{1*}, PhD; Lin Zhao^{1*}, PhD; Kerryn Butler-Henderson^{1*}, PhD; Karen Livesay^{1*}, PhD

School of Health and Biomedical Sciences, Science, Technology, Engineering, and Mathematics College, Royal Melbourne Institute of Technology University, Melbourne, Australia

* all authors contributed equally

Corresponding Author:

Robab Abdolkhani, PhD

School of Health and Biomedical Sciences

Science, Technology, Engineering, and Mathematics College

Royal Melbourne Institute of Technology University

289 McKimmies Rd

Bundoora

Melbourne, 3083

Australia

Phone: 61 98098654

Email: robab.abdolkhani@rmit.edu.au

Abstract

Background: The COVID-19 pandemic has accelerated the uptake of digital health innovations due to the availability of various technologies and the urgent health care need for treatment and prevention. Although numerous studies have investigated digital health adoption and the associated challenges and strategies during the pandemic, there is a lack of evidence on the impact on the nursing workforce.

Objective: This study aims to identify the impact of digital health transformation driven by COVID-19 on nurses.

Methods: The online software Covidence was used to follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. Relevant scientific health and computing databases were searched for papers published from January 2020 to November 2021. Using the 8D sociotechnical approach for digital health in health care systems, the papers were analyzed to identify gaps in applying digital health in nursing practice.

Results: In total, 21 papers were selected for content analysis. The analysis identified a paucity of research that quantifies the impact of the digital health transformation on nurses during the pandemic. Most of the initiatives were teleconsultation, followed by tele-intensive care unit (tele-ICU), and only 1 (5%) study explored electronic medical record (EMR) systems. Among the sociotechnical elements, the human-related factor was the most explored and the system measurement was the least studied item.

Conclusions: The review identified a significant gap in research on how implementing digital health solutions has impacted nurses during the COVID-19 pandemic. This gap needs to be addressed by further research to provide strategies for empowering the nursing workforce to be actively involved in digital health design, development, implementation, use, and evaluation.

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KEYWORDS

digital health; COVID-19 pandemic; nursing informatics; nursing workforce

Introduction

In 2019, when the COVID-19 pandemic was declared worldwide, the delivery and organization of health care were propelled into an environment of rapid change. The change was associated with the deployment of staff, isolation of patients,

protection of staff well-being, and public health education and initiatives to reduce or slow the transmission of the virus [1]. The pandemic has likely accelerated the adoption of digital health implementation [2]. Similarly, nurses providing care across a broad range of health care contexts, including community, primary health care, tertiary health care, and

specialist services, such as aged care, are likely to be impacted by the uptake of digital technologies [3].

As the pandemic has not yet passed, it is expected that digital health will play an increasingly critical role in the future and even the postpandemic era due to the availability of various technologies and the urgent health care need for treatment and prevention [4]. The pandemic created a widespread and rapid adaptation to previously limited or unused forms of technology; this rapid adaptation has changed the ways clinicians and patients interact, for example, the now commonplace use of telehealth appointments rather than face-to-face appointments. Indeed, health care systems are investing much effort and focus on establishing long-term strategies to integrate digital health care models into routine practices and equip clinical professionals with knowledge and expertise to apply digital technologies efficiently [5].

The need for digital health implementation requires a transformation in nursing roles to acquire informatics-related skills to optimize and advance in this field in research, practice, and education. The pivotal contribution of nurses to the population's health worldwide is undeniable. However, despite the necessity for increased digital health adoption in the health care system, the skills nurses need to obtain to participate in digital health implementation are not comprehensively understood. As stated in Wu's study [6], the literature that discusses the need for nursing informatics skills was significantly increased since the COVID-19 outbreak (from January 2020 to August 2021), of which 36.7% emphasized informatics skills for nurses in clinical settings and 28.6% highlighted nursing informatics education. It is yet unclear how the COVID-19 pandemic is transforming the nursing professionals' awareness of digital health—in other words, what skills nurses are required to achieve and how they can be trained during nursing education to efficiently act in digitally rich health care organizations.

Although digital health competencies for nurses were extensively outlined in the nursing informatics field [7], there are still uncertainties as to which technologies and to what extent nurses need to learn and work. Before the pandemic, digital health adoption was lacking due to numerous technical, organizational, environmental, behavioral, and operational challenges, whereas most of these issues were abandoned due to the pandemic priorities. However, despite the unprecedented expansion of digital health technologies during the pandemic, many countries worldwide were not sufficiently ready to utilize them due to these challenges [8]. Therefore, these issues need to be considered for adopting these initiatives to prepare the health care workforce for future pandemics [9].

The COVID-19 pandemic has transformed current digital health models to have an increased focus on interdisciplinary teams to co-design, develop, and implement digital health solutions [10]. Experienced nurses who received professional training in informatics can play a critical role in such teams. It is essential to understand which digital health technologies were established during the pandemic. Moreover, the environments in which they are used, the users interacting with those technologies, the communication between different tools and users, and the

workflows and processes being performed all impact the data, information, and knowledge generated and the decisions made.

The digital health implementation experience during the pandemic indicates the need for effective planning to use these initiatives distinct from the prepandemic models. For example, it is critical to avoid disparities in accessing care when selecting digital health solutions [11]. These disparities include nurses who faced challenges accessing and using digital health technologies during the pandemic. To mitigate such inequities, nurses need to be educated and actively involved throughout the digital health pipeline. This study aims to answer the question “How did the digital health transformation driven by COVID-19 impact nurses?” The following questions address this overall question:

- Which digital health initiatives were implemented or expanded in health care during the COVID-19 pandemic?
- In what contexts were the digital health initiatives implemented or expanded?
- What issues influenced nurses' experience of these digital health initiatives?
- What methods were used to identify these issues?
- What gaps were raised in these studies about nurses' digital health experience during the pandemic that need to be considered?

Methods

Search Strategy

A literature review was conducted using the online software Covidence following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol [12] shown in Figure 1. The search concepts fell into 3 categories: COVID-19, digital health, and nursing. The concepts and their associated Medical Subject Headings (MeSH) and non-MeSH terms are described in Table 1. Cited and citing sources were double-checked to ensure no relevant items were missed.

The Boolean operator OR was used between the terms in each category, and then the operator AND was applied to combine the results by category. The search was applied to terms occurring in the title, abstract, or body text of full-text publications. The time frame selected was when COVID-19 was announced as a pandemic up to the time we conducted this study from January 2020 to November 2021. Scientific subscription databases searched contained both health and computing and information science databases, including PubMed, Ovid MEDLINE, Scopus, Web of Science, Institute of Electrical and Electronics Engineers (IEEE) Xplore, and Association for Computing Machinery (ACM) Digital Library. Google Scholar's database was also searched using the same terms.

The search results were imported from Endnote into Covidence. The authors double-screened the titles and abstracts based on the eligibility criteria defined at the screening stage shown in the PRISMA flowchart. In the case of conflicts among the authors on a title or abstract exclusion, discussions were undertaken in regular meetings to reach a consensus. This

approach was then applied to the selected abstracts to conduct the full-text review. The papers selected following double full-text review were accepted for the content analysis.

Figure 1. PRISMA diagram. ACM: Association for Computing Machinery; IEEE: Institute of Electrical and Electronics Engineers; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

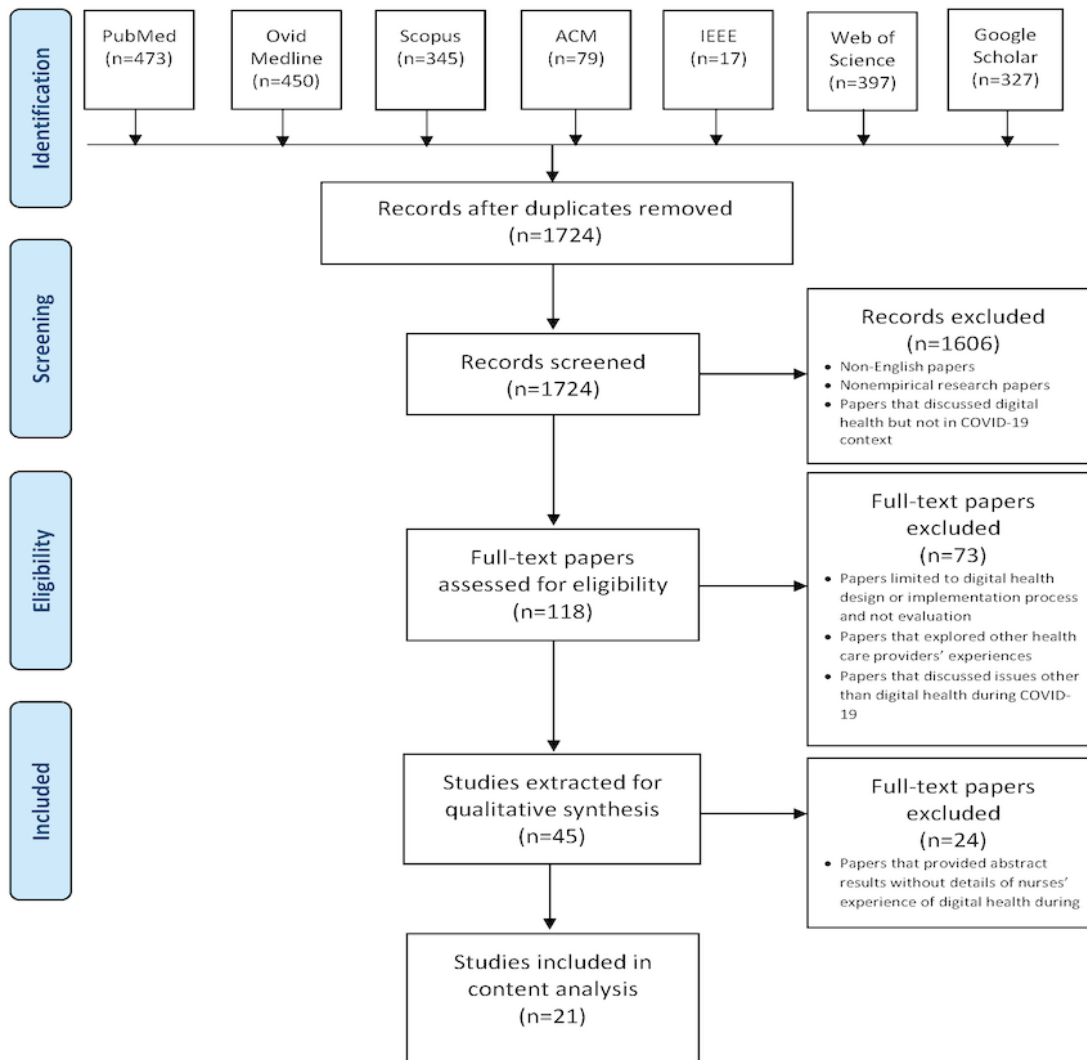


Table 1. Search terms.

Search concepts	MeSH ^a terms	Non-MeSH terms
COVID-19	<ul style="list-style-type: none"> • COVID-19 	<ul style="list-style-type: none"> • Coronavirus disease • COVID-19 • COVID-19 pandemic • COVID-19 disease • Global pandemic
Nursing	<ul style="list-style-type: none"> • Nurse • Telenursing • Advanced practice nursing • Evidence-based nursing • Nursing education • Nurse practitioners 	Nurs* +: <ul style="list-style-type: none"> • educators • professional • informatics • informatician
Digital health	<ul style="list-style-type: none"> • Artificial intelligence • Augmented reality • Big data • Clinical decision support systems • Computerized medical record • Deep learning • Electronic health record • Electronic medical record • Electronic record systems • Health information exchange • Machine learning • Patient portals • Remote sensing technology • Social media • Telemedicine • Virtual reality 	<ul style="list-style-type: none"> • Connected health • Digital health • Digital medicine • Digital therapeutics • eHealth • mHealth^b • Mobile health • Remote patient monitoring • Remote monitoring • Smart home • Telehealth • Telemonitoring • Telerehabilitation • Virtual care

^aMeSH: Medical Subject Headings.

^bmHealth: mobile health.

Eligibility Criteria

Studies were eligible for review if they presented original research in the English language, discussed digital health initiatives implemented during the COVID-19 pandemic, and addressed nurses' experience in using digital health during the pandemic. Exclusion criteria were considered at each stage of the PRISMA flowchart to exclude publications not relevant to this study.

Content Analysis

A descriptive qualitative approach to content analysis [13] was used to describe the characteristics of the included studies that were relevant to the research questions outlined in the background. This approach is well suited for analyzing the multifaceted use of digital health in nursing practice in various health care contexts. Inductive reasoning was applied to investigate the literature to answer the study questions [14]. Next, the 8D sociotechnical model designed by Sitting and Singh [15] was selected to deductively analyze the selected studies and explore the interaction between digital health tools and technologies, individuals, and activities. This approach was applied to better understand the nurses' experience of issues inherent in the design, development, implementation, use, and evaluation of digital health solutions during the pandemic. The findings were synthesized based on the 8 themes of the sociotechnical approach, including hardware and software computing infrastructure; clinical content; human-computer

interface; people; workflows and communication; internal organizational policies, procedures, and culture; external rules, regulations, and pressures; and system measurement and monitoring. To ensure interrater reliability, 3 researchers undertook the content analysis independently.

Results

Characteristics of the Included Studies

A total of 21 studies met the inclusion criteria: 4 (19%) qualitative studies targeted nurses only [16-19], whereas the remaining 17 (81%) studies included nurses and other health care providers and did not differentiate nurses' responses from others [20-36].

In addition, 13 (62%) studies explored users' experience with digital health applications for COVID-19 control [16,17,19-22,26-30,35,36]. In comparison, 8 (38%) studies investigated the use of digital health to manage other acute and chronic conditions during the pandemic, including pediatric otolaryngology [23], alcohol management [18], cancer management [24], hemophilia [25], opioids [31], pediatric chronic pain [34], and mental [32], behavioral, and sexual health [33].

In terms of digital health services, 16 (76%) studies used teleconsultations in home care [16-25,30-34,36], 4 (19%)

applied tele-intensive care unit (tele-ICU) [27-29,35], and 1 (5%) study focused on electronic medical records (EMRs) [26].

Regarding the type of health care setting, 10 (48%) studies were conducted in hospital settings [16,20,23,25-29,34,35], 8 (38%) studies were conducted in primary care facilities

[17,19,21,24,30,31,33,36], 2 (10%) studies included both primary care and hospital organizations [18,32], and 1 (5%) study involved national nonclinical institutes [22].

The characteristics of the selected studies are shown in [Table 2](#). The studies were sorted in alphabetical order.

Table 2. Characteristics of the selected studies (N=21).

First author/year	Type of digital health service	Study aim	Method
Arem/2021	Teleconsultations	Understanding the provider and survivor perspectives on the impact of telemedicine on cancer survivorship care during the pandemic	Of 607 health care providers, 273 (45%) were nurses. They were surveyed about their experience with telehealth.
Bavare/2021	Tele-ICU ^a	Studying how hybrid ward rounds could facilitate social distancing and maintain patient-centered care	Of 114 participants, 32 (28%) were nurses. They participated in a mixed methods study to evaluate the usability of a video conference platform implemented for interaction between the patient, the nurse, and the partial ICU team.
Belcher/2021	Teleconsultations	Understanding providers' experience of a 1-month otolaryngology teleconsultation pilot during the COVID-19 pandemic	Of 16 participants, 8 (50%) were nurses. They were surveyed about telehealth appointments that occurred during the study period.
Connolly/2021	Teleconsultations	Assessing provider perceptions of virtual care for mental health by comparing virtual (phone and telehealth) care to in-person care	Of 998 participants, 120 (12%) were nurses. They were surveyed about the quality and efficacy of virtual care versus face-to-face care with masks, the challenges of virtual care, and their willingness to continue virtual care in the future.
Esmailzadeh/2021	Electronic health records (EHRs)	Examining the impact of using EHRs on clinicians' burnout in wards with COVID-19 cases	Of 368 participants, 147 (40%) were nurses. They were asked via a survey about cases of EHR-related burnout and usability challenges.
Franzosa/2021	Teleconsultations	Understanding clinicians' experience of COVID-19-related video visits	Of 13 participants, 3 (23%) were nurses. They were interviewed about the flexibility, benefits, and limits of teleconsultations, as well as factors to consider for future implementation of these services.
Garber/2021	Teleconsultations	Identifying the difference between the COVID-19 telehealth training levels for clinicians and the perceived usefulness, self-efficacy, knowledge, satisfaction, and frequency of actual use of telehealth	Of 224 participants, 47 (21%) were nurses. They were surveyed on the usefulness, self-efficacy, knowledge, use, and satisfaction of telehealth based on the telehealth training provided.
Gilkey/2021	Teleconsultations	Characterizing primary care professionals' recent use and attitudes of adolescent telehealth during COVID-19 and their support of offering telehealth after the COVID-19 pandemic	Of 1047 participants, 123 (12%) were nurses in a national survey of primary care professionals on their experience of teleconsultations with adolescents.
Hughes/2021	Teleconsultations	Exploring nurses' experiences of utilizing virtual care and remote working during COVID-19 to identify what elements could be implemented into a recovery model following the pandemic	In total, 17 operational lead nurses and 31 nurses at different levels of seniority were interviewed (semistructured) on the advantages and disadvantages of telehealth and whether they would support telehealth after the pandemic. Interviews of the first cohort (n=17, 100%) informed the interviews of the second cohort (n=31, 100%).
Hunter/2021	Teleconsultations	Understanding the change of service delivery with opioid treatment programs through the use of teleconsultations during COVID-19	Of 20 participants, 3 (15%) were nurse practitioners. Semistructured phone interviews were conducted on their experience of using teleconsultations and quality implications.
James/2021	Teleconsultations	Exploring the experiences of primary health care nurses in the use of teleconsultations during COVID-19	All 25 (100%) participants were nurses. Semistructured phone interviews were conducted on their preparedness and experience of telehealth.
Killackey/2021	Teleconsultations	Understanding how pediatric pain care clinics operated during COVID-19 and the uptake of virtual care	Of 151 participants, 17 (11%) were nurses. Two online cross-sectional surveys on experience of virtual care were conducted.
Mohammed/2021	Teleconsultations	Exploring the use of virtual visits among primary care providers during COVID-19 and anticipated use postpandemic, understanding user perceptions of the available support tools, and identifying factors that influence success and challenges to adoption and incorporation of virtual visits	Of 200 participants, 37 (19.5%) were nurse practitioners. A descriptive cross-sectional survey of their experience with virtual visits was conducted.

First author/year	Type of digital health service	Study aim	Method
O'Donovan/2020	Teleconsultations	Exploring patient and health care provider experience of telehealth in the European Haemophilia Comprehensive Care Centre during COVID-19	Of 21 health care provider participants, 9 (43%) were nurses. A systematic evaluation of patient surveys and health care provider surveys was performed, and a comparison of in-person appointments and teleconsultations was made.
Park/2021	Teleconsultations	Assessing the satisfaction of patients and medical staff with telemedicine used during the 17-day hospital outpatient/emergency department (ED) closure due to COVID-19	Of 155 medical staff participants, 100 (64.5%) were nurses. Surveys via text were conducted to assess their satisfaction with and experience of teleconsultations.
Pilosof/2021	Tele-ICU	Examining the implementation of telemedicine in COVID-19 ICUs	Of 30 participants, 3 (10%) were nurses. Semistructured interviews were conducted with medical staff, telemedicine companies, and architectural design teams on the use of telemedicine.
Ramnath/2021	Tele-ICU	Developing, implementing, and evaluating a novel tele-ICU program during the COVID-19 pandemic	Of 27 participants, 10 (37%) were nurses. Performance metrics were collected, and surveys of staff perceptions of tele-ICU were conducted.
Safaenili/2021	In-patient telemedicine	Assessing the acceptability and effectiveness of in-patient telemedicine during the COVID-19 pandemic	Of 15 participants, 5 (33.3%) were nurses. Semistructured interviews were conducted with nurses and attending and resident physicians on the use of telemedicine.
Searby/2021	Teleconsultations	Examining the experiences of alcohol and other drug (AOD) nurses transitioning to telehealth during COVID-19	All 19 (100%) participants were nurses. Semistructured interviews were conducted with AOD nurses from Australia and New Zealand on the use of telehealth.
Silva/2021	Teleconsultations	Reporting on monitoring of patients by nursing students who volunteered at COVID-19 clinics with telehealth duties.	All 17 (100%) participants were nurses, including nursing students (n=14, 82%) and nursing professors (n=3, 18%). A descriptive experience report was prepared on phone monitoring 1400 patients, ~80 cases per day.
Srinivasan/2020	Teleconsultations	Assessing rapid transformation to video consultations at an academic medical center during COVID-19	Of 53 participants, 4 (7.5%) were nurses. Semistructured interviews of perspectives on video visit acceptability were conducted.

^aICU: intensive care unit.

Sociotechnical Elements of Using Digital Health in Nursing Practice

The selected studies were synthesized according to the sociotechnical approach. Table 3 shows the frequency of the 8 dimensions of the sociotechnical approach for using digital health technology systems in the selected studies.

As shown in Table 3, none of the selected studies addressed all the 8 dimensions of the sociotechnical approach when exploring nurses' use of digital health during the pandemic. Among the 8 dimensions, the people-related aspect was the most frequently discussed item, studied by 17 (81%) papers, whereas system measurement and monitoring were mentioned in only 2 (10%) papers. Details of each dimension are addressed in Table 4.

Table 3. Frequency of the sociotechnical themes in the included studies (N=21).

Author	Sociotechnical theme addressed (yes/no)							
	Hardware and software computing infrastructure	Human-computer interface	Clinical content	People	Workflows and communication	Internal organizational policies, procedures, and culture	External rules, regulations, and pressures	System measurement and monitoring
Arem	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Bavare	Yes	Yes	No	Yes	Yes	Yes	No	No
Belcher	Yes	No	No	No	Yes	No	No	No
Connolly	Yes	Yes	No	Yes	Yes	No	No	No
Esmailzadeh	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Franzosa	Yes	No	No	Yes	Yes	No	No	No
Garber	No	No	No	Yes	No	No	No	No
Gilkey	Yes	No	Yes	Yes	No	Yes	No	No
Hughes	Yes	No	No	Yes	No	No	No	No
Hunter	Yes	No	No	No	Yes	Yes	No	No
James	No	No	No	Yes	No	Yes	No	No
Killackey	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Mohammed	Yes	No	No	Yes	Yes	Yes	No	No
O'Donovan	No	No	No	No	Yes	Yes	No	No
Park	Yes	No	No	Yes	Yes	No	No	No
Pilosof	Yes	Yes	No	Yes	No	No	No	No
Ramnath	No	No	No	Yes	No	No	No	No
Safaeinili	No	No	No	Yes	Yes	No	No	No
Searby	Yes	No	No	Yes	Yes	No	No	No
Silva	No	No	No	Yes	Yes	Yes	No	No
Srinivasan	Yes	No	No	Yes	Yes	No	Yes	Yes

Table 4. Considerations for sociotechnical elements of digital health practice in nursing addressed in the literature.

Sociotechnical themes	Considerations
Hardware and software computing infrastructure	<ul style="list-style-type: none"> • Unreliable internet access [18,21,24] • Variable audiovisual quality and internet connection [16,21,29,33,34,36] • Lack of appropriate video and audiological mechanism to perform a physical examination remotely [18,20,23,30-34,36] • Limited visibility in tele-ICU^a cameras [35]
Human-computer interface	<ul style="list-style-type: none"> • Screen freezing and audio delays [20,24,34] • Alarm interference [29] • Difficulties in video platform usability [32] • High volume of data entry [26] • Multiple visual communication on segregated screens [35]
Clinical content	<ul style="list-style-type: none"> • Lack of interpretation services [24,33] • Need for a data analyst to extract meaningful insights from data [26]
People	<ul style="list-style-type: none"> • Limited training on using telehealth and in-patient telemonitoring [17,19,21,24,28,30,32-34,36] • Concerns about the privacy of patients' information [21,24,33-36] • Concerns about missing something important about patients [16-18,24,36] • Lack of teaching during rounds and lack of situational awareness [29] • Poor leadership support for telehealth [21,32,34] • Increased burnout in using EMRs^b due to lack of training [26] • Lack of trust in discussing sensitive topics via video visits [30] • Lack of provider's adoption of telehealth due to training as written instructions without actual telehealth use [22] • Fatigue from conducting a large number of video visits [16,20,36] • Feelings of disconnection and lack of social interaction with patients [16,18,28,35] • Need for the implementation team to perform innovative change in implementing tele-ICU in critical care [27]
Workflows and communication	<ul style="list-style-type: none"> • Inconsistency in team communication and presence at the bedside [28,29] • Concern about full responsibility of clinicians for connectivity that limits the volume and efficiency of telehealth visits [23] • Difficulties in scheduling procedures [28,32] • Need for streamlined video integration into clinical workflows [21,32] • Challenges in setting up a large number of patient portal accounts [30] • Challenges when needing to rapidly consent patients [30] • Need for extra time to communicate and coordinate visits [21,25,28,31] • Lack of local information technology (IT) support and communication [34,36] • Lack of integration between telehealth visits and EMRs and need for roles to support these integrations [21] • Miscommunication [20] • Nursing being the only profession left to work on-site during the transition to telehealth [18] • Constant updates for actions [19]
Internal organizational policies, procedures, and culture	<ul style="list-style-type: none"> • Difficulty capturing reimbursement for services [21,24,25,33,34] • Lack of integrated approach to implementing tele-ICU across the setting [29] • Need for clear regulations and policies about clinicians' responsibilities when making errors using technology [26] • Lack of preparedness and strategies on which platform to use for video visits [17,31] • Constraints of the funding models in health care settings [17] • Lack of equipment for using telehealth services [19]
External rules, regulations, and pressures	<ul style="list-style-type: none"> • Issues with multijurisdictional licensure [24,36] • Concerns about complying with legal standards [24] • Litigation concerns [24] • Need for unified standards for order entry and reporting among hospitals [26] • Limited licenses for video visit platforms [34]
System measurement and monitoring	<ul style="list-style-type: none"> • Need for regular assessment of technology effectiveness [26] • Need for a systematic approach to measure workplace burnout in using technology [26] • Need for new digital data sources and comprehensive remote monitoring systems to continue and scale up the services and make them ongoing part of clinical practice [36]

^aICU: intensive care unit.

^bEMR: electronic medical record.

Hardware and Software Computing Infrastructure

This dimension focuses on the hardware and software components of digital health technologies, such as machines, devices, storage, network, and power required to run the applications. Most studies addressed audiovisual issues with variable quality in telehealth services, which led to difficulties in undertaking physical exams virtually [18,20,23,30-34,36]. An unreliable internet connection [16,21,29,33,34,36] and lack of access [18,21,24] also delayed the communication between nurse and patient in these services. Limited connectivity in the network caused poor visibility when using tele-ICUs, which resulted in a noncomprehensive picture of the patients, wards, and beds [35].

Human-Computer Interface

The interface includes aspects of the technology with which the user can interact. It contains any issues that users find in using the systems. The studies on telehealth reported that screen freezing, audio delays [20,24,34], and alarm interference [29] impacted their interaction with patients during the virtual visits. As health care organizations rapidly implemented telehealth during the pandemic and workflows highly increased, there was a heavy load of data entry and a lack of time for it and documentation [26]. Moreover, the implementation of various platforms that the nurses were unfamiliar with brought usability challenges [32]. Connecting via segregated screens led to multiple visual communications that added a burden to the workforce [35].

Clinical Content

The lack of interpretation services was challenging to nurses and other health care providers [24,33]. The new digital health services provide new information and insights to the health care workforce and require further interpretation. Of the 21 studies, 1 (5%) study reported a need for a data analyst to extract meaningful information and insights from the large volume of data collected from various tools to manage people's health during the pandemic [26].

People

Most of the studies addressed the lack of training in using new home telehealth and in-patient telemonitoring initiatives and EMR use, which led to burnout as well as fatigue from conducting a large number of virtual visits [16,17,19-21,24,26,28,30,32-34,36]. There were concerns among nurses and other clinicians that they might miss important things, such as emotional interactions, when the visits were conducted virtually [16-18,24,36]. The respondents felt disconnected and did not have the social interaction they usually would during in-person visits [16,18,28,35]. Being connected through various devices and networks, many reported concerns about patients' privacy [21,24,33-36] and felt there was not enough trust to discuss sensitive topics virtually [30]. Poor support from leadership in providing training and improved situational awareness was another challenge to using digital health efficiently [21,29,32,34]. The studies also showed that written instructions on using different technologies without proper

practical testing do not enhance providers' adoption of the digital health [22]. Nurses were not involved during digital health implementation to understand the process and raise the issues nurses encounter in incorporating digital health into their workflow [27].

Workflows and Communication

The pandemic has interrupted clinical workflows due to increased demands for health care. The increased use of digital health has added another layer of interruption. Inconsistency in team communication [28,29]; difficulties in scheduling procedures [28,32], setting up different accounts, and obtaining various consents [30]; and constant updates [19] were among the issues the studies raised about workflows. The nurses were concerned about having the full responsibility for connectivity [23], which required extra time to communicate and coordinate visits [16,20,23,26], in turn limiting the number and efficiency of telehealth visits. Therefore, the nurses requested streamlined video integration into clinical workflows [21,32]. Nurses also raised disconnection [20] and lack of support from information technology (IT) support teams when using digital health services [34,36].

Internal Organizational Policies, Procedures, and Culture

The shortage of funding and reimbursement models was a significant internal issue that impacted the implementation of digital health use during the past 2 years [17,21,24,25,33,34]. The studies reported a lack of strategies and policies for integrating different tools across health care settings, workflows, training, and preparedness [17,29,31]. In addition, once the pandemic escalated, limited equipment was available for telehealth services [19]. There was an absence of policies on integrating different platforms and clarity about accountability for medical errors when using digital health services [26].

External Rules, Regulations, and Pressure

As many telehealth services were implemented, concerns arose around the lack of compliance with legal standards for data sharing, multijurisdictional licensure, and litigation [24,34,36]. The studies emphasized the need for unified standards for data collection, documentation, usage, and sharing among health care settings [26].

System Measurement and Monitoring

This element was the least explored sociotechnical dimension, with only 2 (10%) papers presenting relevant data in this area. They reported a lack of regular assessment of technology effectiveness. They suggested developing a systematic approach to measure burnout and usability and the need for new digital data sources and strategies to scale the initiatives to be integrated into the workflow [26,36].

Discussion

Principal Findings

This literature review identified that the sociotechnical aspects of digital health in nursing practice are not widely investigated

by the literature examining the impact on nursing practice due to the digital health transformation driven by COVID-19. Despite their recognized importance for efficient interaction between nurses, the technology and process within the health care environment were largely not addressed. This suggests that there are gaps in how the interaction with digital health innovations contributes to nurses' practice to provide efficient care and ensure patient safety and the quality of care. The results showed that the clinical participants mainly discussed patient experiences of digital health, not their own experiences. This indicates a lack of emphasis on understanding nurses' struggles within their workflows.

Of the 21 studies selected, only 4 papers examined the nurses' views and experiences of digital health during the pandemic. Undoubtedly, implementing digital health innovations requires a multidisciplinary team, which may explain the multidisciplinary approach of many of the papers examined. However, there needs to be a dedicated examination of the issues nurses face in using digital health during their routine practice in different care settings to identify nursing-specific needs.

Teleconsultations were the most used type of digital health during the pandemic, as evidenced in 16 studies. The high demand for social distancing and the reduction in in-person visits shifted clinic appointments to the virtual model. The findings showed that the health care settings that had already implemented telehealth services and needed to expand them during the pandemic were more confident, satisfied, and less challenged than those that implemented them for the first time in the pandemic. Overall, the studies reported positive attitudes among nurses toward applying telehealth consultations, such as satisfaction, improved communication with patients [23,30,33], improved productivity and quality of care [16,32], and enhanced flexibility in the workflow [16].

The other digital health service applied during the pandemic was tele-ICU, explored in 4 studies, to keep the optimal distance between the control team and clinical providers within acute care departments. The studies showed overall satisfaction with the service that improved the workflow, teamworking, and patient-centered care [27-29,35].

Surprisingly, only 1 study investigated the issues related to the EMR system during the pandemic. EMRs are 1 of the tools that might have been implemented by most of the health care settings before the other digital health services in the prepandemic era. The study explored the causes of EMR-related burnout during the pandemic as the workload and documentation suddenly increased. In contrast to the positive outcomes of virtual visits reported in the studies discussed earlier, the burnout of EMR utilization mainly was reported due to a lack of face-to-face interactions [26].

Regarding disease treatment and monitoring, 13 studies used digital health exclusively for COVID-19, while 8 reported transitioning to telehealth to manage other conditions during the pandemic. Considering the opportunities and challenges expressed in the studies, the digital health transformation requires strategies to overcome the barriers and provide ways to sustain the initiatives for integration with routine nursing practice.

Gaps in Sociotechnical Elements of Digital Health in Nursing Practice

The synthesis of the elements of the sociotechnical approach in the literature showed that the rise and acceleration of digital health during the COVID-19 pandemic era has posed challenges regarding usability, functionality, and transformation. The sociotechnical elements were not thoroughly investigated in the literature, whereas the implementation and use of digital health services require interaction between the human, technology, and process-related factors shown via the sociotechnical approach elements to provide efficient and quality care.

The predominant consideration discussed in the literature was the people factor, which highlights the need to focus further on the nursing workforce. As most digital health studies concentrate on the technology, intervention, or outcome, the people factor, people's needs, and their competencies are usually overlooked. System measurement and monitoring was the least explored element, indicating that despite the massive implementation of digital health services, there is little research on evaluating effectiveness and plans for ongoing use of services and nurses' roles in these evaluations.

The literature showed that nurses are less likely to adopt the appropriateness of telehealth services [24] and to use secure messaging in providing virtual care [21]. Anxiety was the biggest challenge for nurses transitioning to telehealth, because moving toward telehealth would reduce patients' and nurses' engagement to interact with each other [18]. Nurses reported that the nursing care provided face to face cannot be easily replicated in a telehealth setting due to the type of care provided and the patient group's needs [16]. Telehealth is a barrier to providing basic nursing skills, such as reassuring a patient [18]. Nurses perceived that their exposure to patients stays at a similar level after implementing in-patient telemedicine [28].

Lack of training has been identified as 1 of the core causes hampering the usability of the digital health system. Further, the literature has identified the connection between poor usability and varying levels of trust in using new technology in privacy protection [21,24,30,33-36]. Therefore, the solution lies in ensuring safe implementation training embedded in the routine training of nurses from undergraduate courses to postgraduate training and continuous professional training. Dedicated training in health informatics provides nurses with in-depth knowledge and skills to become comfortable with technological changes. It translates more robust safeguards to health information used in the digital health platform [37].

Although the telehealth services were perceived as an acceptable solution to increase access to care services during the pandemic [17] and were rapidly deployed during the pandemic, insufficient resources to implement telehealth at a large scale lowers the reimbursement and nurses' motivation to use the services [24]. The prepandemic studies have addressed the reimbursement challenge as the most significant barrier to scaling up pediatric telehealth programs. The participants reported that reimbursement was a major barrier to the widespread use of telemedicine before the pandemic [31]. However, the payer reimbursement rapidly expanded during the pandemic [33]. As telehealth services are increasingly adopted in primary care,

funding for general practice nurses needs to continue to facilitate better use of their roles [17].

There was a vast difference among nurses in various specialties in the perceived quality of care delivered via telehealth. This emphasizes the need for training in virtual physical examinations for different diseases [32]. Similarly, Esmailzadeh et al [26] found that the leading cause of EMR-related stress is insufficient training in the use of technology. However, receiving education as written instructions only was deemed the equivalent of having no education in using telehealth and did not enhance the adoption of these services [22]. There was insufficient training on how staff should use and support video visits conducted for the first time [36]. Limited telehealth education in health care professional programs might result from a lack of faculty expertise, technology, or opportunities for clinical experience in telehealth [22]. Nurses' preparedness to use telehealth depends on the availability of technology and the skillset [17]. Moreover, interpretive services need to be embedded in future telehealth implementations to facilitate communication and improve nursing practice [23].

The other most challenging issues were the usability issues of technology and complicated workflows and communication. Clinicians had challenges deciding which infrastructure, logistics, and platforms to use [34]. The technological challenges were often linked to financial barriers [34]. Lack of adequate resources and the need for more time to conduct teleconsultations were the main challenges reported by O'Donovan et al [25].

System-level challenges exist in navigating payment models offered by different insurance companies, licensure, and litigation issues [24]. Nurses raised concerns about poor phone connectivity that hampered communication and jeopardized patient safety [29]. They felt that telehealth consultations increase their responsibility for connectivity and intake, which would severely limit the volume and efficiency of telehealth services [23]. For example, in tele-ICU services, nurses were frustrated about staying away from the bedside to overcome communication barriers. This increased the need for another nurse to fulfil the needs of critically ill patients [29].

A significant drawback of virtual visits is the inability to conduct physical examinations remotely [32]. There are concerns about not getting a holistic picture of the patient's status in video visits due to technological and connection issues [20,30]. The inability to adequately assess the patient's situation due to audiovisual issues reduces the quality of care [31]. There was an increased risk of nurses being unable to visually assess the patients and having difficulties assessing risks, such as domestic violence [18]. The findings showed that those with more EMR experience were more likely to be concerned about patients' increased demand for virtual care, which is not integrated into EMR workflows [21]. Therefore, more investment is required in the internet infrastructure and access [34]. Effective support processes, such as change management strategies for integrating EMRs and virtual care services, will improve nurses' practices in providing efficient care [21].

These challenges are not surprising. The rapid adoption of new digital health technologies at short notice in complex health care systems is an economically challenging and time-consuming process [2]. However, this justifies the need for more research in this area. Understanding these challenges can help better prepare nurses for using digital health in clinical practice and not stretch already exhausted systems.

Comparison With Prior Work

Several literature review studies have been published since the pandemic began that explore the use of digital health in this context [5,8,38-40]. However, these studies have discussed digital health in general and have not focused on nursing practice. This study is the first of its kind that reviewed original research conducted during 2020-2021, focusing on nurses' digital health experience. It used the 8D sociotechnical approach to comprehensively address the challenges related to the design, development, implementation, use, and evaluation of digital health initiatives that nurses confront in their practice in complex, real-world settings.

Limitations and Future Work

As the scope of this review was limited to the past 2 years, it did not cover the research conducted before the pandemic on nurses' experience with digital health. Moreover, it was limited to English papers and original research. Due to the pressure on the health care systems, nursing practice in many regions might not have researched the nurses' experience and outcomes during the pandemic or their findings might have been published as white papers or industry reports that were excluded from our screening.

Conclusion

This literature review studied the role and engagement of nurses in the digital transformation of health during the first 2 years of the COVID-19 pandemic. Despite the rapid growth and adoption of digital health [41], as the largest group of health care providers, nurses remained passive users of these technologies. The sociotechnical elements showed a lack of assessing nurses' interaction with and use of digital health. Despite overwhelming evidence suggesting digital health care improves efficiency and equity, many of the studies reviewed highlighted concerns about adopting digital health. Examples included disrupted workflows, lack of regulatory support, and ongoing system monitoring. It is well known that the health care industry is always slow in implementing new technology, which is often a safety-driven decision or due to a lack of supportive evidence [42]. Further, it usually takes a long time to validate and integrate digital health into the existing health services due to the complexity of this process. Recognizing the impact of the health service system and policy on digital health, all stakeholders need to be involved so their needs and interests can be incorporated into the digital health policy development and planning. Future work can explore ways in which nurses can be actively engaged in the design, development, implementation, and efficiency assessment of digital health within health care systems.

Conflicts of Interest

None declared.

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Abbreviations

EMR: electronic medical record

ICU: intensive care unit

MeSH: Medical Subject Headings

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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Review

Digital Technologies and the Role of Health Care Professionals: Scoping Review Exploring Nurses' Skills in the Digital Era and in the Light of the COVID-19 Pandemic

Valentina Isidori¹; Francesco Diamanti¹; Lorenzo Gios²; Giulia Malfatti²; Francesca Perini²; Andrea Nicolini²; Jessica Longhini³; Stefano Forti²; Federica Fraschini⁴; Giancarlo Bizzarri⁵; Stefano Brancorsini¹; Alessandro Gaudino¹

¹Department of Medicine and Surgery, University of Perugia, Terni, Italy

²TrentinoSalute4.0, Centro di Competenza per la Sanità Digitale, Trento, Italy

³Azienda Provinciale per i Servizi Sanitari, Trento, Italy

⁴Azienda Unità Sanitaria Locale Umbria 2, Terni, Italy

⁵Amministratore Unico di PuntoZero, Perugia, Italy

Corresponding Author:

Valentina Isidori

Department of Medicine and Surgery

University of Perugia

Viale Tristano di Joannuccio

Terni, 05100

Italy

Phone: 39 3398830048

Email: valeisi97@gmail.com

Abstract

Background: The nursing role significantly changed following reforms in the nurse training process. Nowadays, nurses are increasingly trained to promote and improve the quality of clinical practice and to provide support in the assistance of patients and communities. Opportunities and threats are emerging as a consequence of the introduction of new disruptive technologies in public health, which requires the health care staff to develop new digital skills.

Objective: The aim of this paper is to review and define the role of nurses and the skills they are asked to master in terms of new methodological approaches and digital knowledge in a continuously evolving health care scenario that relies increasingly more on technology and digital solutions.

Methods: This scoping review was conducted using a thematic summary of previous studies. Authors collected publications through a cross-database search (PubMed, Web of Science, Google Scholar) related to new telemedicine approaches impacting the nurses' role, considering the time span of 2011-2021 and therefore including experiences and publications related to the first phase of the COVID-19 pandemic.

Results: The assessment was completed between April and July 2021. After a cross-database search, authors reviewed a selection of 60 studies. The results obtained were organized into 5 emerging macro areas: (1) leadership (nurses are expected to show leadership capabilities when introducing new technologies in health care practices, considering their pivotal role in coordinating various professional figures and the patient), (2) soft skills (new communication skills, adaptiveness, and problem solving are needed to adapt the interaction to the level of digital skills and digital knowledge of the patient), (3) training (specific subjects need to be added to nursing training to boost the adoption of new communication and technological skills, enabling health care professionals to largely and effectively use new digital tools), (4) remote management of COVID-19 or chronic patients during the pandemic (a role that has proved to be fundamental is the community and family nurse and health care systems are adopting novel assistance models to support patients at home and to enable decentralization of services from hospitals to the territory), and (5) management of interpersonal relationships with patients through telemedicine (a person-centered approach with an open and sensitive attitude seems to be even more important in the framework of telemedicine where a face-to-face session is not possible and therefore nonverbal indicators are more problematic to be noticed).

Conclusions: Further advancing nurses' readiness in adopting telemedicine requires an integrated approach, including combination of technical knowledge, management abilities, soft skills, and communication skills. This scoping review provides a wide-ranging

and general—albeit valuable—starting point to identify these core competences and better understand their implications in terms of present and future health care professionals' roles.

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KEYWORDS

role of the nurse in telemedicine; telenursing; new technological approaches; communication and technological skills; leadership; nursing training; nursing; health care; digital knowledge; online health; digital health; COVID-19; telehealth; telemedicine

Introduction

Over the years, the nursing profession has been exposed to relevant changes, from the mother-rescuer's role to the intuitions of Florence Nightingale [1,2] and considering the reforms in the nurse training process, which now requires a 3-year university degree in most countries [2,3].

Thanks to higher education curricula and advanced educational training, nurses have become increasingly prepared, competent, and autonomous [1,3]. Even if this advancement has led to a tangible improvement in the quality of clinical practice and assistance to the person and the community [4], much more has to be done considering the wide-ranging digital health revolution we are witnessing over the past years. Nowadays, health care is undergoing profound changes, moving toward the decentralization of services and promoting outpatient activities. The delivery of health care treatments with the support of new technologies has an increasingly significant impact on the health care management and organizational asset.

This new scenario highlights the need for highly skilled nursing staff, able to adapt to new contexts and challenges that are constantly and quickly emerging within the digital health revolution [5].

In this rapidly changing context, the training of nursing skills and competences need to include the use and administration of new technologies, as well as the capacity to support the use of technological tools for patients and caregivers [6], identifying those who are eligible candidates for services enabled by digital technologies [7].

The whole process has been inevitably accelerated by the COVID-19 pandemic, which is highlighting the limited amount of resources in terms of health care staff and in terms of technological tools. The pandemic is also pushing health care institutions in reshaping service delivery, the management of patients' journeys, and the use of telemedicine [8].

The aim of this paper is to review and define the role of nurses and the skills they are asked to master in terms of new methodological approaches and digital knowledge, considering the changes that have occurred in the health sector in the past decade (2011-2021). The COVID-19 pandemic has led to an exponential increase in the use of telemedicine, and consequently, this has led to a radical change in the health care organization and in the role of professionals as well, particularly in the past couple of years. In fact, a large part of the available literature (including reviews) is related to a pre-COVID-19 period. Despite a considerable number of current reviews including robust systematic and statistical analysis, these papers

(1) mainly address the issue of telemedicine only as case studies or isolated experiments, focusing on the perception of its use among nurses and students and on possible future prospects, underlining the main limitations [9,10], and (2) somehow miss detecting the massive impact of the pandemic on the health care sector and its recent acceleration in terms of the digital revolution.

In the continuum of experiences that have occurred in the past 10 years in the field of digitalization of the health care sector, this review also covers the recent COVID-19 outbreak that has contributed to largely expand telemedicine across several countries, with the aim of mapping the key concepts and implications underpinning the fast/changing role of the nurse in the digital era, as well as exploring the boundaries of the role and the skills that need to be acquired as they are redefined through the COVID-19 pandemic.

Therefore, this paper can be considered a preliminary—albeit necessary—exercise prior to conducting a structured systematic review.

Methods

Aim

The core objective is to review and define the role of nurses and the skills they are asked to master in terms of new methodological approaches and digital knowledge that have emerged before and during the COVID-19 pandemic (2011-2021). The review maps present (and future) skills that nurses are expected to develop when using new technologies, considering the novel organizational assets that are emerging in the digitalization process of health care.

Design

From a methodological viewpoint, the scoping review has been identified as the most suitable tool as this approach is particularly useful for exploring new evidence, embracing evidence from heterogeneous sources of data, and providing a broad overview of the current and rapidly changing health care scenario [11]. Authors performed a scoping review [12-14]. In line with the scoping review principles, the steps of the review were as follows: (1) defining the focus of the review, (2) identifying relevant studies using inclusion and exclusion criteria, (3) charting the studies, and (4) summarizing the core results. Results were analyzed adopting a thematic synthesis approach. Further details about the method adopted will be presented in the following sections.

Search Strategy

The search strategy was defined as follows:

- Participants: nursing professionals, researchers, and university professors
- Interest: application of telehealth in nursing practice
- International electronic databases: PubMed, Google Scholar, and Web of Science, considering the time span of 2011-2021
- Keywords used: “telenursing,” “nursing,” and “telemedicine”
- Search strings: (telenursing) AND (role of the nurse in telemedicine), (nurse's role) AND (eHealth), (nurse's role) AND (telemedicine COVID-19), ((community nurse) AND (telemedicine)) AND (COVID-19), and (telenursing) AND (telemedicine)

Authors conducted the research through the Perugia University library (Italy) using PubMed, Google Scholar, and Web of Science. The search was planned considering a 10-year span from 2011 to 2021.

Table 1. Paper selection process.

Step	Process
Identification	<ul style="list-style-type: none"> • In total, 250 papers written in English, with international significance, in the time span of 2011-2021 were identified through the PICO method based on the keywords selected: (telenursing) AND (role of the nurse in telemedicine), (nurse's role) AND (eHealth), (nurse's role) AND (telemedicine COVID-19), ((community nurse) AND (telemedicine)) AND (COVID-19), and (telenursing) AND (telemedicine). • No additional records were found from other searches.
Screening	<ul style="list-style-type: none"> • A cross-database search (PubMed, Web of Science, Google Scholar) allowed the elimination of 8 (3.2%) redundant papers. • The remaining 242 (96.8%) papers were reviewed, and 156 (64.5%) that did not have free full text and did not meet the purpose of the research were excluded.
Eligibility	<ul style="list-style-type: none"> • All the remaining 86 (35.5%) papers with free full text were considered eligible. Of these, 26 (30.2%) papers with redundant topics not in sufficient detail were further excluded.
Included	<ul style="list-style-type: none"> • Finally, 60 (69.8%) papers were included.

Publication Assessment

An assessment of the risk of bias in the publications is usually not performed in the framework of a scoping review; therefore, no assessments of the papers' quality were performed [14].

Data Abstraction and Synthesis

After collection, the papers were divided and analyzed. The results of authors' analysis are presented in Tables A1-A3 in [Multimedia Appendix 1](#). The tables summarize the core pieces of information for each item: numerical code, title of the paper, aim, journal, authors, year, telehealth/eHealth application, data collection methods, and summary of contents.

Inclusion and Exclusion Criteria

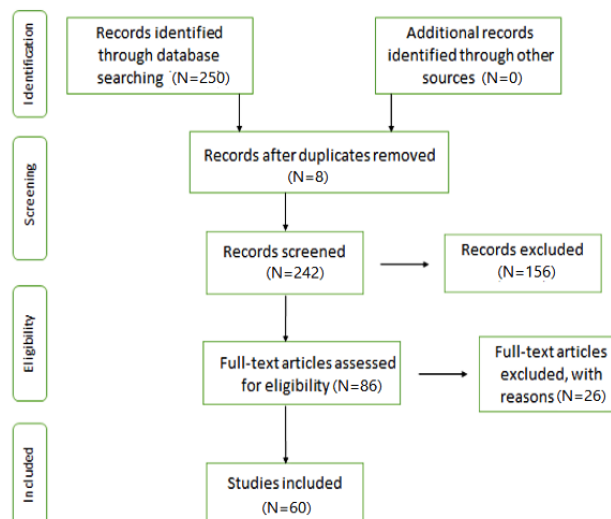
Papers from 2011 to 2021 were identified using the keyword search strings through the PICO (population, intervention, control, outcome) method. During screening, all papers meeting the following selection criteria were selected: written in English; being of international significance; being searched through a cross-database search (PubMed, Web of Science, Google Scholar), considering elimination of redundant papers; including a reference to the nursing figure and the role of the nurse, with reference to the leadership role; and including the use of telemedicine systems. In addition, papers considering at least 1 of the following issues/topics were selected: nursing education and introducing clinical practice supported by telemedicine systems into the curriculum, interpersonal and communication skills in terms of telemedicine systems, and telemedicine experience (see [Table 1](#)). The final list included 60 papers.

Results

Search Outcomes

In the initial phase, authors selected many papers from international peer-reviewed journals. In total, 250 papers were found matching the topic of the review. After reading the abstracts, papers that were not in line with the inclusion criteria of the review were removed. A total of 60 (24%) papers were selected to be reviewed. Of these 60 papers, 22 (37%) covered the period 2011-2018 and were therefore not affected by the COVID-19 pandemic (process summarized in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart in [Figure 1](#)).

Specific recurring themes and fundamental constructs that emerged in this review are presented in the following sections and then elaborated in the Discussion section.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart for the scoping review process.

Communication Skills in Telemedicine for Nurses

This scoping review highlighted the importance of communication skills that appear to be even more important for nurses in the case of telemedicine compared to in-person visits [15]. Communication abilities and the capacity to manage interpersonal relations with patients through telemedicine tools are described as key abilities. In this case, solid professional experience is evidenced to be a vital factor in ensuring ideal quality in organizational assets supported by new technologies. This research explored the importance of improvements telemedicine systems and informatics in nurse practitioner (NP) education [5,16]. Recent research from the American Academy of Family Physicians (AAFP) highlighted the lack of training as 1 of the most common barriers to using telehealth [7]. Furthermore, another systematic review emphasized insufficient access and lack of training and education as key factors in the nonadoption of new technologies [7]. For these reasons, international organizations (eg, the Commission on Accreditation for Health Informatics and Information Management Education and the International Medical Informatics Association) have proposed a new mobile health (mHealth) skills training framework to prepare health professionals to deploy and implement mHealth interventions. This framework considers teaching digital communication skills, technology literacy and usage skills, telehealth business cases, regulatory and compliance issues, interprofessional teams, and deploying of telehealth products and services [7]. The skills are considered as basic competences to conduct remote consultation, monitor, diagnose, and treat patients. The final goal is to expand the use of digital tools and technological devices in different health care contexts, such as telepresence robots, patient-monitoring devices, pulse oximeters, blood pressure monitors, radiofrequency identification and temperature sensors, electrocardiography (ECG), and others.

From this perspective, the following list [7] of skills emerged as core competencies:

- Technical skills to use telemedicine (system use and troubleshooting telemedicine software and hardware issues)

- Skills in terms of using mobile communication devices and wireless remote patient-monitoring applications for treatment support, chronic disease management, and disease surveillance
- Skills in designing patient-centered health informatics systems
- Skills in understanding specific health informatics issues and suggesting/designing technological solutions
- Skills to assess data integrity and health data analysis

It is therefore possible to affirm that there is a need to recommend specific skill training; however, a clear and effective training method to properly train clinicians is far from being determined yet. The current education based on traditional lectured instruction methods is presumably not sufficient for proper adoption of new technologies, leading to bottlenecks in integrating monitoring technologies into daily practice.

Management of Interpersonal Relationships With Patients Through Telemedicine

Telehealth nursing primarily focuses on patients' long-term wellness, self-management, and health. According to the American Telemedicine Association, information technology (IT) solutions provide the delivery of nursing care, regardless of distance, while expanding the care providers' ability to monitor, educate, follow up, collect data, and provide multidisciplinary care, including remote interventions, pain management, and family support, in an innovative fashion [17]. When targeting elderly people, 1 of the emerging skills for nurses adopting telemedicine is communication, which is essential in telephone counseling. A person-centered approach with an open and sensitive attitude seems to be even more important in the framework of telemedicine where a face-to-face (FTF) session is not possible and therefore nonverbal indicators are more problematic to be noticed.

Another relevant item to consider is the nurses' working environment, which should be carefully considered. A quiet, disturbance-free environment was clearly indicated as a core issue when delivering telemedicine sessions in order to promote a contextual environment supporting mutual understanding and smooth interaction [18].

Remote Management of COVID-19 or Chronic Patients During the Pandemic

A role that has proved to be fundamental is the community and family nurse. Health care systems are adopting novel assistance models to support patients at home and to enable decentralization of services from hospitals to the territory [19]. The process was further fostered—and it is still evolving—by the recent COVID-19 pandemic, which represents an engine of massive acceleration for digital health. During the strict lockdown period, the reduction of routine FTF care, the provisional interruption of most outpatient care services and the stay-at-home directives added a significant pressure to the community component of health care systems.

From this perspective, community nurses play a key role in integrating health and social care services, particularly supporting self-care that has also proved to be beneficial during the pandemic. Community nurses have shifted from FTF care to teleconsultations to keep services accessible during the pandemic [19]. If this was possible for standard support, during the most critical phases of the COVID-19 pandemic, a reduced level of direct assistance was experienced from patients in the last stage of the disease, given the need for isolation at home. To overcome this problem, in some areas, end-of-life health care services are delivered remotely and support to the families/patients can be managed through technological platforms [20]. UK national guidelines have been delivered to allow family caregivers to administer end-of-life medications, if appropriate, and have access to timely clinical advice. Often, district nursing teams provide ongoing training and support to family caregivers willing to take on increased responsibility for patient care and associated management techniques. One of the enduring implications of the COVID-19 pandemic is also the increased need to deliver remote consultations in the field of end-of-life planning and palliative care [20].

eHealth can be supported by rapid counseling models based on remote calling by health care professionals, as shown in a randomized controlled trial [21] that evaluated the effect of remote nursing-monitoring of overweight women and confirmed the benefits in terms of improved anthropometric measurements.

This study, therefore, allows us to understand the positive effect of this approach (monitoring via phone calls) and confirms the effectiveness of the home remote control method, mainly as an educational strategy, for flexibility of schedules, optimization of times and resources, and the ability to reach many users who encounter difficulties related to geographical and financial barriers to access the health service.

Management and Leadership Within Advanced Telemedicine Systems

The nurse is increasingly becoming a key figure for the implementation of telemedicine in clinical practice. This requires specific leadership skills. Leaders set standards, develop plans, and remove barriers to implementation. The leader understands and can deliver and adapt evidence-based practice knowledge. The leader supports the efforts of others to learn and use evidence-based practice, as well as supports the implementation of evidence-based practice in a consistent and deliberate way

[22]. The nurse plays a fundamental role in assistance supported by telemedicine systems. In fact, as demonstrated by Parimbelli et al [6], the nurse is the figure who participates in the creation of the project and is responsible for the patient's enrollment phase, for the explanation of the service to the patient and the caregiver, and, finally, for the management of the data they receive through the device used. As modes of delivery for services such as telehealth and telenursing changes, nurses are increasingly working independently and using information and communication technologies to collaborate with the health team. The goals for the future are better use of technology and information, promotion and dissemination of innovation and quality improvements, and the creation of leaders and capacities in terms of administering new technologies. This means that nursing care must focus on the delivery of services such as telemedicine and teleassistance [23].

Impact of Nurses' Previous Professional Experience When Using Telemedicine

If the technology is not optimal, more experienced nurses can compensate the suboptimal technology with their clinical experience, while younger nurses often face bigger challenges, despite their higher digital skills. In some cases, it is emphasized that digital natives often have more doubts about the correct application of digital tools in health care. The study titled "Telehealth and Telenursing Perception and Knowledge Among University Students of Nursing in Poland" [24] was conducted to investigate the perception of telenursing among nursing students, providing some predictive data for the near-future nursing practice in the country. The current generation of nursing students appear to be well qualified in the use of IT and medical technology (personal computers, personal email, etc). They seem to be better prepared for joining the information society, including the practice of telemedicine. Most of the students interviewed reported a positive attitude toward the use of telenursing. The fact that a significant number of students are familiar with the terms "telemedicine" and "telenursing" could be a prognostic factor in the future development of telenursing [24].

Discussion

Principal Findings

This review aimed at exploring the present (and future) nursing role, considering the new digital health era where the use of telemedicine is becoming a standard in health care delivery. From a methodological viewpoint, the scoping review represents the most suitable tool for this exercise, as this approach is appropriate when exploring emerging evidence from heterogeneous sources of data [25,26].

Revising the literature published within a 10-year span, authors were able to outline (1) the emerging skills and attitudes nurses are required to master within a digitalized health care system, (2) the new responsibilities that are emerging for health care staff (and nurses in particular) when digital health approaches are adopted, and (3) the (potential) impact of digital innovation in terms of requirements for the nurses' university curricula.

Among the core emerging issues highlighted in this paper, the leadership role that the nurse plays is key when new technologies are structurally part of the health care process and service delivery. In fact, nurses are (and will increasingly be) the cornerstone of communication and coordination among different professional stakeholders (eg, general practitioners, specialists), patients, and caregivers. Another important point emerging from our analysis is the need for developing new communication, adaptation, and problem-solving capabilities to flexibly adapt the use of technologies to the level of digital literacy (digital skills) of patients. This implies the capacity to assess not only the clinical profile of a patient but also the extent to which new technologies can be used in managing a specific case. This is even more important, considering an increasing body of publications [16,24] highlighting the key role of telemedicine also during first contacts with patients, in the case of urban, rural, and remote settings. This is the case for developing countries but also in industrialized areas (eg, Canada) and in emergency scenarios (eg, pandemic). Finally, the need for introducing transversal, communicative, and technological skills in the university curricula of nurses was highlighted in order to improve their capability of using and adapting new technological approaches to current (and future) health care delivery pathways.

Limitations

The authors acknowledge some limitations of this review. First, the level of eHealth literacy of nurses was assessed only in a limited number of papers, in many cases outdated, as in the case of Norman and colleagues [25,26]. This can be considered an intrinsic limitation for this kind of study. Second, potentially relevant sources of information may have been omitted because of different wording that is sometimes adopted in the literature targeting telemedicine. In addition, the wording adopted for the review might have led to potential biases. In addition, the study considered health care approaches supported by telemedicine systems as its main topic, which is constantly evolving, especially after the COVID-19 pandemic. Future studies can further explore the multifaceted impact of the COVID-19 pandemic on the health care system. Another limitation is the

scarce presence of papers relating to experiences in the field of nursing care supported by telemedicine systems. The nursing role in terms of new technologies is not yet well defined; in fact, this study can represent a basis from which to start to define a nurse with new specific skills and technological capabilities. Only when these skills are included in the educational path will it be possible to witness the detailed delineation of the nurse of the future in terms of technological knowledge. Finally, a core limitation lies in the lack of a standard curriculum throughout Europe regarding the nursing figure. This does not allow a clear mapping of proper strategies to integrate technological skills into educational courses for nurses.

Conclusion

As highlighted in this review, the role of nurses has widely changed over the past decades, with tremendous acceleration in the past few years and in the COVID-19 era. Studies included in this scoping review provide insight into present and future skills that might constitute the core abilities of the nurses' curricula. At the same time, additional information is needed to better understand how these skills can be included in the training and nurses' formal curricula, particularly considering the radical transformation we are witnessing, where the traditional models of care are continuously modified and sometimes replaced with advanced approaches enabled by up-to-date technologies. Our research can be considered a starting point to outline the core areas of development for the future nurse, in terms of technological, organizational, and relational skills [27]. These areas of development clearly impact the training curricula that are still wide ranging at a global level, leading to a still fragmented scenario in terms of digitally skilled nurses. This lack of professional nurses familiar with telemedicine is recurrent evidence across the literature [8,16]. The large majority of the selected papers refer to experiments or possible future training initiatives that are not yet in place, calling for a revolution also in terms of educational curricula in order to further improve the capacity and flexibility of nurses in the digital era. This issue needs to be further investigated through future research.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Results of authors' analysis of 60 papers selected for this study.
[DOCX File, 50 KB - [nursing_v5i1e37631_app1.docx](#)]

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Abbreviations

- ECG:** electrocardiography
FTF: face-to-face

IT: information technology

mHealth: mobile health

NP: nurse practitioner

PICO: population, intervention, control, outcome

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Original Paper

Nurses' Experiences Using an Interactive System to Assess and Manage Treatment-Related Symptoms of Patients With Pancreatic Cancer: Interview Study

Maria Mangsbacka^{1,2}, MSc; Tina Gustavell^{3,4}, PhD

¹School of Health and Welfare, Dalarna University, Falun, Sweden

²Nursing Research, Department of Surgical Sciences, Uppsala University, Uppsala, Sweden

³Division of Nursing, Department of Neurobiology, Care Sciences and Society, Karolinska Institutet, Stockholm, Sweden

⁴Department of Upper Abdominal Diseases, Cancer Theme, Karolinska University Hospital (Huddinge), Stockholm, Sweden

Corresponding Author:

Tina Gustavell, PhD

Department of Upper Abdominal Diseases

Cancer Theme

Karolinska University Hospital (Huddinge)

Hälsövägen, Flemingsberg (Main entrance)

C1:77

Stockholm, 14186

Sweden

Phone: 46 724682250

Email: tina.gustavell@ki.se

Abstract

Background: Treatment for pancreatic cancer entails symptom distress and a high burden of self-care. Patient-reported outcomes, collected with the support of mobile health (mHealth), have shown positive effects on symptom management, patient satisfaction, and quality of life for patients with cancer. For mHealth tools to become an integral part of clinical routine, experiences from health care professionals are needed.

Objective: The aim of this paper is to describe nurses' experiences of integrating an interactive system (Interaktor) for symptom assessment and management into daily practice, when caring for patients following pancreaticoduodenectomy and during chemotherapy treatment due to pancreatic cancer.

Methods: Patients reported symptoms via the Interaktor app daily for 6 months. In the event of alarming symptoms, an alert was triggered to the patient's nurse who then called the patient to offer advice and support. All nurses (n=8) who assessed patients were interviewed either individually or in a group. Transcribed interviews were analyzed using qualitative thematic analysis.

Results: mHealth can facilitate person-centered care by offering nurses a way to gain knowledge about patients and to build relationships. Further, obstacles to implementation could be seen due to a lack of structural prerequisites and uncertainty about multiple ways to interact with patients.

Conclusions: The Interaktor system can provide person-centered care. However, to implement mHealth tools as a clinical routine, focus needs to be placed on creating the necessary organizational conditions.

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KEYWORDS

app; health care professionals; mobile health; mHealth; nurses; pancreatic cancer; person-centered care; symptom-management; qualitative interview; nursing; interview

Introduction

Pancreatic cancers have a high mortality rate and short median survival. The best hope of curing the cancer is to undergo

surgical resection followed by adjuvant chemotherapy. The most common surgical procedure is pancreaticoduodenectomy where the head of the pancreas, duodenum, distal common bile duct, the gall bladder, and sometimes the gastric antrum and

pylorus are removed. Unfortunately, the surgery often results in severe symptoms and a prolonged reduction in quality of life [1]. Common symptoms are related to eating, bowel function, and emotional well-being, along with fatigue and pain [2]. Great demands are placed on patients to manage their illness following surgery, and patients experience high levels of unmet physical and psychological supportive care needs [3]. Collecting electronic patient-reported outcomes (PRO) has an important role in supportive care to patients with pancreatic cancer [4]. Medical and public health practices supported by mobile devices have been defined by the World Health Organization as mobile health (mHealth) [5]. Several studies have shown positive effects on symptom management and quality of life when mHealth is used to collect and monitor PROs and to support self-management in cancer care [6,7].

The Interaktor system has been developed to meet the different needs patients may experience as they manage symptoms and concerns related to their illness. Interaktor includes a web interface and an app that is downloaded onto a smartphone or a tablet. The components are as follows: (1) patients' assessment of the occurrence, frequency, and distress level of symptoms; (2) a web interface for the health care providers, for monitoring patients' data in real time; (3) an alert function based on a risk assessment model, which sends alerts to the nurses via SMS text messaging; (4) access to evidence-based self-care advice related to symptoms and links to relevant websites; and (5) graphs of symptom report history. The web interface functions both as an aid in patient-clinician communication about symptoms and self-care and as a decision aid for health care professionals to manage symptoms. The reported data are stored on a designated secure server [8]. The Interaktor app has been evaluated for patients with breast-, pancreatic-, or prostate cancer with positive effects on symptom burden [9-11]. Patients with pancreatic cancer described that the app enabled them to be seen as a person by allowing their voices to be heard, to have access to an extended arm of health care, and to learn about their own health [12].

In Sweden, patients with a cancer diagnosis are offered a nurse navigator. The nurse navigator is a registered nurse (3 years of higher education with a bachelor's degree) who functions as a support for the patients and relatives throughout the care chain. The role includes being accessible, informing about future steps in care and treatment, providing support in the event of normal crisis reactions, and mediating contacts with other professional groups [13].

The benefit to patients with cancer of using mHealth to interact with health care is clear. However, there is limited research regarding health care professionals' perspective on how mHealth can enhance care and be implemented as clinical practice. To implement mHealth as clinical practice, there is a need to gain further knowledge about how the use of mHealth can be helpful for health care professionals in their work and about requirements for implementation. Therefore, the aim of this study was to describe nurses' experiences of integrating an interactive system (Interaktor) for symptom assessment and management into daily practice when caring for patients following pancreaticoduodenectomy and during chemotherapy treatment due to pancreatic cancer.

Methods

Design

This study has a qualitative descriptive design.

Setting, Procedure, and Participants

The study was performed at a high-volume center for pancreatic surgery, with over 100 pancreaticoduodenectomies performed annually. At the time of the study, standard care after discharge following pancreaticoduodenectomy and during adjuvant chemotherapy meant that patients were able to call the clinic's advice line during office hours (daytime, Monday to Friday) to contact their nurse navigator when necessary. A few weeks after discharge, patients had one scheduled visit to the surgeon and sometimes the nurse navigator where symptoms could be discussed. Patients undergoing adjuvant chemotherapy were monitored weekly before the start of the intravenous treatment. Patients with severe symptoms were referred to an advanced home care team offering frequent visits by nurses at home.

In addition to standard care, patients using the Interaktor app reported symptoms to their nurse navigator, starting the first day after discharge and until 1 week after their final dose of intravenous chemotherapy. They were encouraged to report symptoms once a day, preferably in the morning. They were informed that alerts were only monitored during office hours, and if they needed help at other times, they were to telephone the national Healthcare Advice Line or visit the nearest Emergency Department. The nurse's involvement was to monitor alerts and call patients following an alert to give support. The alerts came as an SMS text message to a study-specific mobile phone, one at each unit. For red alerts, a nurse should contact the patient within 1 hour. For yellow alerts, contact should be made within the same day.

Before the study started, the nurse navigators were invited to attend a 2-hour training session on the use of the Interaktor platform and their responsibilities throughout the study. Nurse navigators who could not attend the training session, or those employed after the session, received "in-house" training from nurses who had attended the training session. The training was held by one of the researchers, and throughout the study, the same researcher was available to answer questions that might arise. The total study period was 21 months. During that time, the nurse navigators at the surgical clinic monitored all patients who started to use the app ($n=36$), and they had 1-10 patients to monitor at the same time. Not all patients received adjuvant chemotherapy treatment. Those who did ($n=21$) were allocated to one of two oncological clinics. Those two clinics had, respectively, 1-8 patients and 1-5 patients to monitor at the same time.

Sample

All nurse navigators ($n=8$, hereafter referred to as nurses) who had monitored symptom alerts of patients with pancreatic cancer using the Interaktor app were invited to participate in the study, and all consented. The nurses worked either at the surgical clinic where they monitored patients after discharge and until start of adjuvant chemotherapy, or at one of the oncological clinics

where the patients received their chemotherapy for up to 6 months.

Data Collection

Focus groups were chosen since this method takes advantage of group processes to explore and clarify participants’ attitudes, needs, and ideas of structural solutions [14]. The focus groups (n=3) were held at the workplace during working hours with

nurses from the same unit, to take advantage of natural interactions. One nurse was interviewed over the phone since she was unable to participate in the focus group with her colleagues. To ensure trustworthiness, the interviews followed a semistructured interview guide (Textbox 1). The interviews were audio recorded and lasted for 18, 22, 23, and 25 minutes, respectively.

Textbox 1. Semistructured interview guide used for the focus groups (n=3) and the individual interview (n=1).

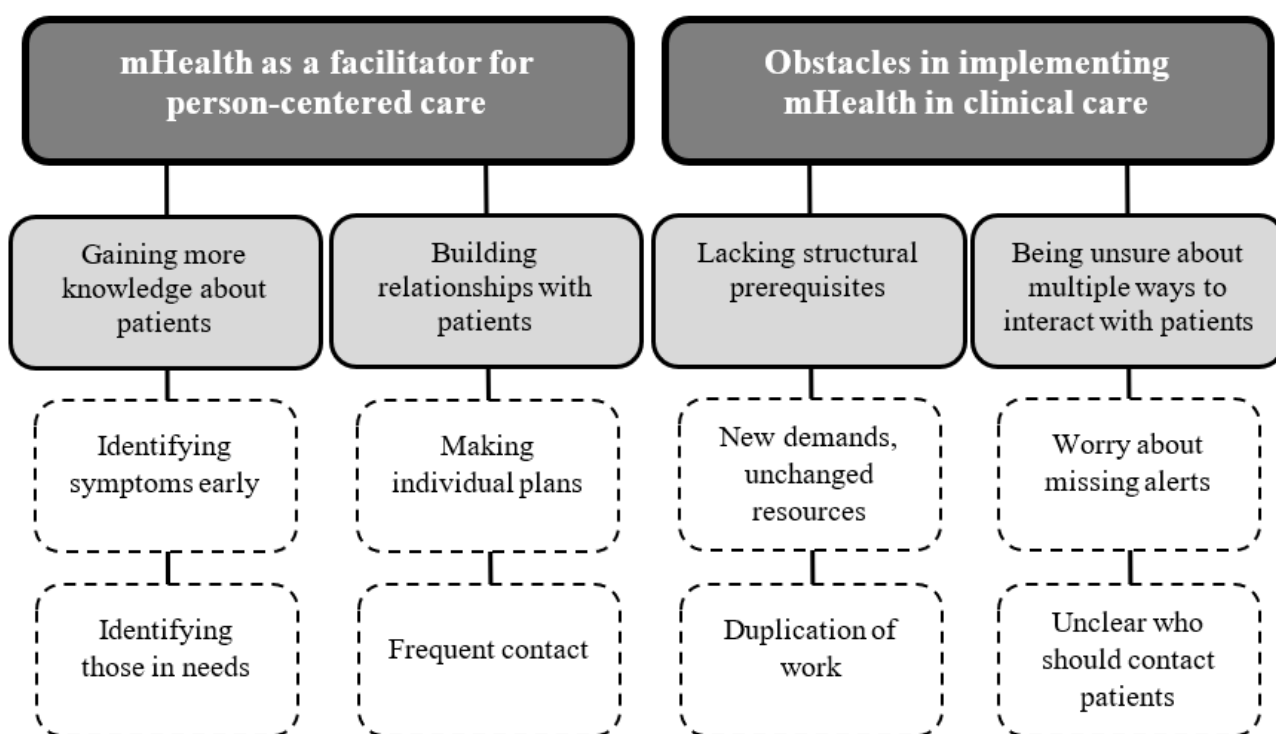
Main questions
<ul style="list-style-type: none"> • What was it like to implement the app system? • How did it affect your working situation? • What was it like to monitor alerts? • How well did the technology function? • Can you describe in which way the patients using the app contacted you during the study and if there were any differences between them and other patients? • What were your thoughts about the benefits for patients who used the app?

Data Analysis

The interviews were analyzed using thematic analysis [15]. To begin with, the first author transcribed all interviews verbatim, and both authors read through the transcripts several times to familiarize themselves with the data. Then, the text was systematically coded throughout the entire data set with an inductive approach. A code consisted of a few words or a sentence related to the aim of the study. After the initial coding,

matching codes were put together into areas. The areas were then reviewed so that they covered all codes. After this step, the areas were analyzed into themes. The themes were reviewed, discussed, and revised several times by both authors. The final analysis resulted in 2 main themes with 2 subthemes each (Figure 1). Some quotes were chosen to exemplify the findings, which are presented in the Results section. To establish rigor of the analysis, the 15-point checklist of criteria for good thematic analysis by Braun and Clark [15] was followed.

Figure 1. Examples of areas (white rectangle) connected to sub-themes (light grey rectangle) and overarching themes (dark grey rectangle) identified through the thematic analysis of interviews with nurses (n=8) responsible for monitoring and responding to alerts coming from patients using the Interaktor app following pancreaticoduodenectomy due to cancer.



Ethical Considerations

Ethical approval was given by the Regional Ethical Review Board in Stockholm, Sweden (Registration number 2011/1780-13/2), and the research followed the Declaration of Helsinki. Before inclusion in the study, all participants were informed, both verbally and in writing, about the voluntary nature and confidentiality of participation and their right to withdraw at any time. They were also made aware that confidentiality would be preserved and that access to the audio recordings would only be given to researchers involved in the analysis. Further, they were informed that quotes from the interviews would be formulated to protect the identity of the participants.

Results

The two main themes identified were as follows: “mHealth as a facilitator for person-centered care” and “Obstacles in implementing mHealth in clinical care.”

mHealth as a Facilitator for Person-Centered Care

Gaining More Knowledge About the Patients

The nurses described that through the Interaktor system, they could capture patients who did not normally contact them. Even though they told their patients to call if distressing symptoms occurred, they were aware that some patients hesitated to call since they did not want to bother the nurse. In the nurses' experiences, many patients normally waited a long time before contacting their health care provider. The alerts enabled the nurses to be notified right away if a patient had symptoms at home that needed attention. Thereby, even patients who hesitated to call were acknowledged and could receive rapid support, and attention could be focused on patients most in need.

Some might think to themselves, okay, I've got a fever but it's probably nothing to worry about, even though we've told them to call if they have a fever. The system allows us to automatically call in the event of an alarm, I think that's the most important thing. Then, hopefully, you can spend time on the patients with problems, rather than calling the ones who are well and don't really need any help. [Nurse at Unit C]

The nurses mentioned that the alerts and their different response times contributed to the rapid reaction. The early identification of symptoms and the possibility to view symptom graphs enabled the nurses to check on their patients at home. From the nurses' perspective, the patients felt secure and relaxed knowing that someone was monitoring them and that someone other than themselves was responsible for them being contacted.

The patients could rely on us to contact them, meaning that they did not need to feel responsible for contacting us. They trusted that we would contact them when they reported more severe symptoms. I really think they appreciated that. [Nurse at Unit A]

Building Relationships With Patients

The nurses stated that they had more regular contact with the patients who used the app and therefore spent more time with

them. Thus, this experience showed the nurses that patients felt close to them even if the patients were at home.

The alert levels did not suit all patients, which resulted in alerts being triggered even if the patient was not in need of support. Patients sometimes felt guilty and apologized if the nurse called several times for the same alert. As a solution, the nurses made individual plans together with the patients about when to call and when not to call. In addition, the patients were encouraged to write messages in the free text section to specify if they needed contact or not. This enhanced the communication between the nurse and the patient.

And then there was a patient who we had a lot of contact with. She had numbness all the time and felt that many times I called unnecessarily. But after a few times I still wanted to call, but then she said, I will write a comment if I want you to call. That was --- [mentions patient by name], I think you knew her even better [addresses colleague]. [Nurse at Unit C]

The self-care advice enabled the nurses to give personalized advice to the patients. When talking to a patient, the advice could form the basis of the conversations. The nurses and the patients could then discuss different actions and what suited that patient, or the nurse could clarify the text that the patient had read. Further, by reading the self-care advice, patients could ease their symptom burden at home without having to seek medical care, and self-control of the disease could be achieved, which created security.

Obstacles in Implementing mHealth in Clinical Care

Lacking Structural Prerequisites

The nurses felt that they lacked a clear structure for how to set up the work around the patients who used the app. The nurses themselves had to create a structure for how to monitor and respond to alerts, which took time from their usual tasks. Moreover, the experience was that they spent more time on patients who used the app, which resulted in extra work. None of the units had adapted their workflow in any way when introducing the app, which meant that the resources available were the existing staff. The lack of structure, time, and staff resulted in work with the Interaktor system being deprioritized. However, there was a varying engagement in working with the system among the nurses, with different views on how to structure the work. Here is a discussion between 2 nurses:

The other day we talked about how we didn't have any good routines for this system, or at least I felt that we didn't have a routine for when to check for alerts, so that it just became automatic.

Hmm, but for myself, every time I walked by the phone, I checked it for alerts. [Two nurses at Unit C]

The nurses mentioned that it was time-consuming to work with both the Interaktor system and the regular electronic medical records system. There was a strong wish that the two systems could have been integrated to a greater extent, so that information about the patients was easy to access when an alert came, and they could facilitate documentation of actions and advice.

Being Unsure About Multiple Ways to Interact With Patients

Often, when the nurses came to work on Mondays, there was a long list of alerts that had come in over the weekend. This created a concern that patients had not received help with their problems, and they felt obliged to call to make sure that no one was feeling unwell at home. Sometimes patients had awaited a call from the nurse, which made the nurses unsure about how to clarify ways to contact health care. Further, there was uncertainty as to whether alerts might have been missed or not, due to technical problems with the phone, or it not being checked regularly.

Since only a few patients were included in the study at any one time, the nurses felt that it was hard to set routines and keep track of patients who used the app. Most patients they cared for did not participate in the study and did not have access to the app, which made their work more difficult as different patients could reach them in different ways.

At a small unit, it was hard to respond to alerts within the specified times. Therefore, it happened that patients called the clinic's advice line as well, which resulted in uncertainty as to whether the patient had already spoken to someone or not. In the same way, uncertainties arose about the responsibility to contact patients who were connected to the advanced home care team or who were about to receive chemotherapy at the treatment unit. As a result, the nurses found that patients received numerous phone calls and had contact with several nurses.

They meet a nurse in the treatment unit quite regularly and then maybe they feel that they do not need to report an alert. They know that tomorrow they can discuss this at the treatment unit. At least half of the alerts were connected to the treatment and then the nurses needed to talk to them to adjust the doses or something like that. [Nurse at Unit B]

Discussion

Principal Results

Important findings in this study are that the nurses emphasized that incorporating mHealth in clinical practice is helpful in facilitating person-centered care. The Interaktor system enabled the nurses to form partnerships with patients and to capture patients in most need. However, they experienced obstacles in incorporating the Interaktor system due to lack of structural prerequisites and uncertainty about the multiple ways of interacting with patients.

Limitations

There are some limitations with this study. For some periods of time, the nurses had few patients to monitor, which could well have affected their understanding of the system and its use. If other patient groups had been included in the study, the nurses might have gained more experience and insights about this new way to support and monitor patients with cancer. Further limitation is the risk that, when using focus groups, individual voices and certain views are prevented from emerging due to

group dynamics [14]. Sometimes it was notable that someone expressed themselves more strongly than the others in the group. However, discrepancies were captured even at the same workplace, indicating that diverse views were given room in the interviews. A strength with the analysis is that the authors have different preunderstandings of the study and the data. The initial coding and analysis of themes was carried out without the influence of previous evaluations of the Interaktor app. Later in the analysis process, the researchers who conducted the interviews were involved, which facilitated the validation that initial thoughts were not lost during the analysis.

Comparison With Prior Work

Forming partnerships with patients has been described as the foundation for person-centered care [16]. According to Swedish law and regulations, nurses are obligated to create conditions for individual planning, and to allow patients to participate in their own care and to perform self-care as much as possible [17,18]. The results illustrate several ways in which partnership and participation can be achieved by implementing the Interaktor app. The nurses had a close connection to patients, even if they were at home. Further, they could follow up on patients' self-care through the symptom monitoring and then interact with patients and make individual plans. The results demonstrate that nurses are ready to use mHealth to bring knowledge and increase patients' participation in care, a focus that has been highlighted by international and national nurse associations [19,20].

One of the main findings, that the Interaktor system could capture patients in most need without patients having to be responsible for contacting health care themselves, is consistent with descriptions from patients using the app [12]. To be able to implement such a tool as a clinical routine, it is important that there is consensus on its benefits. On the other hand, when the responsibility was placed on the nurses, a worry arose that patients might be neglected. This highlights the importance of creating clear routines when implementing new ways of working.

Neither workplace had adapted their structure in any way prior to the introduction of the app, meaning that the nurses received this new workload in addition to their regular duties. Monitoring patients and responding to alerts took more time than the standard care, where patients got in touch with them when they needed something. The description of an extra workload has been highlighted previously in evaluations of mHealth and must be considered before implementation [21,22]. A clear structure, proper training, and introduction along with positive and engaged nurses are prerequisites when implementing mHealth [22]. Further, previous research has found that nurse managers have shown stronger motivation to use information and communication technology than registered nurses and that team climate and collegial and organizational support are essential to build positive experiences for health care professionals [23]. If the app is to be implemented in the standard care, it is important for workplace managers to adapt the workplace so that the app becomes part of the normal routine. This will require clear manuals and steering documents. Furthermore, focus needs to be placed on engaging nurses and making them identify

benefits themselves, along with suitable training and introduction to the system.

Since the web interface was not incorporated in the systems that nurses already used daily, they experienced duplicated work, using two systems to document interactions and support to patients. This is in line with findings from a review where a major barrier for health care professionals to incorporate collection of PROs as clinical routine was that PROs were not incorporated in the hospital's electronic records resulting in multiple log-ins with the risk of ineffectiveness [24]. For implementation work, it will be important to incorporate collection of PROs along with self-care advice and documentation of support into systems that are used daily.

The nurses pointed out that it was not optimal to call patients on Mondays for alerts that had occurred over the weekend. This was also brought up by patients as a flaw with the system, as it is often over weekends and during the night that feelings of loneliness can arise and thereby the need to talk to someone [12]. It has been concluded that a lack of outpatient services on weekends for patients following pancreatic cancer surgery leads

to increased emergency room use, and that early identification and triage of adverse events are essential [25]. This highlights the need to offer patients with pancreatic cancer support outside of office hours, even for symptoms of less acute nature.

Conclusions

In conclusion, the findings show that with the help of mHealth, health care professionals can gain more knowledge about patients at home and build relationships from a distance. As such, person-centered care can be facilitated for patients undergoing treatment for pancreatic cancer. By identifying patients in most need, health care professionals can allocate their resources accordingly, which makes care more effective. For tools such as Interaktor to be implemented in standard care, there are important organizational issues to consider. Health care professionals need time and resources to create new routines and adapt the workplace, together with proper introduction, training, and support from unit managers. Further, it would be beneficial if the app was incorporated in already-used systems and if alerts were monitored and responded to during all hours of the day.

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Conflicts of Interest

None declared.

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Abbreviations

mHealth: mobile health

PRO: patient-reported outcomes

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Original Paper

The Outcomes of App-Based Health Coaching to Improve Dietary Behavior Among Nurses in a Tertiary Hospital: Pilot Intervention Study

Wei Xiang Lim¹, MBBS, GDOM, GDFM; Stephanie Fook-Chong², BSc, MSc; John Wah Lim¹, MBChB, GDFM, MPH; Wee Hoe Gan¹, MBBS, MPH, MRCP, DAvMed

¹Department of Occupational and Environmental Medicine, Singapore General Hospital, Singapore, Singapore

²Programme in Health Services and Systems Research, Duke-NUS Medical School, Singapore, Singapore

Corresponding Author:

Wee Hoe Gan, MBBS, MPH, MRCP, DAvMed

Department of Occupational and Environmental Medicine

Singapore General Hospital

Academia, Level 4

20 College Road

Singapore, 169856

Singapore

Phone: 65 65767438

Email: gan.wee.hoe@singhealth.com.sg

Abstract

Background: At the workplace, health care workers face multiple challenges in maintaining healthy dietary behaviors, which is the major factor behind obesity. A hospital-wide mass health screening exercise showed an increasing trend in the prevalence of obesity and median BMI from 2004 to 2019, as well as a higher crude obesity rate among shift workers.

Objective: We aimed to evaluate the effectiveness of mobile app-based health coaching and incentives for achieving weight loss from better dietary choices among hospital nurses.

Methods: We conducted a pilot study from June 2019 to March 2020, involving the use of a health-coaching app by 145 hospital nurses over 6 months. Weight and BMI were self-reported, and food scores were calculated. Data among overweight nurses, shift work nurses, and incentive groups were analyzed.

Results: A total of 61 nurses were included in the final analysis. Of these 61 nurses, 38 (62%) lost weight. The median percentage weight loss was 1.2% (IQR 0%-2.9%; $P < .001$), and the median decrease in BMI was 0.35 (IQR -0.15 to 0.82; $P < .001$), but they were not clinically significant. The median improvement in the food score was 0.4 (IQR 0-0.8). There was no difference between the incentive and nonincentive groups. A total of 49 (34%) participants engaged for ≥ 8 weeks.

Conclusions: The study demonstrated an association between the use of app-based health coaching and the attainment of some weight loss in nurses, without a significant improvement in the food score. Incentives may nudge on-boarding, but do not sustain engagement.

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KEYWORDS

smartphone app; weight loss; dietary behavior; nurse; app; mobile health; mHealth; app-based health; health coaching; diet; dietary choice

Introduction

Background

Overweight and obesity are the leading risk factors for a multitude of noncommunicable diseases around the world, including cardiovascular diseases, diabetes mellitus, and some

types of cancers [1-3]. Health care professionals may themselves be obese [4-6] and less healthy compared with the general population [7,8]. Studies have identified dietary behaviors to be the major factors behind obesity, in particular, the consumption of high caloric food rich in fat and sugar [7,9]. At

the workplace, health care workers face multiple challenges in maintaining a healthy diet [6,10,11].

Prior to this study, we conducted a mass health screening exercise for 5171 of our hospital staff members across various job classifications, and the results showed an increasing trend in the prevalence of obesity and median BMI from 2004 to 2019. The median BMI increased from 22.6 kg/m² in 2004 to 23.5 kg/m² in 2019, and the crude obesity rate (BMI ≥30 kg/m²) has correspondingly increased from 7.5% to 13.2%.

Comparing the results to the most recently available data provided by Singapore's National Population Health Survey in 2020 [12], our hospital staff members have a higher crude obesity rate of 12.0% (gender standardized) as compared to a rate of 10.5% in the Singapore population. Hence, we identified the health care worker population as a group increasingly at risk for obesity and other long-term effects associated with obesity.

Among our staff, the crude obesity rate (BMI ≥30 kg/m²) among shift workers is higher than that among nonshift workers (13% vs 11%). The barriers to healthy dietary behavior include shift duties, having irregular meals, or absence of a diet plan as a result of shift work [11,13,14]. Standard dietary interventions often involve face-to-face programs during day time working hours and rarely address those performing shift work. Nurses form the majority of the hospital workforce, and they are susceptible to the negative effects of shift duties on nutrition patterns and obesity [15,16].

A systematic review of 136 lifestyle health promotion intervention studies for nurses found that interventions targeting diet, body composition, physical activity, or stress are most likely to have positive outcomes for nurses' health or well-being [17]. The review also suggested that interventions aimed at improving nutrition amongst nurses commonly result in improved outcomes, especially when the interventions are education based. However, the use of web technology was mainly limited to education websites and not mobile apps. A study involving female health care workers found that a web-based educational tool was not useful for improving and modifying their lifestyle [18].

There have been efforts launched to address obesity and other health outcomes among the general and patient populations using smart apps both locally in Singapore [19-21] and internationally [22-26]. Mobile app-based health coaching has been used in a local study to target the diabetic patient population with a similar study period of 6 months for the participants [19]. Another local pilot randomized controlled trial targeting overweight pregnant women [20] had a different objective to control gestational weight gain and macronutrient intake rather than weight loss. A local randomized controlled trial protocol has also been proposed locally to evaluate the effectiveness of a comprehensive diabetes management package involving 2 health apps over 24 months, with weight loss as its secondary objective [21]. An American study also indicated that the use of diet/nutrition apps is associated with diet-related behavior change, namely increased actual goal setting to eat a healthy diet, increased frequency, and consistency of eating healthy foods [27].

However, based on published literature, there are limited programs using smart apps targeted at health care workers. Therefore, we hope to provide a multi-domain nonface-to-face dietary behavior coaching program by leveraging digital technology. Instead of a prescribed date and time of a physical session, this modality enables nurses to interact and participate in the program any time at their convenience.

Objective

With funding from Singapore's Health Promotion Board (HPB), a small pilot study was implemented by onboarding nurses onto a digital app to participate in a dietary behavior health coaching program.

The primary aim of this study was to evaluate the effectiveness of a mobile app for improving dietary behaviors among nurses, especially among shift workers, which include improving quality of food choices and achieving weight loss from better dietary choices.

The secondary aim was to evaluate the effectiveness of incentives for modifying and sustaining health behavioral change.

The data received were analyzed for program effectiveness and for the institution to gain insights into the implementation challenges around the use of digital technology for this purpose. These learning points include participant recruitment strategies, potential problem areas, and real-world operational concerns, all of which will allow us to recommend changes if the program is to be scaled to a much larger population in the future.

Methods

Study Design

This was a pilot study conducted within a tertiary acute hospital in Singapore between June 2019 and March 2020. As part of the corporate health improvement initiative and as an extension of the Workplace Alliance for Health Scheme, the hospital's Department of Occupational and Environmental Medicine partnered the national HPB to start a program of using a commercially available mobile app-based intervention to promote and improve dietary behavior among nurses.

The mobile app is a proprietary healthy lifestyle management program that was originally developed by a private company for use in Singapore for adults with type 2 diabetes mellitus (T2DM) [28]. Screenshots of the mobile app are shown in [Multimedia Appendix 1](#) and [Multimedia Appendix 2](#). It is a commercially available app downloadable from either the Apple App Store or Google Play Store, and users can access its features through paid subscriptions. It comprises the following 2 components: (1) a comprehensive T2DM educational curriculum delivered through online lessons and (2) the mobile app with a health coaching feature. The mobile app enables users to log and monitor their blood glucose levels, weight, meals, and physical activity, which is captured via the mobile phone's built-in pedometer. The app also serves as a vehicle for accredited dietitians, known as health coaches, to provide personalized feedback to participants on their progress and to present opportunities for improvement.

Based on the quantum of funding secured, we were able to use only part of the suite of features offered by the mobile app, such as weight and meal logs, real-time health coaching, and general health information, for up to 145 users.

Participants

We recruited 145 nurses who are currently working in the hospital. The recruitment onboarding process took place across 3 months as planned. It was an open recruitment process where instructions for registration were cascaded through nursing leaders. Registration was on a first-come first-serve basis. Participants were included if they (1) were nurses within the hospital and (2) had a smart mobile device. We did not specifically set a target proportion of shift workers, or overweight or obese workers. Participants were excluded if they (1) were not permanent staff of the hospital or (2) did not have a smart mobile device. All successfully registered participants received 6 months of free unlimited access to mobile app-based health coaching. The app allowed them to (1) voluntarily log their weight and food intake via photos or text comments, (2) communicate with a dedicated health coach in real time via the secured in-app messaging feature, and (3) receive general health information provided within the app, such as food choices during Ramadan, the fasting month observed by Muslims.

The participants were also randomized to the low incentive group (group A) or the high incentive group (group B) in a 73:72 allocation ratio. Both groups of participants were provided with full access to the mobile app-based health coaching and its services for 6 months. Group A received S \$15 (US \$10.70) worth of health points in HPB's Healthy 365 app at the end of the first 3 months and no further incentive for the next 3 months, while group B received S \$30 (US \$21.40) worth of health points in HPB's Healthy 365 app at the end of 6 months. Healthy 365 is a mobile app by Singapore's HPB, which aims to encourage users to adopt a healthier lifestyle through the use of gamification and rewards [29]. The app seamlessly pairs with fitness tracking devices to help users log their daily step count and amount of time spent on active exercise. Users can sign up for in-app challenges and health programs to earn health points, which they can redeem for healthy lifestyle rewards from a catalogue. The criterion for the group A incentive was engagement with the app for 8 weeks out of the first 12 weeks of the program. The criteria for the group B incentive were (1) at least 4 engaged weeks in the last 12 weeks of the program and (2) qualification for the first incentive.

Data

Data, such as biodata, age, height, and weight, were self-reported by the participants in the app, and BMI was calculated based on self-reported height and weight. Food scores were assigned by the mobile app's dietitians and nutritionists based on the user's uploaded photos or text comments. The meals were given a rating of 1 to 5, in half-point increments, with 1 being the least healthy and 5 being the healthiest. The food log meal reading improvement was then derived by subtracting the mean of the last 5 food logs from the mean of the first 5 food logs. The health coaches also trended the frequency of engagement and reached out to participants who had reduced engagement with the app. An engaged week was defined as the user logging at

least one food, weight, or message into the app. However, biochemical data, such as fasting glucose and lipid profiles, were not collected.

All data were self-entered by program participants into the app itself. Data from the app were kept strictly confidential and safe on a secured password-protected server, with limited access given to program coaches. Access to data was limited to the program team only. The hospital team obtained only deidentified data for program evaluation. No identifiable data were used for analysis.

Ethics Approval

We conducted the study according to the tenets of the Declaration of Helsinki and obtained approval from the SingHealth Centralized Institutional Review Board (CIRB 2019/2456). Consent was embedded in the mobile app, as part of the on-boarding/registration process to create an account within the app. Potential candidates were considered to be enrolled in the program only after they pressed the accept button on the consent page.

Statistical Analysis

Data for continuous variables were reported as median (IQR), as most data had a skewed distribution, and categorical variables were reported as count (%). Comparisons of categorical data between comparison groups of overweight nurses, shift workers, and randomization arms were performed using the chi-squared test, and the Mann-Whitney test was used for continuous variables. All tests were 2-sided, with a *P* value <.05 taken as indicating statistical significance. Statistical analyses were performed using IBM SPSS Statistics Version 19 software (IBM Corp).

Results

A total of 145 hospital nurses were enrolled in the program. **Table 1** shows the demographic characteristics of our study population. There were 129 (89.0%) females and 16 (11.0%) males. The median age was 34 years (IQR 30-43 years, range 22-66 years). The majority of nurses were Chinese (67/145, 46.2%) and Malay (48/145, 33.1%). Moreover, 114 (78.6%) nurses were overweight (BMI ≥ 23 kg/m²). The median starting weight was 67 kg (IQR 57-78 kg, range 38-125 kg), and the median starting BMI was 26.0 kg/m² (IQR 23.0-30.0 kg/m², range 17.0-45.0 kg/m²). Overall, 85 (58.6%) nurses were shift workers.

Among the 145 nurses recruited for the program, 49 (33.8%) engaged for ≥ 8 weeks and 38 (26.2%) engaged for ≥ 12 weeks. The median total logs (meal and weight logs) was 17 (IQR 4-37), and the median total touchpoints (Ask Coach) was 47 (IQR 17-104) per participant. Among the 61 nurses in the final analysis, the median interval between weight logs was 10 weeks (IQR 5-21 weeks).

The results of 61 (42.1%) participants were included in the final analysis (**Table 2**). The other 84 participants were excluded as they did not self-report their before and after weights. The median weight loss was 0.8 kg (IQR 0-2.3 kg; *P*<.001), and the

median percentage weight loss was 1.2% (IQR 0%-2.9%; $P<.001$). Of the 61 participants, 38 (62.3%) lost weight. There was a median decrease in BMI of 0.35 (IQR -0.15 to 0.82; $P<.001$). The median improvement in the food score was 0.4 (IQR 0-0.8; $P=.07$). Among the 84 participants who were

excluded due to insufficient weight data, 16 had sufficient food logs for analysis. When analyzed together with the group of 61 participants having weight data, the median improvement in the food score (77 participants with food score data) was 0.4 (IQR -0.1 to 0.8; $P=.07$).

Table 1. Demographic characteristics of the participants.

Characteristic	Value (N=145)
Gender, n (%)	
Female	129 (89.0)
Male	16 (11.0)
Ethnicity, n (%)	
Chinese	67 (46.2)
Indian	14 (9.7)
Malay	48 (33.1)
Others	16 (11.0)
Age (years), median (IQR)	34 (30-43)
Height (m), median (IQR)	1.59 (1.56-1.63)
Starting weight (kg), median (IQR)	67 (57-78)
Starting BMI (kg/m ²), median (IQR)	26 (23-30)
Shift work, n (%)	
Nonshift	60 (41.4)
Shift	85 (58.6)

Table 2. Analysis of the health outcomes of participants.

Outcome	Overall (n=61), median (IQR)	P value	Over-weight or obese (n=49), median (IQR)	Nonover-weight or nonobese (n=12), median (IQR)	P value	Shift work (n=33), median (IQR)	Nonshift work (n=28), median (IQR)	P value	Double incentive (n=30), median (IQR)	Single incentive (n=31), median (IQR)	P value
Weight loss (kg)	0.8 (0 to 2.3)	<.001	N/A ^a	N/A		N/A	N/A		N/A	N/A	
Percentage weight loss	1.2 (0 to 2.9)	<.001	1.2 (-0.2 to 3.1)	0.5 (0 to 1.9)	.60	1.6 (0 to 3.6)	0.4 (-0.1 to 2)	.12	1.1 (-0.2 to 1.0)	1.2 (0 to 1.0)	.53
Reduction in BMI	0.35 (-0.15 to 0.82)	<.001	0.41 (-0.14 to 0.9)	0.24 (-0.11 to 0.57)	.55	0.43 (-0.8 to 0.96)	0.23 (-0.20 to 0.59)	.22	N/A	N/A	
Improvement in the food score	0.4 (0 to 0.8)	.07	0.5 (0.1 to 0.9)	0.2 (-0.1 to 0.6)	.13	0.3 (-0.6 to 1.4)	0.4 (-0.6 to 1.3)	.67	0.4 (-0.1 to 0.8)	0.4 (0.1 to 0.8)	.83

^aN/A: not applicable.

Among the 61 participants, there were 49 (80.3%) overweight or obese nurses (BMI ≥ 23 kg/m²), and we observed that 63.3% (31/49) of them lost weight compared to 58.3% (7/12) of nonoverweight or nonobese nurses. The median percentage weight loss in the overweight or obese group was 1.2% (IQR -0.2% to 3.1%), and the value was higher compared to 0.5% (IQR 0%-1.9%) in the nonoverweight or nonobese group. There was a greater reduction in BMI in overweight or obese nurses (0.41, IQR -0.14 to 0.9) compared to that in nonoverweight or nonobese nurses (0.24, IQR -0.11 to 0.57). The overweight or obese group also showed better improvement in the food score,

with a median improvement of 0.5 (IQR 0.1-0.9) compared to 0.2 (IQR -0.1 to 0.6) in the nonoverweight or nonobese group. However, both differences were not statistically significant.

Among the 61 participants, there were 33 (54.1%) shift workers. We observed that the median percentage weight loss in shift workers was 1.6% (IQR 0%-3.6%), and the value was higher compared to 0.4% (IQR -0.1% to 2%) in nonshift workers. There was also a greater reduction in BMI in shift workers (0.43, IQR -0.8 to 0.96) than nonshift workers (0.23, IQR -0.20 to 0.59). However, both differences were not statistically

significant. There was also no difference in meal improvement between shift workers and nonshift workers.

Comparing group B participants (n=30) who received 2 incentives (3rd month and 6th month) and group A participants (n=31) who received a single incentive (3rd month), there were no differences in both percentage weight loss and improvement in the food score.

Discussion

Principal Findings

Smart apps are being increasingly employed to address obesity and other health outcomes among the general population and patient populations. App-based interventions have been shown to be effective in promoting weight control through shaping positive dietary behavioral change, thus leading to desired health outcomes in the long term [30,31]. One main aspect that smart apps focus on is dietary self-monitoring, which is the cornerstone of behavioral weight loss treatment and has been associated with greater weight loss [31-34]. The health coaching mobile app in this pilot study was originally developed for use in Singapore as a proprietary lifestyle management program for adults with T2DM [19].

The WHO has also recommended the use of nonfood rewards in obesity treatments [35]. However, previous trials and systematic reviews have reported mixed results [36-39], with some studies suggesting that financial incentives may be appropriate when properly administered, but behavioral maintenance persists as a weakness in most cases [40,41]. Locally, the National Steps Challenge [42] is an incentive-based national program to encourage Singaporeans to be more physically active, and 90% of those who have already received all rewards continue to persist for at least another 2 months.

The median percentage weight loss was 1.2% for overweight participants after 6 months of app-based health coaching, compared to a 2.3% reduction in baseline weight in a local study by Koot et al [19]. In a systematic literature review by DiFilippo et al [23], 2 out of 3 randomized controlled trials reported percentage weight loss values of 3.2% and 2.7%. These were lower than the minimum clinically meaningful weight loss of 5%, even though the weight loss was statistically significant. The guideline of the National Heart, Lung, and Blood Institute recommends a 10% reduction in weight for overweight and obese people [43], although considerable literature indicates that 5% weight loss is clinically meaningful and associated with reduced health risks [44].

Another meta-analysis of 12 studies by Flores Mateo et al [24] found that those who used a mobile app showed significant decreases in weight of 1.04 kg and BMI of 0.43 kg/m² compared with control groups. This is higher than the median weight loss of 0.8 kg and median decrease in BMI of 0.35 kg/m² in our study. While the meta-analysis included studies with a duration of 6 weeks to 9 months, more than half of the studies had physical activity interventions embedded in the mobile apps. Most of the studies involved only overweight patients, and only 2 of the 12 studies reported high attrition rates. These may

explain the higher weight loss and median decrease in BMI in the other studies. Although the median reductions in percentage body weight were modest in our study, it should not be expected to achieve clinically meaningful weight loss with a single weight loss intervention when compared with programs with multiple interventions [45,46]. We recognize that health behavior modification is complex and requires a multi-faceted yet integrated approach. However, it is not the intent of this study to delve into surrounding health behavioral change, such as through the use of the Health Belief Model as an explanatory framework. The mobile app allows fast onboarding and may offer easy access to some of these other multiple interventions that are available in the full version of the app, such as glucose monitoring and physical activity tracking. Further studies can evaluate the effectiveness of an integrated program or workplace health promotion that includes a mobile intervention and its full suite of features.

A systematic review of 12 studies by Wang et al [25] found that the greatest weight loss differences were seen in patients who employed multiple tactics within their weight loss strategy. The authors postulated that while the net effect of the joint nontechnological intervention is unknown, it suggests that even though applications alone promote the self-regulation aspect of weight loss behaviors, they ought to be used in conjunction with other avenues for weight loss. A recent review by Ghelani et al [26] also found that randomized controlled trials have reported smartphone apps to be ineffective for weight management as stand-alone interventions, as they were reported to not achieve the clinically significant target percentage weight loss of 5%. The authors suggested that mobile apps showed potential to be used as an adjunct to other weight management interventions instead.

We observed that engagement levels fell greatly after the short-term engagement period of 3 months, which is consistent with other local studies using smartphone apps [19,20]. This may potentially attenuate the longer-term benefits of sustained lifestyle management, hence accounting for the clinically insignificant weight loss among the studies. The fall in sustained engagement was before Singapore had its first case of COVID-19 [47], and local hospitals had already begun preparatory work and work intensification prior to that. Less than half (61/145, 42.1%) of our participants managed to log their before and after weights. Given the self-reported nature of the dietary and weight data, the accuracy is subjected to social desirability bias and recall bias. Based on systematic reviews performed, high attrition rates are not uncommon in weight-loss intervention programs, and the reasons are varied and complex [48-51]. We also postulate that the low adherence may be due to more considerable effort required to self-monitor diet than to monitor physical activity through a passive method of using motion sensors or pedometers [34,46,52]. We suggest to appoint internal ambassadors to champion the effort and to increase peer-driven engagement, as well as to engage users with in-person events, such as booths providing in-person app support, receiving feedback, and providing healthy snacks as incentives in future studies.

Strengths and Limitations

The strengths of our study are its prospective study design and the use of standard protocols in dietary food score assessments by qualified dietitians. The limitations of the study include the small sample for analysis relative to the number of enrolled participants and the exclusion of a group of participants due to incomplete self-entered data. As this was a pilot study, the sample size was small in proportion to the nursing population of the hospital, which is around 4000 nurses. Moreover, the use of app features and the frequency of engagement with health coaches were entirely voluntary and up to the individual. Hence, the benefits of dietary modification and extent of weight management were largely dependent on user initiative. The study was also limited by its short duration, and it was not able to demonstrate the longer-term sustainability of health behavioral change and its attendant benefits.

Interestingly, we also observed no differences in percentage weight loss, improvement in food scores, and number of touch points between the low and high incentive groups. However, this can be attributed to the incentives being not too significant in terms of monetary value. According to a systematic review by Purnell et al, larger incentives are associated with better outcomes, although behavior change did not appear to be maintained [36]. Maintenance of behavior could be addressed by using financial incentives to facilitate the desired behavioral outcome rather than to reward the completion of the said behavior, as suggested by Burns et al [53]. To increase the compliance of weight reporting and to reduce the conflict of interest between an incentive and self-reported weight loss of a participant, weight should be taken in-person under supervision.

Future Directions

Although our study used healthy dietary coaching as the main intervention, physical activities play a significant role in weight loss as well [54-56]. We postulate that enrollment in the program may result in a step up in other active lifestyle measures, such as physical activity, that are not monitored and measured. We hope to look at multi-faceted health-seeking behaviors to better understand our context going forward and to include qualitative methods, such as in-depth interviews and focus group discussions, to better focus on our target population. Future studies could also include deeper insights into the nursing occupation, and could analyze the results while taking into account the working conditions and environment. Such analyses would serve to inform how we may influence health behaviors in the health care worker population, and to adjust health promotion interventions to achieve better outcomes.

Conclusion

Our study has demonstrated some benefits in achieving weight loss among nurses and has shown some indication of increased benefits among shift workers and overweight participants, even without significant improvements in food scores. We recommend a shorter duration of incentives (3 months) due to a decay in the engagement rate with time. We found that incentives may nudge onboarding, but do not result in sustainment of engagement over time. Future efforts should assess the effectiveness of mobile app-based health promotion using a randomized controlled trial of at least 12 months to evaluate longer-term health behavioral changes and health outcomes. It may also be useful to include more outcome parameters, such as blood pressure, random glucose, and lipid profile. Mobile apps should be used in conjunction with other nontechnological interventions, such as physical activity, group sessions, and face-to-face health coaching, to achieve a more positive effect overall.

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Liang Sai; Department of Occupational and Environmental Medicine, Singapore General Hospital, Singapore

Zeenathnisa Mougammadou Aribou; Department of Occupational and Environmental Medicine, Singapore General Hospital, Singapore

Kang Lee Lin; Health Promotion Board, Singapore

Nidu Maran Shanmugam SO Bala Krishnan; Division of Nursing, Singapore General Hospital, Singapore

Tien Choo Eng; Division of Nursing, Singapore General Hospital, Singapore

Leong Siew Teing; Division of Nursing, Singapore General Hospital, Singapore

Nur Fidtria Binte Sahat; Division of Nursing, Singapore General Hospital, Singapore

Nazrul Hisyam Bin Hamzah; Division of Nursing, Singapore General Hospital, Singapore

Xin Xiao Hui; Health Services Research Unit, Singapore General Hospital, Singapore

Wong Hui Mei; Department of Dietetics, Singapore General Hospital, Singapore

Ashley Toh; Holmusk Pte Ltd

Gracia Ho; Holmusk Pte Ltd

Bonnie Lau; Holmusk Pte Ltd

Patricia Cheong; Holmusk Pte Ltd

Yau Teng Yan; Holmusk Pte Ltd

Conflicts of Interest

None declared.

Multimedia Appendix 1

Screenshot of the mobile app and in-app health coaching.

[[PNG File , 276 KB - nursing_v5i1e36811_app1.png](#)]

Multimedia Appendix 2

Screenshot of the mobile app, weight logging, and food scoring.

[[PNG File , 840 KB - nursing_v5i1e36811_app2.png](#)]

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Abbreviations

HPB: Health Promotion Board

T2DM: type 2 diabetes mellitus

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Original Paper

Supporting Decision-Making About Patient Mobility in the Intensive Care Unit Nurse Work Environment: Work Domain Analysis

Anna Krupp¹, BSN, MSHP, PhD; Linsey Steege², PhD; John Lee³, PhD; Karen Dunn Lopez¹, RN, MPH, PhD; Barbara King², RN, PhD

¹College of Nursing, University of Iowa, Iowa City, IA, United States

²School of Nursing, University of Wisconsin-Madison, Madison, WI, United States

³Department of Industrial and Systems Engineering, College of Engineering, University of Wisconsin-Madison, Madison, WI, United States

Corresponding Author:

Anna Krupp, BSN, MSHP, PhD

College of Nursing

University of Iowa

50 Newton Rd

480 CNB

Iowa City, IA, 52242

United States

Phone: 1 608 213 7191

Email: anna-krupp@uiowa.edu

Abstract

Background: Patient mobility is an evidenced-based physical activity intervention initiated during intensive care unit (ICU) admission and continued throughout hospitalization to maintain functional status, yet mobility is a complex intervention and not consistently implemented. Cognitive work analysis (CWA) is a useful human factors framework for understanding complex systems and can inform future technology design to optimize outcomes.

Objective: The aim of this study is to understand the complexity and constraints of the ICU work environment as it relates to nurses carrying out patient mobility interventions, using CWA.

Methods: We conducted a work domain analysis and completed an abstraction hierarchy using the CWA framework. Data from documents, observation (32 hours), and interviews with nurses (N=20) from 2 hospitals were used to construct the abstraction hierarchy.

Results: Nurses seek information from a variety of sources and integrate patient and unit information to inform decision-making. The completed abstraction hierarchy depicts multiple high-level priorities that nurses balance, specifically, providing quality, safe care to patients while helping to manage unit-level throughput needs. Connections between levels on the abstraction hierarchy describe how and why nurses seek patient and hospital unit information to inform mobility decision-making. The analysis identifies several opportunities for technology design to support nurse decision-making about patient mobility.

Conclusions: Future interventions need to consider the complexity of the ICU environment and types of information nurses need to make decisions about patient mobility. Considerations for future system redesign include developing and testing clinical decision support tools that integrate critical patient and unit-level information to support nurses in making patient mobility decisions.

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KEYWORDS

clinical decision-making; early ambulation; intensive care unit; nursing; qualitative research; cognitive work analysis

Introduction

Background

Patient mobility is a critical intervention for intensive care unit (ICU) patients because hospital-acquired functional decline or a new loss in independently completing activities of daily living is a common complication of hospitalization, occurring in at least 50% of patients who require intensive care [1,2]. Mobility is a daily, progressive physical activity intervention for physiologically stable hospitalized patients, beginning with exercises in bed, transferring to a chair, and advancing to walking. International ICU guidelines recommend beginning mobility interventions in the ICU and continuing throughout hospitalization to maintain patients' physical functioning during hospitalization as a standard of care [3,4]. Prolonged bedrest is a modifiable risk factor associated with functional decline, and increasing mobility in patients in the ICU is a priority, as patients who develop functional decline are at increased risk for prolonged hospitalization, discharge to a skilled nursing facility, readmission, inability to return to work, and premature death [5-9]. Despite increasing research on the benefits of ICU-based patient mobility interventions, routine implementation of mobility into clinical practice is limited.

Possible explanations for the lack of widespread implementation of mobility interventions into routine practice may include the fact that mobility guidelines are complex and challenging to implement and require thorough assessment to determine a patient's stability and mobility status, team training and coordination to maintain safety and monitor equipment, and sufficient physical space for the patient, team, and equipment to complete activities. Mobility fits within several clinical practice domains, with physical therapists (PTs) or registered nurses (RNs) being most frequently involved in planning and implementing ICU mobility interventions [10]. RNs and PTs face multiple barriers when trying to implement mobility interventions. The major barriers to ICU-based mobility interventions have been categorized by previous researchers into the following 4 domains: patient (eg, physiologic instability, sedation, patient safety concerns), clinician (eg, inadequate training, workload, safety risk), process (eg, lack of coordination, unclear protocols), and organizational (eg, lack of mobility culture, competing priorities) [11-13]. Strategies to address barriers have included use of structured quality improvement models to identify and target local barriers [14], RN-initiated mobility protocols to standardize patient assessment and goal setting [15], and focused interdisciplinary communication and collaboration [16,17]. However, these resources and approaches have not spread widely. A limitation to mobility protocols is the poor usability given the temporal and cognitive demands associated with RN workflows.

Clinical decision support (CDS), or tools that integrate guideline recommendations with patient-specific information at the right time and at the point of care, has the potential to support the implementation of mobility guidelines into practice. CDS interventions are particularly relevant in ICU settings due to the large amounts of electronic health record (EHR) data generated and the need for time-critical decisions. CDS

interventions to identify risk for clinical deterioration [18] and sepsis recognition [19] have led to improved intervention timeliness and decreased patient mortality. CDS data visualization has been shown to improve timeliness for delivering evidence-based sedation and mechanical ventilation practices [20], yet CDS to support mobility practice does not exist. In addition, CDS has focused primarily on medical decision-making, and less research has targeted decision support for acute care RNs [21]. CDS can provide data visualizations, alerts, reminders, and decision support to augment clinicians in complex processes and support coordinated care delivery [22]. However, without understanding the environment within which decisions are made, CDS may not be successfully developed and implemented [23].

We propose examining mobility decision-making using human factors methods to understand the work environment in which mobility decisions are made. Human factors methods aim to understand interactions between humans and elements of a system to optimize outcomes [24,25]. The ICU setting is a complex and dynamic environment with high levels of technology, uncertainty, time pressure, and interprofessional teamwork. Therefore, a naturalistic decision-making model is relevant for exploring the process of making decisions while appreciating the complexity of the ICU setting [25]. Because nurses provide the greatest amount of direct patient care, are responsible for patient monitoring and care coordination, and determine the patient's mobility intervention (eg, standing, walking), we aim to understand nurse decision-making regarding patient mobility. The complexity of ICU nursing work includes multiple types of demands, such as physical, emotional, and cognitive, with nurses often making decisions under time pressure and unpredictability [26]. Understanding the environment in which ICU nurses make decisions, coordinate, and implement interventions is needed to guide the development of future interventions aimed at implementing and sustaining ICU mobility programs.

Cognitive Work Analysis

One approach that has been used effectively to study real-world decision-making and inform informatics-based interventions in health care is cognitive work analysis (CWA). CWA is a methodological 5-phase framework that includes analytic tools used for systematically identifying different constraints or limitations in a work environment [27]. A fundamental concept of CWA is understanding constraints that result from the work environment, as they influence behavior and actions [28,29]. CWA uses a formative approach to analyzing the work environment. In contrast to analyzing how work should be done or how work is actually done, CWA describes principles of the work environment that are necessary for success and the range of ways that work is accomplished [27]. From this perspective, the work analysis identifies possible actions and requirements for those in a work environment to behave in new ways.

In addition, results of CWA inform system redesign and support developing decision support tools that offer flexibility in complex and unpredictable settings [29]. CWA has been applied in multiple health care settings, including ICUs, to understand complex settings and has informed design of new displays and

decision support tools [30]. In summary, the theoretical approach of CWA aligns well with the current clinical challenge of implementing mobility interventions, as patients in the ICU are heterogeneous, there are multiple ways to achieve mobility interventions within a complex ICU work environment, and this analysis facilitates our long-term goal to develop CDS.

Work Domain Analysis

Work domain analysis (WDA) is the foundational phase of CWA and focuses on understanding work environment purposes,

constraints, and how the purpose(s) are achieved within the constraints of the work environment [27,31]. A result of the WDA is an abstraction hierarchy model, which provides a visual representation of the structure and functions of the work environment at different conceptual levels with means-ends linkages between levels. Table 1 summarizes the 5 abstraction levels. Each level provides a different perspective of the work environment; a linkage to a higher level describes *why* something exists and a linkage to a lower level describes *how* a purpose or function exists in the work environment.

Table 1. Abstraction hierarchy levels used for work domain analysis.

Abstraction level	Description	Example
Functional purpose	Reason why the work environment exists	Why does the ICU ^a exist?
Values and priorities	Criteria to assess how well the work environment is performing its purpose	How do we know the ICU is achieving its purposes?
Purpose-related functions	High-level functions needed to support the values and priorities	What functions must be performed in the ICU to achieve its values and priorities?
Object-related processes	Describes what processes the objects in the work environment support	What are the functions of the resources in the ICU?
Physical objects	Objects within the work environment	What physical resources are in the ICU?

^aICU: intensive care unit.

Despite increasing research on the benefits of ICU-based patient mobility interventions, routine implementation of mobility guidelines into clinical practice is inadequate. A greater understanding of the environment in which ICU nurses make patient mobility decisions is needed to inform the development of future interventions. Therefore, the aim of this study was to apply WDA to develop an understanding of the complex ICU work environment and identify constraints as they relate to nurses carrying out patient mobility interventions.

Methods

Study Design

In this descriptive study, WDA was used as an approach for data collection and analysis. A WDA was conducted using data from multiple sources and followed an iterative process of data collection and model development. The scope of the WDA was the ICU work environment in the context of nurses carrying out patient mobility interventions.

Setting

The study was conducted in 2 adult ICUs at 2 different health systems in a Midwestern US city. The study ICUs were chosen because they had established interdisciplinary mobility programs. Both ICUs had implemented protocols for managing pain, agitation, delirium, and immobility, which included orders for nurses to advance patient mobility as tolerated and PT orders dependent upon the medical team. Mechanically ventilated patients were routinely mobilized out of bed to the chair by nurses and often walked with PTs or RNs before ICU discharge. Both sites had a well-established safe patient handling and mobility program with patient lift equipment provided in the unit and staff training in safe patient handling. In addition, both units had similar nursing characteristics (eg, nurse staffing, unit

leadership, shift length) and each organization had obtained Magnet Recognition for high-quality nursing care. Site 1 was a 24-bed closed-model ICU in an academic tertiary care center, and site 2 was a 12-bed open-model ICU in an academically affiliated Veterans Administration hospital. Although site 2 had slightly lower patient acuity, both units routinely admitted a range of medical and postsurgical patients.

Data Sources

Multiple data sources were chosen to understand the ICU work environment within the perspective of mobility practice.

Organizational policies and published mobility guidelines were reviewed for relevance. Organizational policies were provided by nurse leaders at each site, and mobility guidelines were retrieved from PubMed. The following search terms were used: “guideline,” “intensive care units,” and “early mobility.” One researcher (AK) reviewed each document and extracted information related to the abstraction hierarchy levels.

Nurse observations (N=4, 32 hours total) were conducted at site 1 by 2 researchers (AK and another researcher) during normal routines of the first 4 hours of 2 separate shifts using a paper data collection tool. Both researchers observed the same nurse to capture communication, workflow, assessment, and coordination information to inform interview questions. Each nurse was interviewed within 1 week following the final observation.

Semistructured interviews (N=20) were conducted using an interview guide (Multimedia Appendix 1). Participants were asked to define mobility, describe case examples of mobilizing routine and complex patients, identify information used to make mobility decisions, barriers to mobility, and strategies used to overcome barriers. In addition, interviews with observation participants also included tailored questions based upon

observation findings. For example, after one participant was observed using the EHR, an interview question was added to understand the specific information the participant was seeking. All interviews were conducted by 1 primary researcher (AK), audio recorded, and transcribed verbatim. Interviews lasted 45 to 60 minutes and were conducted in a private office at the nurse's place of work.

Participants

Nurses with 6 months or greater of current ICU experience and working 20 hours or more each week were eligible to participate. A purposive sampling method was used to select nurses with a range of experience while including expert nurses who routinely engaged patients in mobility activities. Participants were recruited via advertisement and recruitment materials in the unit and by nurse managers providing contact information for expert nurses with experience mobilizing patients.

Ethics Approval

The University of Wisconsin-Madison institutional review board and the Madison Veterans Administration Research and Development Committee approved the study (approval #2016-1389).

Analysis

Data analysis and abstraction hierarchy development were conducted iteratively with the data collection process. Nurse observation data were summarized, and follow-up interview questions were generated after each observation. Interview data were coded using an inductive approach. Two investigators, one with expertise in critical care nursing (AK) and the other in hospital ambulation interventions and qualitative methods (BK), analyzed the interview data using inductive content analysis [32]. Investigators individually performed open coding line by line by breaking down the data and assigning labels to identify preliminary key thoughts or concepts. Together, the research team grouped labels that were related to each other by content or context into subcategories. Subcategories were then collated into higher order main categories. Dedoose software

(SocioCultural Research Consultants) was used for data management [33].

The abstraction hierarchy was developed by systematically and iteratively synthesizing data extracted from document review and subcategory and category codes from interview data. Steps from Naikar's [31] 9-step method were used to develop the abstraction hierarchy. The first 5 steps describe decisions to consider before beginning the analysis and include defining the purpose and boundaries of analysis, identifying project and work domain constraints, and identifying sources of information for the analysis. For the purposes of our analysis, the boundaries of analysis were the ICU system, and interview information was limited to nurse participants. Our purpose focused on patient mobility work in the ICU system. Steps 6 through 8 consisted of iterative development of the abstraction hierarchy using available sources of information (eg, documents), special data collection (eg, observations, interviews), and domain expert review. The final step is validating the abstraction hierarchy. The initial abstraction hierarchy was developed based on data extracted from organizational mobility policies and published mobility guidelines. For example, documents described functions of team members, processes, and equipment available for mobility. The abstraction hierarchy was refined with data from interviews to include additional description and establish means-ends linkages between levels. The research team routinely discussed coding and refined the abstraction hierarchy. Later-occurring interviews at site 1 and all interviews at site 2 also included a review of the abstraction hierarchy. Participants were asked to identify if there were any missing, unclear, or redundant categories. The model was updated based on participant responses.

Results

Overview

Twenty nurses participated in the study (site 1=15, site 2=5). Participants had a range of 4 to 15 years of ICU experience, with a median of 7.8 years (Table 2).

Table 2. Demographic characteristics of participants (N=20).

Characteristic	Value
RN ^a experience (years) median (IQR)	10.5 (6.6-16.4)
ICU ^b experience, (years) median (IQR)	7.8 (4-14.8)
Highest degree, n (%)	
Associate degree	1 (5)
Bachelor's degree	17 (85)
Master's degree	2 (10)
Critical care certification	7 (35)

^aRN: registered nurse.

^bICU: intensive care unit.

Work Domain Analysis

Results of the WDA are presented by abstraction hierarchy level and shown in part in Figure 1. Table 3 summarizes example

category codes and representative quotes from the qualitative analysis that were used in developing the abstraction hierarchy. Results are presented by abstraction level.

Figure 1. Abstraction hierarchy describing ICU work environment within the context of nursing implementing patient mobility. ICU: intensive care unit.

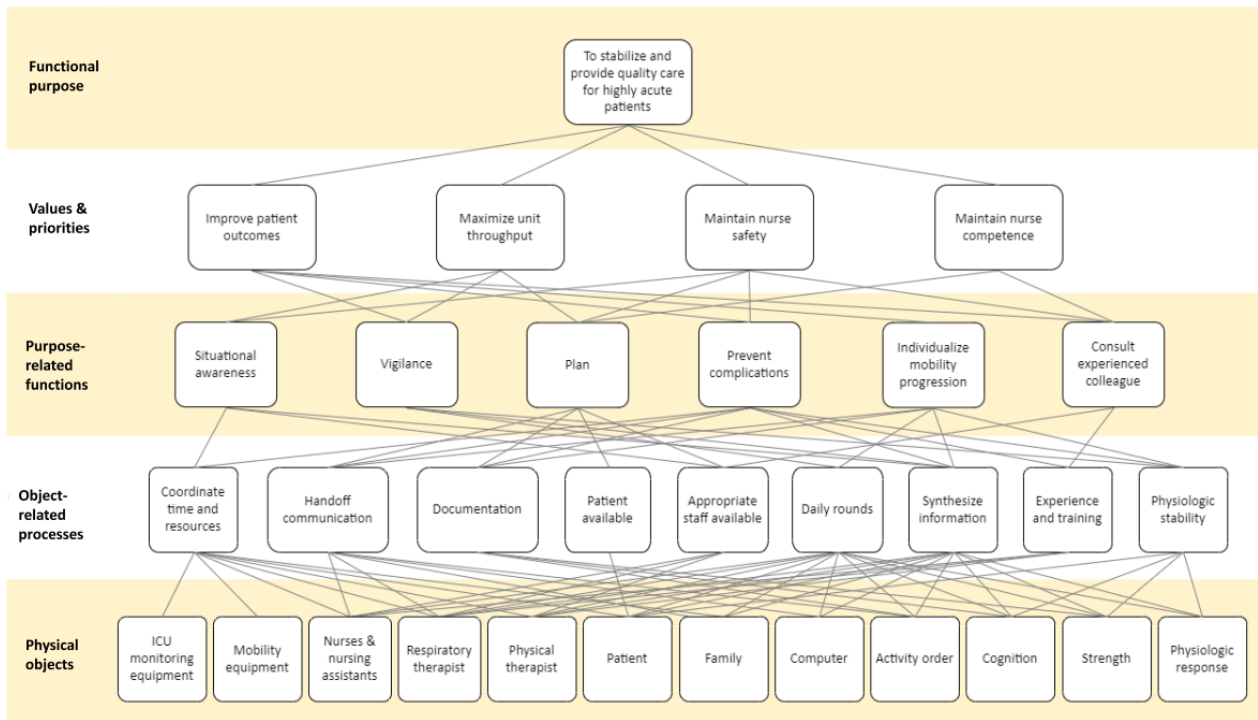


Table 3. Sample codes and representative quotes by abstraction level.

Sample code by abstraction level	Representative quotes
Functional purpose	
Stabilize	“There are some patients that are so critical that you really can’t move them, but I would say that is a small portion.” [RN ^a 6]
Quality	“... mobility is a huge factor in getting somebody home because even if their illness has passed, if they’re not strong enough to take care of themselves they can’t go home.” [RN 2]
Values and priorities	
Patient outcomes	“We’ve gotten so safety oriented for fear of people falling that it’s hard sometimes to find a balance because even if a person seems totally alert and doesn’t have a lot of tubes, I think we’re still so scared that they’re going to fall.” [RN 11]
Nurse safety	“I’m not going to put myself in a situation or someone else in a situation where we’re going to get hurt... I have to protect myself.” [RN 13]
Throughput	“We’re moving people in and out, getting people to procedures, people are coming and going from everywhere.” [RN 4]
Purpose-related functions	
Vigilance	“If I come on a shift and they were moving up and down on the pressors all night or unstable in their heart rate, then I probably wouldn’t get them out of bed until at least the afternoon, so 4 to 6 hours of stability.” [RN 10]
Situational awareness	“We were getting 2 sick admissions, so I had to get him back to bed a little earlier than I wanted to.” [RN 3]
Individualize	“I want to know how they get up, with what equipment, and how many people do they need?” [RN 6]
Object-related processes	
Coordination	“About 20 minutes before that time I just started getting things together.” [RN 7]
Availability	“If it [a procedure] is not scheduled it can go one of two ways, you either leave them in bed until it happens, or you just get them up and hope and pray they don’t come right away.” [RN 1]
Appropriate staff available	“There are some patients, especially if we are talking about walking for the first time, that I will partner with physical therapy and not necessarily feel comfortable being the first person to stand them.” [RN 12]
Physical objects	
Human resources	“I usually need 2 to 3 people depending upon how many lines they have, if they’re intubated, if we need to pull the bed out of the room...” [RN 1]
Mobility equipment	“Walkers are a big problem because we have to order them up, they’re big, and somethings they take time to come [to the bedside].” [RN 6]
Computer	“I’d like to look more in the notes and see some progress, but I feel we don’t have time to do that.” [RN 14]

^aRN: registered nurse.

Functional Purpose

The functional or overall purpose of the ICU is to initially stabilize patients experiencing life-threatening illness or injury and to provide high-quality care that improves outcomes for critically ill patients.

Values and Priorities

Four values and priorities were identified: improve patient outcomes, maintain nurse safety, maintain nurse competence, and maximize unit throughput. Most nurses described organizational priorities that focused on improving patient quality and outcomes, such as preventing patient falls. Moreover, staff safety and maintaining competency were promoted, as most participants described organizational training and resources available to nurses for safely assisting patients with movement. Maintaining ICU throughput was an additional priority, as most nurses described the routine, rapid turnaround of admitting highly unstable patients, stabilizing patients, and then

transferring patients as soon as they met criteria for a lower level of care.

Purpose-Related Functions

Six purpose-related functions were identified, which describe how the values and priorities are achieved.

1. *Situation awareness* is recognition of unit activities and resources. Nurses described the need to assist with other unstable patients as a priority over patient mobility and increased activity on the unit limiting staffing resources to assist with mobility.
2. *Vigilance* is monitoring a patient’s stability over the work shift. For example, participants described watching patient vital signs on the bedside monitor while assisting them with repositioning in the bed or assessing for improvement in ability to follow directions over time. Multiple shifts with a patient provided nurses with more time to know the patient. Nurses stated that they felt more confident to

- progress mobility on the second day of providing care, based upon their assessment of how the patient tolerated a lower level of mobility the day prior.
- Plan* is the process of preparing for mobility interventions. Participants described multiple barriers that required clarification or adaptation before progressing mobility interventions. For example, nurses described time spent clarifying mobility orders with the medical team or asking family members about the type of assistive equipment a patient used prior to admission.
 - Prevent complications* is implementing interventions to avoid harm. For the most severely ill patients, when short-term survival is not known, nurses identified that the priority is to achieve and maintain physiologic stability. As patients stabilize, participants described implementing progressive mobility interventions to prevent functional decline.
 - Individualize mobility progression* is the process of assessing and determining the mobility goal for the shift. For patients that had not yet gotten out of bed in the ICU, nurses described spending considerable time assessing and

synthesizing patient information to determine if the patient would tolerate out-of-bed mobility.

- Consult experienced colleague* is identifying and communicating with another health care professional to inform the daily mobility goal. In some situations, nurses described talking with a nursing assistant to learn how the patient tolerated walking during a prior mobility session, whereas in other situations, nurses described talking with a PT for medically complex patients with weakness or unsteady balance, or it being their first time out of bed after bed rest.

Object-Related Processes

Nine object-related processes were identified and are presented in Table 4. The object-related processes include the following: coordinate time and resources, handoff communication, daily rounds, documentation review, patient availability, staff availability, information synthesis, experience and training, and physiologic stability. These object-related processes describe how purpose-related functions are achieved and why physical objects exist in the work environment.

Table 4. Object-related processes identified in the abstraction hierarchy.

Object-related process	Description
Coordinate time and resources	Planning and organizing when mobility interventions occur in relation to patient needs, status of unit, and availability of human and equipment resources
Handoff communication	Information exchanged during nurse shift report
Daily rounds	Opportunity for various health care providers to discuss patient assessment, plan, and goals of care
Review documentation	Data and communication in the EHR ^a that convey information about patient mobility, such as level and tolerance of previous mobility event
Patient available	Awareness of patient's daily schedule included planned interventions, such as dialysis, and unanticipated events, such as a bed side procedure
Appropriate staff available	Matching patient needs as it relates to weakness, instability, and/or equipment with health care team member(s). For example, ensuring the respiratory therapist is available to assist with walking a patient requiring mechanical ventilation
Synthesize information	The process of analyzing information from multiple sources to individualize mobility progression
Experience and training	Training or experience with psychomotor skills, such as body positioning, body mechanics, and use of patient handling equipment
Physiologic stability	The ongoing assessment for changes in a patient's physical status in relation to organ support required and evaluation of tolerance to changes in position or movement

^aEHR: electronic health record.

Physical Objects

Twelve physical objects were identified and were grouped into components of human resources, equipment, and information sources. Physical objects describe how the object-related processes are implemented. Participants described human resources, primarily nursing assistants, other nurses and PTs, and mobility equipment, such as a walker, as necessary to support mobility interventions. Nurses used information from multiple sources to establish a mobility goal for the shift. Nurses described comparing current patient assessment information (eg, strength, cognition, and physiologic response to movement) and data from bedside monitors (eg, hemodynamic, respiratory, or neurologic values) to previous values to assess stability.

Nurses also relied on peers during shift handoff reports and on patients or family members for verbal information.

Means-Ends Linkages

Means-ends linkages were identified between levels in the abstraction hierarchy and are illustrated in Figure 1 as connecting lines between abstraction hierarchy levels. The connections provide understanding between items, as moving from the top to a lower level in the abstraction hierarchy describes *how* the concept is achieved or carried out and moving from the bottom to a higher level in the abstraction hierarchy describes *why* a concept exists. For example, the object-related process of synthesizing information is connected to 10 physical objects, illustrating how nurses seek information from a variety of sources to inform mobility decision-making. Synthesizing

information is also linked to 4 higher-level purposes, indicating why nurses integrate both patient and hospital unit information when making mobility decisions.

Discussion

Principal Findings

Our WDA describes the complexity of the ICU work environment within the context of nurses carrying out patient mobility interventions. The abstraction hierarchy depicts multiple high-level priorities that nurses balance, specifically, providing quality, safe care to patients while helping to manage unit-level throughput needs. Connections between levels on the abstraction hierarchy describe how and why nurses seek patient and hospital unit information to inform mobility decision-making. The WDA identifies several opportunities for technology design and future study at the nurse level and unit level to support nurse decision-making about patient mobility.

One key information need is to provide assessment information about patient stability to nurses. Nurses in this study described assessing the patient over the course of a shift or several shifts to individualize mobility progression, and nurses described information sources they used to determine patient stability for mobility. To improve the efficiency for nurses in seeking information about mobility decision-making, a trended display of patient stability for physiologic metrics that nurses currently use (eg, vital signs, respiratory indicators, sedation level) from the EHR may support decision-making. A second key information need is to provide historic patient mobility information to nurses. Participants described using information about the patient's past mobility activity to inform their planning for the shift and looking for this information in multiple places. There are valid numerical scales to quantify mobility status and to efficiently communicate the highest level of activity a patient has achieved [34,35]. A current mobility value and trended display of the patient's previous mobility progress or decline added to the EHR may support decision-making, as nurses in this study routinely sought out information about the patient's previous mobility and response.

We have identified information that may be amenable to technology-based interventions to support nurse decision-making for mobility in the ICU. Studies using WDA-informed information displays have demonstrated improved ability for ICU and emergency room nurses to detect patient changes when compared to use of the existing EHRs [36,37]. From our WDA, we identified a need for indicators of patient stability (or instability) using trended patient data and indicators for mobility status. Future research on the feasibility and acceptability of prototypes that communicate this clinically meaningful information is needed.

Findings from the WDA also demonstrate opportunities and recommendations for unit-level information needs. Using technology interface design to organize relevant patient and unit information may offer several benefits. For example, displaying patient and unit information simultaneously may assist with limited resource allocation by prioritizing patients who display a greater need for mobility, such as a patient that

has a greater duration of immobility. A unit display may also support a unit culture of accountability for mobility progression, as each patient's mobility status is visible to the ICU team. A unit-based display or dashboard of real-time EHR data for promoting guideline-based mechanical ventilation care has been found to improve interprofessional care coordination, communication, and patient outcomes [20]. Future work is needed to develop and test visualizations for communicating guideline-based mobility care within the ICU.

Limitations

This study should be considered within the context of several limitations. First, the study was conducted in 2 medical-surgical ICUs at 2 academic medical centers. Therefore, our findings may not be generalizable to all ICUs, but we expect the findings to be transferrable to similar settings. Differences in patient population, unit culture or available resources, ICU type, such as specialty surgical ICUs or community-based ICUs, may change work environment barriers. In addition, both study ICUs had experience with implementing mobility interventions. Work environment constraints and nurse decision-making might look different depending upon the status of implementing mobility practices, unit culture, teamwork, and ICU resources. Finally, the study focused on the work environment from the perspective of nurses. Although nurses described communication and coordination with other health care providers, future work is needed to include data from patients, family members, and additional team members in the work environment. The WDA is by no means a complete representation of the ICU work environment within the context of mobility interventions. Future work should expand the analysis to other layers of CWA.

One goal of the current study was to inform future system design to support the nurse in progressing patient mobility interventions. Therefore, our focus was on possible improvements in the work environment, such as information visibility, that could influence prototype designs as opposed to physical improvements in the work environment, such as reconfiguring the structural layout of the ICU room, which might be cost prohibitive.

Conclusions

This WDA provided several important insights for understanding nurse decision-making about patient mobility within the context of the ICU work environment and identified opportunities for technology design to support decision-making. The results of this study identify strategies for integrating critical patient and unit-level information to inform patient mobility decisions. Future studies should investigate the acceptability and feasibility of interventions to support nurse decision-making about mobility interventions. This analysis demonstrates that interdependencies exist between patients, nurses, other members of the health care team, and unit resources. Therefore, multicomponent interventions that address constraints in the work environment, such as lack of human resources and nurse workload, are needed. Systems-based approaches to improve delivery of mobility and patient outcomes must include interventions that are based upon how nurses make these complex decisions within the work environment.

CWA is a valuable framework for understanding the environment in which ICU nurses make patient mobility decisions and for identifying priorities to target with future CDS designs for supporting mobility decisions at the point of care. Findings from this study provide an understanding of how

mobility decisions are made from the perspective of the ICU work environment and identify a need to consider the types of information nurses use to make knowledgeable and efficient patient mobility decisions.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Interview guide.

[[DOCX File, 16 KB - nursing_v5i1e41051_app1.docx](#)]

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Abbreviations

- CDS:** clinical decision support
- CWA:** cognitive work analysis
- EHR:** electronic health record
- ICU:** intensive care unit
- PT:** physical therapist
- RN:** registered nurse

WDA: work domain analysis

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Original Paper

Code-Switching Automatic Speech Recognition for Nursing Record Documentation: System Development and Evaluation

Shih-Yen Hou¹, MS; Ya-Lun Wu¹, MS; Kai-Ching Chen¹, MS; Ting-An Chang¹, PhD; Yi-Min Hsu¹, PhD; Su-Jung Chuang¹, MHA; Ying Chang¹, MS; Kai-Cheng Hsu¹, MD, PhD

Artificial Intelligence Center for Medical Diagnosis, China Medical University Hospital, Taichung City, Taiwan

Corresponding Author:

Kai-Cheng Hsu, MD, PhD

Artificial Intelligence Center for Medical Diagnosis

China Medical University Hospital

No 2, Yude Rd

North Dist

Taichung City, 40459

Taiwan

Phone: 886 +886911284382 ext 168

Email: D35842@mail.cmuh.org.tw

Abstract

Background: Taiwan has insufficient nursing resources due to the high turnover rate of health care providers. Therefore, reducing the heavy workload of these employees is essential. Herein, speech transcription, which has various potential clinical applications, was employed for the documentation of nursing records. The requirement of including only one speaker per transcription facilitated data collection and system development. Moreover, authorization from patients was unnecessary.

Objective: The aim of this study was to construct a speech recognition system for nursing records such that health care providers can complete nursing records without typing or with only a few edits.

Methods: Nursing records in Taiwan are mainly written in Mandarin, with technical terms and abbreviations presented in both Mandarin and English. Therefore, the training set consisted of English code-switching information. Next, transfer learning (TL) and meta-TL (MTL) methods, which perform favorably in code-switching scenarios, were applied.

Results: As of September 2021, the China Medical University Hospital Artificial Intelligence Speech (CMaiSpeech) data set was established by manually annotating approximately 100 hours of recordings from 525 speakers. The word error rate (WER) of the benchmark model of syllable-based TL was 29.54% in code-switching. The WER of the proposed model of syllable-based MTL was 22.20% in code-switching. The test set comprised 17,247 words. Moreover, in a clinical case, the proposed model of syllable-based MTL yielded a WER of 31.06% in code-switching. The clinical test set contained 1159 words.

Conclusions: This paper has two main contributions. First, the CMaiSpeech data set—a Mandarin-English corpus—has been established. Health care providers in Taiwan are often compelled to use a mixture of Mandarin and English in nursing records. Second, an automatic speech recognition system for nursing record document conversion was proposed. The proposed system can shorten the work handover time and further reduce the workload of health care providers.

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KEYWORDS

nursing records; automatic speech recognition; code-switching; transfer learning; meta-transfer learning

Introduction

Background

In Taiwan, more than 80% of health care providers are employed in the acute care system, mainly providing care for inpatients. However, the turnover rate of new recruits in medical centers is considerably high, exceeding 22.5%; in regional hospitals, it

is approximately 29% [1-3]. Turnover rate is defined as the number of people leaving per month divided by the average number of people in the month. According to the equation below, Price [4] thinks that the turnover rate exceeds 50%, which is potentially harmful; Gaukerke [5] considers that the ideal annual turnover rate should be approximately 5% to 10%. On average, 1 in 4 new health care providers leaves because

they cannot endure the harsh working conditions in hospitals. Specifically, the reasons for the high turnover rate are presented as follows. First, the clinical workload is not divided into professional and nonprofessional work; thus, delegating nonprofessional work to others is not possible and, as such, nursing personnel are responsible for various menial tasks. Second, the particularity of three-shift work is highly inconvenient [6,7].



Health care providers spend most of their time in patient rooms, including isolation rooms, and on administrative tasks, including completing nursing records and charting work and reviewing them [8,9]. Descriptions of medical evaluations and their results are included in nursing records such that the medical care team can fully understand the patient's condition. Incomplete or erroneous nursing records are a serious violation of patients' rights. The causes of incomplete nursing records are inadequate human resources and differences in writing styles, which increase cognitive differences during health care providers' shifts and can cause problems in patient care. According to the American Joint Commission International Accreditation Standards for Hospitals, approximately 65% of medical care problems are due to miscommunication [10]. Therefore, nursing records play a vital role in medical care.

Speech recognition programs, which have seen various advances in recent years, can understand human language; their application to the generation of nursing records can potentially improve work efficiency and reduce the workload of health care providers. Many countries have employed speech recognition technology in medicine [11,12]. The speech-to-text automation of nursing records can lighten the burden of administrative work. Although automatic speech recognition in the medical domain was first reported in the 1980s [13], all subsequent studies up to 1999 tested the transcription of single words as opposed to continuous speech in this context [14]. In recent years, a few studies have been conducted on speech recognition in the medical domain in terms of the word error rate (WER) [15-17].

Related Work

The connectionist temporal classification (CTC) [18] and the listen, attend, and spell (LAS) [19] frameworks have been used to record physician-patient conversations [20]. The corpus size is 14,000 hours. Data cleaning comprised a major portion of the work. The WERs of the CTC and LAS methods were 20.1% and 18.3%, respectively, but both methods can be used to transcribe conversations between health care providers and patients. For the CTC method, a clean corpus and a corresponding language model are integral. Compared with the CTC method, the LAS framework has a higher tolerance to corpora containing a small amount of error. Because all the contextual information is considered by the LAS method, its accuracy is slightly higher than that of other models; however, the LAS method cannot perform streaming of automatic speech recognition. In addition, the length of the input voice segment has a significant impact on the accuracy of the model.

The learning method proposed in Winata et al [21] was designed to overcome the shortage of code-switching data by generating

synthetic code-switching sentences. In that study, a sequence-to-sequence model was presented, and pointer-generator networks were used to generate code-switching data. The model had two principal characteristics: learning how to combine words from parallel sentences and determining when to switch from one language to another. However, the model was applied only to general conversations and not to conversations in a specific field. The main reason is that there are few conversations in the nursing data set, mainly nursing records, including records of patients' physiological conditions, records of treatment and medication, and records of doctors' orders.

The Goal of This Study

The shortage of nursing labor in Taiwan has been a concern of Taiwan's Ministry of Health and Welfare in recent years, and this situation has been exacerbated and highlighted by the spread of COVID-19 [22,23]. Health care providers in Taiwan have a heavier workload compared with those in other regions and countries. To mitigate this problem, we established a code-switching automatic speech recognition system enabling health care providers to complete nursing records without typing or editing. We used the China Medical University Hospital Artificial Intelligence Speech (CMaiSpeech) data set for this purpose.

Methods

CMaiSpeech Data Set

In the medical field, automatic speech recognition poses several difficulties. First, background noise is often present during recordings. Second, speaking speed varies considerably among individuals. Third, speech may contain hesitations and utterances, such as repeated words and restarted sentences. The most formidable challenge is code-switching. Taiwanese people often use a mixture of Chinese and English in daily conversation; this is often observed in the medical field and in nursing records. Medical terms, including thousands of drug names, are often written in English or represented by English abbreviations, meaning that sentences commonly contain a mix of Mandarin and English words.

Nursing records in Taiwan mostly contain Mandarin-English sentences. To obtain a code-switching corpus for training the automatic speech recognition model, a nursing record corpus was created and used as the Mandarin-English code-switching corpus. The process of the CMaiSpeech data set has been created as follows. First, some code-switching sentences were selected from the nursing records in the China Medical University Hospital (CMUH) database. Next, volunteers were recruited to speak and record these sentences. After the recording process was completed, each sentence was annotated based on the recording context. Finally, the audio data were converted into a 16-kHz pulse-code modulation format. Figure 1 displays examples of Mandarin-English code-switching utterances in clinical nursing records.

Code-switching is a common language phenomenon and refers to a person alternately using more than one language or its variants in a conversation. A generalized definition of

code-switching includes language alternation within sentences (ie, words of different languages are in the sentence) and outside the sentences (ie, sentences of other languages are in the data set). For our cases, most language alternations happened within sentences. The CMaiSpeech data set contains numerous medical

terms in both English and Mandarin. The data set was established by manually annotating approximately 100 hours of recordings from 525 speakers. Most of the speakers were nurses employed at CMUH.

Figure 1. Examples of Mandarin-English code-switching utterances in clinical nursing records.

病人 GCS E 四 M 六 V 五 此次因吐血解黑便至急診求治。
(Patient GCS E4M6V5 Went to the emergency department for treatment due to vomiting of blood and Black poops.)
左下肢 AK 術後傷口 hemovac 存 leak 嚴重。
(The hemovac of the left lower extremity after the operation of AK is severely leaked.)
病患因 PT prolong 腹水存 經醫師評估後囑 blood transfusion FFP 四 u 依醫囑輸血前給予 normal saline 五百 ml ivd stat。
(The patient had ascites due to PT prolong The doctor ordered blood transfusion FFP four u Give normal saline 500 ml ivd stat before blood transfusion according to doctor's order.)

Ethics Approval

This research was approved by the Institutional Review Board of China Medical University Hospital (CMUH), under approval No. CMUH110-REC2-187.

National Education Radio Data Set

CMaiSpeech is a code-switching data set. But model training requires a Mandarin corpus with a Taiwanese accent. Therefore, National Education Radio (NER) content is considered a Mandarin data set. NER content from the Formosa Speech in the Wild data set [24] is a Mandarin corpus. For the Mandarin corpus, volume 1 of the NER data set, which contains approximately 100 hours of speech recordings, was used. The data were split into training and evaluation sets by the setup described in the source (ie, volume 1 of the NER data set). Both CMaiSpeech and NER data sets were employed in model training, validation, and testing.

Transfer Learning

Transfer learning (TL) refers to the transfer of a trained model and parameters to a new model such that the new model does not need to be retrained [25]: this is considered positive transfer. In 2020, Joshi et al [26] applied TL to the recurrent neural network transducer model in the field of speech recognition [27,28]. When the learning of one kind of knowledge promotes the learning of another kind of knowledge, it is called positive transfer. On the contrary, when the learning of one kind of knowledge hinders the learning of another kind of knowledge, it is called negative transfer. For example, when the tasks of the source domain and the target domain are not related, this may lead to negative transfer. In this study, the TL model was regarded as a benchmark model, and the CMaiSpeech and NER data sets were used for two-stage training.

Meta-Transfer Learning

Meta-TL (MTL), proposed in Winata et al [29], is used to overcome the challenges encountered in code-switching speech

recognition. Specifically, this model is used to map audio recordings to graphemes with relatively few resources. MTL is based on model-agnostic meta-learning [30], with a few modifications for the code-switching tasks. These modifications exchange the model's ability to perform a wide range of tasks for a more favorable ability to initialize code-switching tasks.

Model Selection

The mainstream automatic speech recognition system can be divided into two models: syllable based and character based. Figure 2 shows the difference between the two models. The character-based model uses the hidden Markov model (HMM) to convert syllables to characters. On the contrary, the syllable-based model has no converter. In Taiwan, nursing records are mainly written in Mandarin, with technical terms and abbreviations being written in both Mandarin and English. Accordingly, we selected a method suitable for nursing handover. The syllable-based method [30] is used in Mandarin, wherein Chinese words are converted into syllables to reduce their complexity. Next, a cascade syllable decoder is used to learn the lingual information to map syllables to graphemes.

Although the most commonly used Chinese transliteration system in Taiwan is Bopomofo [31], we employed simplified pinyin (ie, standard Chinese pinyin without tone markers) to standardize the form of the English and Mandarin words at the character level. Task complexity was reduced through vocabulary minimization. For syllable decoding, the HMM was used along with the Viterbi algorithm. A lexicon containing English words was required to decode syllables produced by the speech transformer model into graphemes.

The training and testing flowchart of the proposed MTL models is shown in Figure 3. The training and testing flowchart of the MTL models is made up of three blocks. First, regarding the data set block, the monolingual data set (ie, NER) and code-switching data set (ie, CMaiSpeech) were jointly learned through meta-training; the corpora of the CMaiSpeech and NER

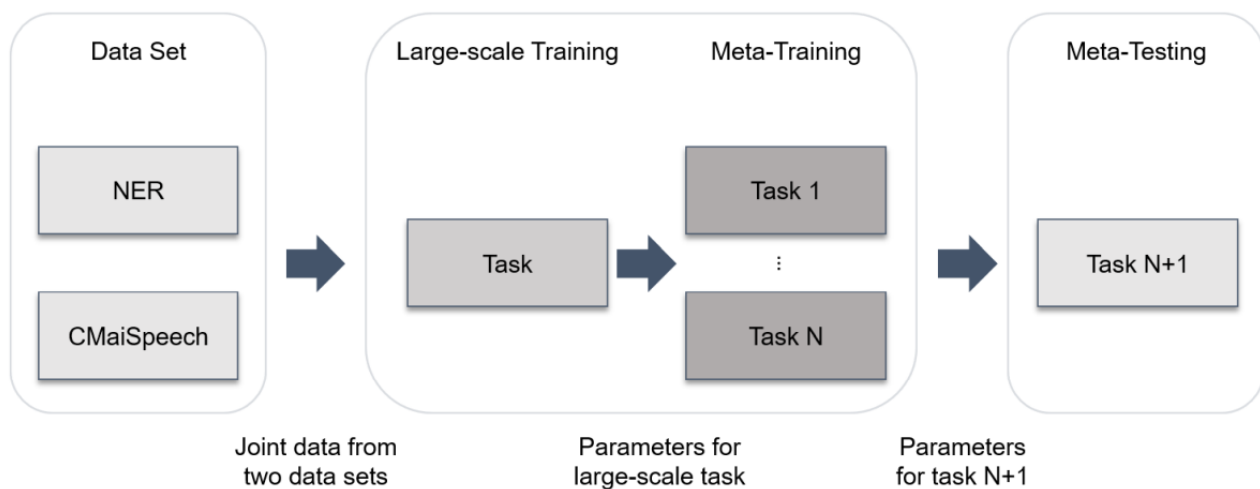
data sets were converted to characters or syllables, a step that can be understood as audio conversion into features; and character-based and syllable-based models were built. Second, regarding the training block, the models were trained using the MTL method proposed by Guzmán et al [15]; all models can

then be further fine-tuned. In addition, for the syllable-based model, an HMM was trained using the CMaiSpeech data set and a lexicon that maps Mandarin characters to pinyin. Third, regarding the testing block, meta-testing was used.

Figure 2. The difference between syllable-based and character-based models.



Figure 3. Training and testing flowchart of the meta-transfer learning models. NER: National Education Radio; CMaiSpeech: China Medical University Hospital Artificial Intelligence Speech.



Results

Data Set Analysis

The MTL and TL algorithms were evaluated and compared with the CMaiSpeech and NER data sets. The statistics and experimental settings of the data sets are presented in [Table 1](#). Regarding wave statistics, approximately 126 hours of monolingual Mandarin data (ie, NER data set) and approximately 107 hours of code-switching data (ie, CMaiSpeech data set) were employed for training and validation, respectively. Next, the TL and MTL models were assessed using approximately 1.8 hours of code-switching data (ie, CMaiSpeech data set). The CMaiSpeech data set contained 136,196 English words and 787,701 Chinese words, whereas the NER data set contained 682 English words and 1,420,101 Chinese words. On the basis of the proportions of English and Chinese words, the code-switching level of the CMaiSpeech data set was

substantially higher than that of the NER data set. Therefore, the CMaiSpeech data set was determined to be more useful for testing. The testing corpus of the CMaiSpeech data set contained 2427 English words and 14,820 Chinese words. To quantify the code-switching level, the language entropy was used to evaluate the code-switching level. The language entropy of the CMaiSpeech and NER data sets in the training process was 0.6033 and 0.0060, respectively, and the language entropy of the CMaiSpeech data set in the testing process was 0.5857. The probability of switching (ie, the integration index [I-index]) [30] was used to describe the code-switching frequency. The mean I-indexes of the CMaiSpeech and NER data sets in the training process were 0.2006 and 0.0006, respectively, and the mean I-index of the CMaiSpeech data set in the testing process was 0.1411. The frequency of Chinese and English words in the CMaiSpeech data set was determined ([Multimedia Appendix 1](#)).

Table 1. Statistics and experimental setting of the CMaiSpeech and NER data sets.

Methods	CMaiSpeech ^a data set		NER ^b data set		CMaiSpeech data set
	Training	Validation	Training	Validation	Testing
Wave statistics					
Duration, hours	105.5334	1.6572	114.2523	12.4390	1.8093
Mean duration, seconds	14.2634	18.9395	21.6751	21.2028	17.5566
Utterances, n	26,636	315	18,976	2112	371
Word statistics, n					
English words	136,196	2342	682	150	2427
Chinese words	787,701	12,115	1,420,101	206,909	14,820
Total words	923,897	14,457	1,420,784	207,059	17,247
Code-switching level					
Language entropy	0.6033	0.6391	0.006	0.0086	0.5861
I-index ^c , mean (SD)	0.2006 (0.1529)	0.1896 (0.16)	0.0006 (0.0052)	0.0011 (0.008)	0.1411 (0.1372)

^aCMaiSpeech: China Medical University Hospital Artificial Intelligence Speech.

^bNER: National Education Radio.

^cI-index: integration index (ie, the probability of switching).

Model Analysis

Table 2 lists the performance of various automatic speech recognition models on CMaiSpeech test sets in WERs. The benchmark models included the character-based TL model, the syllable-based TL model, and the Microsoft Azure cloud application programming interface (API) [32]. The proposed models were the character-based MTL model and the syllable-based MTL model. The total number of words in the testing set was 17,247. The output results were Chinese characters and English words. The test sets had two characteristics: the sentences code-switched between English and Mandarin and the sentences included many drug names and English abbreviations.

Among the evaluated models, the WERs of the character- and syllable-based TL models were 27.22% and 29.54% WER-code-switching (WER-CS), respectively, whereas that of the Azure cloud API was 59.20% WER-CS. By contrast, the WERs of the proposed character- and syllable-based MTL

models were 24.78% and 22.20% WER-CS, respectively. In most cases, the MTL models yielded higher WER values than did the TL models because the CMaiSpeech data set was smaller. The MTL algorithm is suitable for solving small-sample learning problems because the MTL model was jointly trained using both the CMaiSpeech data set and the NER data set. By contrast, the TL algorithm is usually pretrained on a data set to obtain a more favorable initial model, which is then fine-tuned on the new data set. The new data set must have a considerable amount of data; this is typically not the case in a small-sample learning task. Thus, joint training enables the MTL model to have robust code-switching capabilities.

For the same test sets, the performance of syllable-based automatic speech recognition models without HMM was measured on CMaiSpeech test sets (Table S1 in [Multimedia Appendix 2](#)). The WERs of the syllable-based TL and syllable-based MTL models without HMM were 24.16% and 16.85% WER-CS, respectively. The output of the models was syllables, not Chinese characters and English words.

Table 2. Performance of various automatic speech recognition models on CMaiSpeech^a test sets (code-switching) in terms of the word error rate.

Methods	WER-CS ^b , %	WER-EN ^c , %	WER-ZH ^d , %
Character-based transfer learning	27.22	40.15	26.75
Syllable-based transfer learning	29.54	38.13	29.22
Azure cloud application programming interface	59.20	95.57	54.23
Character-based meta-transfer learning (proposed)	24.78	41.23	24.28
Syllable-based meta-transfer learning (proposed)	22.20	36.13	21.54

^aCMaiSpeech: China Medical University Hospital Artificial Intelligence Speech.

^bWER-CS: word error rate-code-switching.

^cWER-EN: word error rate-English.

^dWER-ZH: word error rate-Zhōngwén.

External Verification

Two experiments were conducted for external verification. First, to analyze the performance of the proposed models and the public automatic speech recognition system, based on the experimental settings, the same CMaiSpeech test sets were applied to the automatic speech recognition model of the Azure cloud API. The WER of the Azure cloud API was 59.20% WER-CS (Table 2). This may be attributable to the fact that the CMaiSpeech test sets included domain-specific conversations about nursing care, whereas the Azure cloud API mainly included general conversations.

Second, the proposed models were deployed online in the Medical Information Technology Office of CMUH. The clinical handover data were collected and used as clinical test sets to validate various automatic speech recognition models (Table 3). The total number of words in the clinical test sets was 1159. The WER of the syllable-based TL models was 33.65% WER-CS, whereas that of the Azure cloud API was 31.75% WER-CS. As for the proposed syllable-based MTL model, the WER was 31.06% WER-CS. The WERs of the proposed systems from the online results were not as favorable as those from the offline results, possibly because the clinical test sets contained a high proportion of Mandarin words and a low proportion of English words. Therefore, when output English words were misspelled, their WERs were substantially higher than those of the Chinese words. In the future, we must focus

on increasing the size of the training database to optimize the performance of the proposed automatic speech recognition engine.

Interesting experimental results were found, as seen in Table 3. If the test sets were divided into a long sentence part and a short sentence part, with 15 seconds as the boundary, the length was categorized and the WERs were calculated separately, as shown in Table 4.

Figure 4 shows the relationship between sentence length and the WER. From the experimental results, it can be found that the sentence length has an inflection point at 40 words. When the sentence length is more than 40 words, the sentence length is positively correlated with the WER, and this result is understandable. On the contrary, when the sentence length is less than 40 words, the sentence length is negatively correlated with the WER. There are two main reasons for this. First, uncommon words in short sentences increase the probability of identification errors. Second, there are limited previous occurrences that can be referenced. Both of these reasons may increase the WER value. In addition, the relationship between the code-switching level and the WER was determined (Multimedia Appendix 3). From the experimental results, it can be found that the code-switching level has an inflection point at 0.40. When the code-switching level is more than 0.40, the code-switching level is positively correlated with the WER.

Table 3. Performance of the benchmark and proposed models on clinical test sets in the clinical field in terms of the word error rate.

Methods	WER-CS ^a , %	WER-EN ^b , %	WER-ZH ^c , %
Character-based transfer learning	60.40	107.59	56.88
Syllable-based transfer learning	33.65	85.58	30.31
Azure cloud application programming interface	31.75	96.08	27.80
Character-based meta-transfer learning (proposed)	43.57	114.06	38.41
Syllable-based meta-transfer learning (proposed)	31.06	89.52	27.84

^aWER-CS: word error rate-code-switching.

^bWER-EN: word error rate-English.

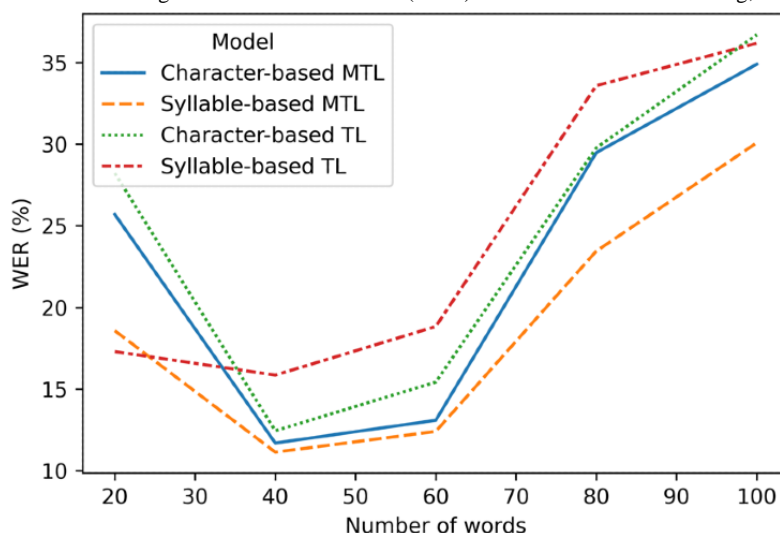
^cWER-ZH: word error rate-Zhōngwén.

Table 4. Performance of the benchmark and proposed models on long and short sentences in terms of the word error rate.

Methods	Long sentences, WER ^a , %	Short sentences, WER, %
Character-based transfer learning	33.58	10.38
Syllable-based transfer learning	35.55	13.63
Character-based meta-transfer learning (proposed)	30.87	8.66
Syllable-based meta-transfer learning (proposed)	27.14	9.11

^aWER: word error rate.

Figure 4. The relationship between sentence length and the word error rate (WER). MTL: meta-transfer learning; TL: transfer learning.



Discussion

In this study, a Mandarin-English code-switching speech recognition system was developed using a corpus of nursing records to allow such records to be completed without typing or editing. The proposed system can lighten the heavy workloads of medical personnel. The WER of the benchmark syllable-based TL model was 29.54% WER-CS, and that of the proposed syllable-based MTL model was 22.20% WER-CS. The test sets

comprised 17,247 words. In a real clinical case, the WER of the proposed model was 31.06% WER-CS. The clinical test sets contained 1159 words.

Future studies should focus on training with large Mandarin corpora to improve the performance of the proposed code-switching speech recognition engine. We plan to release the proposed corpus of nursing data with the accompanying processing software to the research and development community for the study of clinical language processing.

Acknowledgments

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Authors' Contributions

K-CH and Y-LW contributed to the conception and design of the study. Y-MH, S-JC, and YC collected the data. S-YH designed and developed the system. KCC performed the data analysis. T-AC wrote the manuscript. All authors reviewed and provided feedback for each draft of the manuscript, and all authors read and approved the final version of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Frequency of Chinese and English words in the CMaiSpeech data set. CMaiSpeech: China Medical University Hospital Artificial Intelligence Speech.

[[PNG File, 26 KB - nursing_v5i1e37562_app1.png](#)]

Multimedia Appendix 2

Performance of syllable-based automatic speech recognition models without the hidden Markov model (HMM) on the CMaiSpeech test set. CMaiSpeech: China Medical University Hospital Artificial Intelligence Speech.

[[DOCX File, 13 KB - nursing_v5i1e37562_app2.docx](#)]

Multimedia Appendix 3

The relationship between the code-switching level and the word error rate (WER). I-index: integration index; MTL: meta-transfer learning; TL: transfer learning.

[PNG File, 116 KB - [nursing_v5i1e37562_app3.png](#)]

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Abbreviations

- API:** application programming interface
CMaiSpeech: China Medical University Hospital Artificial Intelligence Speech
CMUH: China Medical University Hospital
CTC: connectionist temporal classification
HMM: hidden Markov model
I-index: integration index
LAS: listen, attend, and spell
MTL: meta-transfer learning
NER: National Education Radio
TL: transfer learning
WER: word error rate
WER-CS: word error rate-code-switching

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Original Paper

Web-Based Training for Nurses on Using a Decision Aid to Support Shared Decision-making About Prenatal Screening: Parallel Controlled Trial

Alex Poulin Herron^{1,2}, RN, BSc; Titilayo Tatiana Agbadje¹, MSc; Sabrina Guay-Bélanger¹, PhD; Gérard Ngueta^{1,3}, PhD; Geneviève Roch^{1,2,4,5}, RN, PhD; François Rousseau^{4,6}, MD, PhD; France Légaré^{1,4,7}, BSc, MD, MSc, PhD, CCFP

¹VITAM - Research Center on Sustainable Health, Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale, Quebec City, QC, Canada

²Faculty of Nursing, University of Laval, Quebec City, QC, Canada

³Department of Epidemiology, Faculty of Medicine, University of Laval, Quebec City, QC, Canada

⁴Population Health and Optimal Health Practices, Centre Hospitalier Universitaire de Québec - Université Laval Research Centre, Quebec City, QC, Canada

⁵Centre intégré de santé et de services sociaux de Chaudière-Appalaches Research Center, Lévis, QC, Canada

⁶Department of Molecular Biology, Medical Biochemistry and Pathology, University of Laval, Quebec City, QC, Canada

⁷Department of Family Medicine and Emergency Medicine, Faculty of Medicine, University of Laval, Quebec City, QC, Canada

Corresponding Author:

France Légaré, BSc, MD, MSc, PhD, CCFP

VITAM - Research Center on Sustainable Health

Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale

2480, chemin de la Canardière

Quebec City, QC, G1G 2G1

Canada

Phone: 1 418 663 5313 ext 12286

Email: France.Legare@mfa.ulaval.ca

Abstract

Background: Nurses play an important role in supporting pregnant women making decisions about prenatal screening for Down syndrome. We developed a web-based shared decision-making (SDM) training program for health professionals focusing on Down syndrome screening decisions.

Objective: In this study, we aim to assess the impact of an SDM training program on nurses' intention to use a decision aid with pregnant women deciding on prenatal screening for Down syndrome.

Methods: In this 2-arm, parallel controlled trial, French-speaking nurses working with pregnant women in the province of Quebec were recruited by a private survey firm. They were allocated by convenience either to the intervention group (web-based SDM course that included prenatal screening) or to the control group (web-based course focusing on prenatal screening alone, with no SDM content). The primary outcome was the intention to use a decision aid. Secondary outcomes were psychosocial variables of intention, knowledge, satisfaction, acceptability, perceived usefulness, and reaction to the pedagogical approach. All outcomes were self-assessed through web-based questionnaires, including the space for written comments. We used 2-tailed Student *t* test and Fisher exact test to compare continuous and categorical variables between groups, respectively.

Results: Of the 57 participants assessed for eligibility, 40 (70%) were allocated to the intervention (n=20) or control group (n=20) and 36 (n=18 in each) completed the courses. The mean age of the participants was 41 (SD 9) years. Most were women (39/40, 98%), White (38/40, 95%), clinical nurses (28/40, 70%), and had completed at least a bachelor's degree (30/40, 75%). After the intervention, the mean score of intention was 6.3 (SD 0.8; 95% CI 5.9-6.7) for the intervention group and 6.0 (SD 1.2; 95% CI 5.42-6.64) for the control group (scale 1-7). The differences in intention and other psychosocial variable scores between the groups were not statistically significant. Knowledge scores for SDM were significantly higher in the intervention group (79%, 95% CI 70-89 vs 64%, 95% CI 57-71; *P*=.009). The intervention was significantly more acceptable in the intervention group (4.6, 95% CI 4.4-4.8 vs 4.3, 95% CI 4.1-4.5; *P*=.02), and reaction to the pedagogical approach was also significantly more positive in the intervention group (4.7, 95% CI 4.5-4.8 vs 4.4, 95% CI 4.2-4.5; *P*=.02). There was no significant difference in overall

satisfaction (or in perceived usefulness). Furthermore, 17 participants (9 in the intervention group and 8 in the control group) provided written comments on the intervention.

Conclusions: This study focuses on web-based nursing education and its potential to support pregnant women's decision-making needs. It shows that nurses' intention to use a decision aid to enhance SDM in prenatal care is high, with or without training, but that their knowledge about SDM can be improved with web-based training.

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KEYWORDS

shared decision-making; prenatal screening; training; nurses; nursing; behavioral intention; trisomy; Down syndrome; continuing professional development; continuing education; medical education; decision aid; screening; prenatal; pediatrics

Introduction

Background

In Quebec, prenatal screening for trisomy 21 (Down syndrome) during prenatal follow-up is offered to all pregnant women as part of the state-run health care services, as well as in a few private clinics [1]. Pregnant women face several possible options: whether to take the test, and if so, which one (biochemical test, fetal DNA, or nuchal translucency ultrasound) [2,3]. Prenatal screening is a value-laden decision, and the probabilistic nature of the evidence makes it a difficult decision for expecting parents. It is also complex because new difficult decisions may arise if the results of screening indicate a high probability of Down syndrome in the fetus—that is, whether to perform a more invasive procedure to confirm or deny the screening results (which includes risks of miscarriage) and, ultimately, whether to continue or terminate the pregnancy, given that prenatal treatment options are not available [4].

Faced with the complex nature of this decision, future parents must not only be informed of the evidence regarding the tests but also be supported by the health care team so that their preferences and values are considered in the decision-making process [5]. Thus, shared decision-making (SDM) seems to be the most appropriate approach for setting out the possible options in the most objective and concrete way, fostering informed consent and empowering parents [6-8]. SDM improves the health care experiences of both patients and health professionals and leads to better health care processes, patient experience and outcomes, and optimal health spending [9-12]. To implement SDM in clinical practice, several approaches have been proposed in the literature, including interactive skills workshops for health professionals and implementation of SDM tools known as decision aids (DAs) [13,14]. DAs are tools used by health care professionals to assist patients in their decision-making by providing information on treatment or screening options and their associated benefits and harms and by clarifying their values and preferences regarding the decision to be made [15].

In Canada, prenatal care requires the collaboration and coordination of many health care providers [16,17]. Nurses play an essential role, especially in the province of Quebec. One of their roles is to initiate laboratory examinations and diagnostic tests, such as prenatal screening [18]. Thus, they are in a strategic position to implement SDM as they accompany

pregnant women and their families in decision-making about prenatal screening [18,19]. Owing to their close and trusting relationship with patients, their intimate understanding of their community environment, their understanding of biology, and their communication skills, nurses could be powerful allies in implementing SDM in prenatal care [20]. Most SDM implementation studies focus on physicians [21], but with the transformation of health care systems, nurses are increasingly involved in clinical decision-making, and their crucial role urgently needs acknowledgment [22]. Patients themselves have expressed that nurses could play a significant role in SDM; they could provide information and support as well as communicate with other clinicians [23]. Moreover, many studies highlight that an interprofessional approach to SDM, in the context of team-based health care, has benefits for SDM implementation [24-28]. Investigating nursing training in SDM not only gives us an underexplored perspective but could also inform us about the complexities involved in interprofessional SDM.

However, for nurses to implement SDM in prenatal care, they must acquire the skills to apply this approach in their practice. Web-based continuing professional development (CPD) increased 10-fold from 2002 to 2008 in the United States and has been accelerating ever since [29,30]. The continuing education needs of remote rural practices and, more recently, COVID-19 social distancing rules and health cuts have driven developers of CPD to provide more web-based courses [31,32]. Although the effect of web-based courses on clinical practice is still not clear [33], some evaluations show that they are just as effective as in-person courses [34].

Objective

Therefore, we seek to assess the impact of a web-based SDM training program on nurses' intention to use a DA with pregnant women facing a decision about prenatal screening for Down syndrome.

Methods

Overview

We used the CONSORT-EHEALTH (Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth) checklist (version 1.6.1) as a reporting guideline (except for items related to randomization) to report this study (Multimedia Appendix 1). This checklist suggests information to include when reporting

eHealth or mobile health trials (not only web-based or internet-based interventions and DAs but also social media, serious games, DVDs, mobile apps, and certain telehealth applications) [35]. We also used the guidelines for reporting nonrandomized pilot and feasibility studies proposed by Lancaster and Thabane [36].

Study Design

This study was a 2-arm, parallel controlled trial with pre–post measures. Participants were conveniently allocated to two parallel groups: (1) an intervention group exposed to a 3-hour web-based course on SDM, including SDM for prenatal screening, or (2) a control group exposed to a 3-hour web-based course on prenatal screening alone with no SDM content.

Changes to Methods

Initially, this study was planned as a randomized controlled trial. Through a misunderstanding, however, the private firm who performed the recruitment used convenience allocation, and there was no randomization allocation. No content changes were made to the interventions, and no software malfunctions occurred during the interventions.

Research Approval

This project was approved by the ethics committee of the Centre Hospitalier Universitaire de Québec-Université Laval (MP-20-2019-4571). All stages of this research project were conducted in accordance with the rules of ethics. Further details on ethics can be found in the protocol by Poulin Herron et al [37].

Study Population

Inclusion criteria for nurses were that they (1) were involved in prenatal screening decision-making or prenatal screening processes in the province of Quebec; (2) spoke and wrote French; (3) were active in professional practice during the year of data collection (eg, hospitals and community clinics); and (4) had sufficient internet skills, as all procedures were web-based, requiring a minimum of ability and equipment to enter and navigate through the course. There were no exclusion criteria.

Procedures and Recruitment

Participants were recruited through a web-based approach by a private polling firm that operates an internet panel. Recruitment made use of (1) a pre-existing list of nurses held by the polling firm; (2) social media; and (3) the human resources departments of two regional health authorities, the Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale and the Centre intégré de santé et de services sociaux de Chaudière-Appalaches. Recruitment and enrollment took place on web. The procedures are described in detail in a previously published protocol [37].

Allocation

The allocation of participants to the trial groups was performed after collecting the sociodemographic data. The private firm performed the allocation by convenience, as the nurses entered the study. Participants were not blinded throughout the study

but were also not told which arm (intervention or control) they were allocated.

Study Interventions

Overview

The SDM course was created by members and collaborators of the Canada Research Chair in Shared Decision Making and Knowledge Translation with help from education counselors from Université Laval and supported by the PEGASUS (Personalized Genomics for Prenatal Abnormalities Screening Using Maternal Blood) program, a pan-Canadian program. Nurse with expertise in this field created a prenatal screening course without SDM content. The mode of delivery was asynchronous and web-based.

Both programs, hosted on the Université Laval platform, could be completed in approximately 3 hours. More information about the programs can be found in the protocol by Poulin Herron et al [37]. Some participants required technical assistance with regard to the study questions (eg, about when the course is considered complete or when they should answer the postintervention questionnaire), but no technical problems arose related to the course or the platform. [Multimedia Appendix 2](#) provides a report of both programs according to the TIDieR (Template for Intervention Description and Replication items) [38].

Intervention Group: Web-Based Course on SDM and Down Syndrome Prenatal Screening

The intervention consisted of a web-based self-study course titled *Formation en ligne – La prise de décision partagée pour le test de dépistage prénatal de la trisomie 21* (Shared Decision-Making About Prenatal Screening for Down Syndrome). The course aimed to integrate SDM into prenatal care by focusing on the use of a DA. It was divided into four main modules: (1) SDM, (2) Down syndrome prenatal screening, (3) DAs, and (4) communication between health care professionals and patients. Course development was based on the SDM model [39] and its central concepts [14,39]. These include assessment with the patient and health care professional that there is a decision to be made, exploration of the options available and their pros and cons, discussion about patients' preferences, support of the patient by health care professionals in their decision-making, and discussion surrounding the decision to be made. The course depicted a DA and included a video of a clinical encounter in which the DA was used by a clinician with expecting parents. The DA was created by our research team [40] using the International Patient Decision Aids Standards [41]. The model used in the course was in paper format. Its core element is the decision of whether to undergo prenatal screening for Down syndrome. It describes Down syndrome; presents the various prenatal tests and their benefits, harms, and consequences; and provides an exercise for users to clarify their values regarding the options. [Multimedia Appendix 3](#) includes screenshots of the training content.

Control Group: Web-Based Course on Down Syndrome Prenatal Screening

The control group course was titled *Formation sur le dépistage prénatal de la trisomie 21* (prenatal screening for Down syndrome) and focused on prenatal screening alone (without SDM content such as determining decision points or using a DA). In the control program, the topic of SDM in module 1 of the intervention arm was replaced with “Context and history of prenatal screening.” The topic of DAs in module 3 of the intervention arm was replaced with “Consent in prenatal screening.” There were no DA and SDM simulation videos.

Data Collection

For each study arm, data were collected before and after the nurses completed the courses. All outcomes were self-reported. No postintervention data were collected from the participants who discontinued the intervention. The Kirkpatrick and Kirkpatrick [42] model was used as an overall guide to evaluate the effectiveness of the course, as it has proven useful in guiding the evaluation of training for the health care provider [43]. This model comprises four levels: (1) reaction, (2) learning, (3) behavioral change, and (4) organizational performance (results). Level 1 (reaction) measures how participants react to training (eg, satisfaction). Level 2 (learning) analyzes whether they understood the training (eg, increase in knowledge). Level 3 (behavior) looks at whether they are using what they learned at work (eg, behavior change), and level 4 (results) determines whether the material has a positive impact on the organization [42]. Details on the rationale for the questionnaire guides (Multimedia Appendix 4 summarizes the data collection questionnaire after the training) and further explanations can be found in the protocol by Poulin Herron et al [37]. Data collection took place entirely on web. Participants received CAD \$400 (US \$315) for their participation.

Primary Outcome

The primary outcome was the intention of nurses to use a DA in clinical practice with pregnant women facing a decision about prenatal screening for Down syndrome. Intention was chosen as the primary outcome because of the literature supporting intention as a strong predictor of behavior [44-46]. Intention is defined as the degree to which a person has formulated conscious plans to perform or not perform some specified future behavior, that is, the subjective probability that they will perform the behavior [47]. According to the integrated model of the theory of planned behavior for health care providers by Godin [46], their intention to change their behavior can be predicted by four variables: social influence, beliefs about capabilities, moral norms, and beliefs about consequences, as well as by individual and environmental characteristics. The intention to use a DA could act as a proxy for level 3 in the Kirkpatrick and Kirkpatrick [42] model, that is, a proxy for changes in behavior. Thus, although nurses' mid- or long-term behavior was not evaluated in this study, we assumed that their intention to use a DA in clinical practice with pregnant women could predict their future SDM behavior in clinical practice after receiving the training and once the DA is implemented in clinical settings. Further details on the rationale for the choice of primary

outcome can be found in the protocol by Poulin Herron et al [37].

Intention was measured before the intervention (before the course) and after the intervention (within 24-72 hours after completing the course). It was assessed using the CPD-Reaction questionnaire [48], which measures intention (and its psychosocial variables) to change a behavior after completing a CPD activity. The tool is based on the theory of planned behavior [46,49] and Triandis theory [50]. This validated questionnaire has an acceptable internal consistency for each construct, with a Cronbach α ranging from .77 to .85 [45]. Intention (questions 1 and 7 of the questionnaire) was measured on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Secondary Outcomes

Secondary outcomes included the psychosocial variables of behavioral intention as evaluated with the CPD-Reaction questionnaire, that is, social influence, beliefs about capabilities, moral norms, and beliefs about consequences. These constructs were also measured on a 7-point Likert scale, from 1 (score indicating a weak determinant) to 7 (score indicating a strong determinant). Question 2, on social influence, or the percentage of one's colleagues who use DAs, is on a 5-point Likert scale from 1 (0%-20%) to 5 (81%-100%) [48].

Knowledge (level 2 in the Kirkpatrick and Kirkpatrick [42] model) was measured using a 20-item questionnaire designed by the research team and focused on 4 topics: Down syndrome (2 items), prenatal screening (7 items), SDM (7 items), and ethics (4 items). The questions had from 2 to 5 possible answers, with both true-or-false-type answers and multiple-choice answers. As the knowledge questionnaire did not use Likert scales, the knowledge score was evaluated as a percentage with a maximum knowledge score of 100%.

To measure nurses' overall impression (level 1 in the Kirkpatrick and Kirkpatrick [42] model) of the web-based course in which they were enrolled, we assessed their satisfaction, acceptability, and perceived usefulness of the course, and reaction to its pedagogical approach. We used the questionnaire by Körner et al [26] to assess satisfaction with the content (5 items), with the trainers (6 items), and overall satisfaction. We used the Giangreco [51] questionnaire to assess the perceived usefulness of the program. We assessed acceptability using a 5-item questionnaire based on the Kirkpatrick and Kirkpatrick [42] guidelines for evaluating reactions to educational programs. Finally, we assessed the reaction to the pedagogical approach using a 9-item questionnaire based on both the Kirkpatrick and Kirkpatrick [42] guidelines and the University of Connecticut School of Medicine's continuing medical education evaluation form [52]. All 4 level 1 variables were assessed using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

In open fields, we also collected written comments on how to improve training and sociodemographic data. No changes to trial outcomes were made after the trial commenced.

Data Management

All data collected were kept on the polling firm's secure server for 10 years. Following data collection, the firm sent a deidentified database of all data collected in a Microsoft Excel file (version 2019) and a SAS (version 9.4) file to the research team. An identification number was given to each participant to deidentify and track them throughout the study. The research team saved these data on the secure server of regional health authorities.

Sample Size

To detect an average difference in our primary outcome (intention to use a DA), it was estimated that a sample size of 36 nurses ($n=18$ per group) would be sufficient, with an error of 0.05, a size effect of 0.8, and a power of 80%. This sample size was based on a similar study assessing intention to use a DA for Down syndrome screening among midwives, a profession closely allied with nursing [53].

Data Analysis

Analyses were performed at the individual level. We used the 2-tailed Student *t* test and Fisher exact test [54] to compare continuous and categorical variables between groups (mean intention to use the DA in both groups, knowledge and overall impressions). The difference in scores was estimated by subtracting the preintervention score from the postintervention score. This pre–post measure of change followed a normal distribution and was used in the regression model as a response

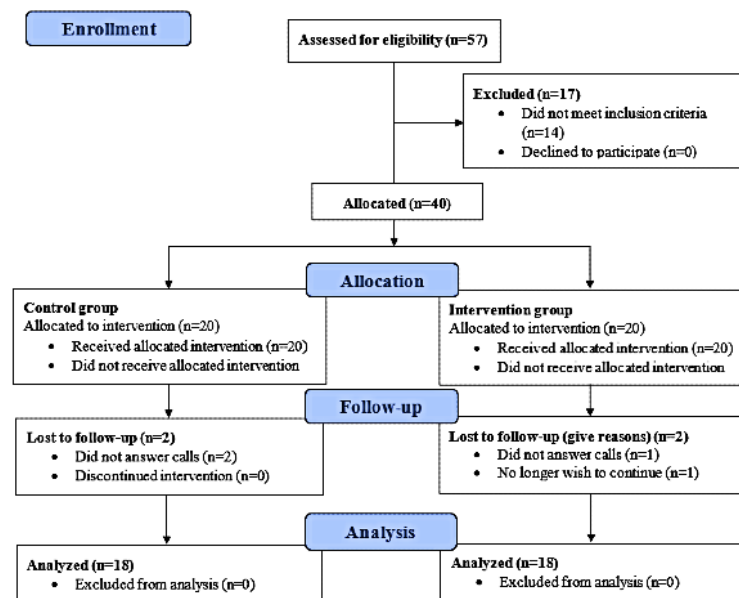
variable without any transformation. The exposure factor under study was the intervention (vs the control group). The identification of confounding factors was carried out using the 10% method [55], and variables whose removal from the full model (ie, including exposure factor and all potential covariates) resulted in a change of $\geq 10\%$ in the effect of the intervention were retained as confounding variables in the final model. To compare the mean values of secondary outcomes between the 2 groups after the intervention, analyses of covariance models were performed to control for confounding factors. For all analyses, SAS was used, and a statistical significance level of .05 was defined. No imputation techniques were used to deal with attrition or missing values, as the sample size of this study could not handle such an analysis. Finally, we conducted a content analysis of written comments. All results are presented as mean scores or percentages with 95% CIs in parentheses.

Results

Participant Characteristics

Data were collected from September 2019 to late January 2020. A total of 57 potentially eligible nurses were assessed for this trial, of whom 40 were allocated to either the control group or the intervention group. Two participants per group (total $n=4$) discontinued participation in the study (ie, they did not complete the full module). The trial ended when 18 nurses in each group completed the course and the postintervention questionnaire (Figure 1).

Figure 1. Participant flow diagram.



Baseline Data

The mean age of the participants was 41 (SD 9) years. Only one male enrolled, and all participants were cisgender people. Most participants had completed at least a bachelor's degree (26/40, 65%), resided in urban regions (19/40, 47.5% in the Capitale-Nationale and 9/40, 22.5% in Chaudière-Appalaches), were White (38/40, 95%), earned between CAD \$60,000 and CAD \$99,999 (US \$46,885 and US \$78,144) (30/40, 75%), were clinical nurses (university vs college-trained; 28/40, 70%),

and worked full-time (35/40, 87.5%) either in a hospital (19/40, 47.5%) or a local community health center (7/40, 35%). The number of pregnant women the nurses had seen in the past month varied: 45% (18/40) had seen from 1 to 20, 15% (6/40) had seen from 21 to 40, 15% (6/40) had seen from 41 to 80, and 18% (7/40) had seen ≥ 81 . Moreover, 3 nurses (7.5%) had not seen any pregnant women in the past month (Table 1). The intervention and control groups did not statistically differ with respect to demographic data.

Table 1. Participants' sociodemographic characteristics.

	Total (n=40)	Intervention (n=20)	Control (n=20)
Age (years), mean (SD)	40.7 (9.4)	39.5 (9.8)	41.8 (9.1)
Biological sex, n (%)			
Male	1 (2.5)	1 (5)	0
Female	39 (97.5)	19 (95)	20 (100)
Other	0 (0)	0	0
Gender, n (%)			
Male	1 (2.5)	1 (5)	0
Female	39 (97.5)	19 (95)	20 (100)
Other	0 (0)	0	0
Formal education^a, n (%)			
College (CEGEP)	9 (22.5)	5 (12.5)	4 (20)
University—bachelor	26 (65)	14 (70)	12 (60)
University—master	4 (10)	0	4 (20)
University—doctorate	0 (0)	0	0
Other	1 (2.5)	1 (5)	0
Residency^a, n (%)			
Capitale-nationale	19 (47.5)	10 (50)	9 (45)
Chaudières-Appalaches	9 (22.5)	4 (20)	5 (25)
Laval	3 (7.5)	1 (5)	2 (10)
Montréal	4 (10)	1 (5)	3 (15)
Bas-Saint-Laurent	1 (2.5)	1 (5)	0
Abitibi-Témiscamingue	1 (2.5)	1 (5)	0
Gaspésie and Îles-de-la-madeleine	1 (2.5)	1 (5)	0
Center-du-Québec	1 (2.5)	0	1 (5)
Other	1 (2.5)	1 (5)	0
Ethnicity^a, n (%)			
White	38 (95)	19 (95)	19 (95)
Racialized minority	2 (5)	1 (5)	1 (5)
Salary^a (CAD \$), n (%)			
<CAD \$29,999 (US \$23,444)	1 (2.5)	0	1 (5)
CAD \$30,000–\$59,999 (US \$23,445–\$46,884)	5 (12.5)	3 (15)	2 (10)
CAD \$60,000–\$99,999 (US \$46,885–\$78,144)	30 (75)	15 (75)	15 (75)
≥CAD \$100,000 (US \$78,145)	4 (10)	2 (10)	2 (10)
Job title^{a,b}, n (%)			
Nurse	11 (27.5)	8 (40)	3 (15)
Clinical nurse	28 (70)	12 (60)	16 (80)
Nurse practitioner	1 (2.5)	0	1 (5)
Job status^a, n (%)			
Preventive withdrawal or maternity leave	1 (2.5)	0	1 (5)
Full-time	35 (87.5)	19 (95.5)	16 (80)
Part-time	3 (7.5)	1 (5)	2 (10)

	Total (n=40)	Intervention (n=20)	Control (n=20)
Retired	1 (2.5)	0	1 (5)
Work settings			
Hospital	19 (47.5)	8 (40)	11 (55)
Family medicine group	1 (2.5)	0	1 (5)
Local community services centers	14 (35)	7 (35)	7 (35)
Other	6 (15)	5 (25)	1 (5)
Estimated number of pregnant women seen in the last month			
0	3 (7.5)	1 (5)	2 (10)
1-5	7 (17.5)	6 (30)	1 (5)
6-20	11 (27.5)	6 (30)	5 (25)
21-40	6 (15)	2 (10)	4 (20)
41-80	6 (15)	3 (15)	3 (15)
≥81	7 (17.5)	2 (10)	5 (25)

^aTo simplify the table, we did not present all the subvariables for the sociodemographic variables marked with “a.” Subvariables not presented in the table contained no data. For the *formal education* variable, the subvariables not presented in the table are *none completed*, *primary school*, *secondary school*, and *professional study diploma*. One participant marked other on their form, referring to a university certificate. The work setting was not found to be a confounding factor. For the variable *residency*, the subvariables not presented are *Saguenay-Lac-Saint-Jean*, *Mauricie*, *Estrie*, *Outaouais*, *Côte-Nord*, *Nord-du-Québec Lanaudières*, *Montérégie*, *Laurentides*, and *I do not know*. For the variable *ethnicity*, subvariables not presented are *Latino-American* (Mexico, Chili, Costa Rica, etc), *Arab* (Middle East, Maghreb, etc), *Sud-Asia* (India, Bangladesh, Pakistan, Sri Lanka, etc), *South-east Asia* (Vietnam, Cambodia, Malaysia, Laos, etc), *West Asia* (Iran, Afghanistan, etc), *Chinese*, *Filipino*, *Korean*, *Japanese*, *Other*, and *I do not know*. For the variable *salary*, subvariables not presented are *I do not know* and *I prefer not to answer*. For the variable *job title*, the subvariable not presented is *none of the above*. For the variable *job status*, the subvariables that are not presented in the table are *student*, *no job/studies*, and *none of the above*. Other types of work settings referred to private clinics, nursing stations, First Nations services, or federal (as opposed to provincial) services.

^bThe difference between nurses and clinical nurses is their education level, proper to the province of Quebec; clinical nurses have a bachelor’s degree, and nurses have a college degree; both have similar scope of practice, with distinctions in regard to care complexity, coordination and clinical supervision.

Primary Outcome: Intention

Before the intervention, the mean intention score was 6.2 (SD 0.9; 95% CI 5.8-6.7) for the intervention group and 5.9 (SD 1.4; 95% CI 5.2-6.5) for the control group. The minimum and maximum scores were 1 and 7, respectively. After the intervention, the mean intention score was 6.3 (SD 0.8; 95% CI 5.9-6.7) for the intervention group and 6.0 (SD 1.2; 95% CI 5.4-6.6) for the control group (Table 2). Between the pre- and postintervention stage, the difference in intention score was 0.1 (95% CI -0.5 to 0.6) for the intervention group and 0.1 (95%

CI -0.8 to 1.1) for the control group. Before the intervention, the difference in intention score between the intervention and control groups was 0.3 (95% CI -0.4 to 1.1). After the intervention, the difference in intention score between intervention and control groups was 0.3 (95% CI -0.4 to 1.0). The intra- and intergroup differences observed were not statistically significant. After adjustment for confounding variables, the pre-post change in intention scores did not vary significantly among the exposure groups (0.2, 95% CI -1.0 to 1.4; $P=.74$).

Table 2. Continuing Professional Development–Reaction construct scores.

	Before intervention			After intervention			P value
	Total (n=40)	Intervention (n=20)	Control (n=20)	Total (n=36)	Intervention (n=18)	Control (n=18)	
Intention							.82
Values, mean (SD; 95% CI)	6.1 (1.2; 5.7-6.4)	6.2 (0.9; 5.8-6.7)	5.9 (1.4; 5.2-6.5)	6.2 (1.0; 5.8-6.5)	6.3 (0.8; 5.9-6.7)	6.0 (1.2; 5.4-6.6)	
Values, median (IQR)	6.3 (5.5-7.0)	6.5 (5.5-7.0)	6.0 (5.5-7.0)	6.5 (5.8-7.0)	6.5 (6.0-7.0)	6.5 (5.5-7.0)	
Social influence							.15
Values, mean (SD; 95% CI)	3.4 (1.7; 2.9-4.0)	2.7 (1.6; 2-3.4)	3.8 (1.7; 2.9-4.6)	3.0 (1.4; 2.5-3.4)	2.7 (1.3; 2.1-3.4)	3.2 (1.5; 2.4-3.9)	
Values, median (IQR)	3.1 (1.8-4.8)	2.5 (1.5-3.6)	4.3 (2.7-5.1)	2.5 (1.8-3.8)	2.3 (1.5-3.9)	2.7 (2.5-3.6)	
Beliefs about capabilities							.07
Values, mean (SD; 95% CI)	5.7 (1.0; 5.4-6.1)	6.1 (1.0; 5.7-6.5)	5.4 (1.0; 4.9-5.9)	5.8 (0.8; 5.5-6.1)	5.8 (0.8; 5.5-6.2)	5.8 (0.9; 5.4-6.2)	
Values, median (IQR)	6.0 (5.0-6.7)	6.3 (5.0-6.8)	5.7 (4.7-6.3)	6.0 (5.3-6.3)	6.0 (5.3-6.3)	6.0 (5.3-6.3)	
Moral norm							.34
Values, mean (SD; 95% CI)	6.6 (0.6; 6.4-6.8)	6.9 (0.4; 6.7-7.0)	6.4 (0.7; 6.0-6.7)	6.5 (0.8; 6.2-6.7)	6.6 (0.9; 6.1-7.0)	6.4 (0.7; 6.0-6.7)	
Values, median (IQR)	7.0 (6.0-7.0)	7.0 (6.8-7.0)	6.5 (6.0-7.0)	7.0 (6.0-7.0)	7.0 (6.5-7.0)	6.5 (6.0-7.0)	
Beliefs about consequences							.68
Values, mean (SD; 95% CI)	6.5 (0.6; 6.3-6.7)	6.8 (0.5; 6.6-7)	6.3 (0.7; 6-6.6)	6.6 (0.8; 6.4-6.9)	6.9 (0.4; 6.7-7.1)	6.3 (0.9; 5.9-6.8)	
Values, median (IQR)	7.0 (6.0-7.0)	7.0 (6.5-7.0)	6.0 (6.0-7.0)	7.0 (6.5-7.0)	7.0 (7.0-7.0)	6.8 (6.0-7.0)	

Secondary Outcomes

Other Constructs of the CPD-Reaction Questionnaire

Scores for social influences, beliefs about capabilities, moral norms, and beliefs about consequences are shown in [Table 2](#). There were no statistically significant differences between the pre- and postintervention scores for any of these constructs.

Knowledge

[Table 3](#) shows knowledge scores assessed after the intervention. The average score for the 7 knowledge questions about SDM was 79% (SD 18; 95% CI 70%-89%) in the intervention group and 64% (SD 14; 95% CI 57%-71%) in the control group. The mean difference between the 2 groups for knowledge about SDM was 15% (SD 16; 95% CI 4%-26%). This difference is statistically significant ($P=.009$). There was no statistically significant difference in the knowledge scores for the questions about Down syndrome, ethics, or prenatal screening.

Table 3. Knowledge scores after the intervention (n=18).

Topics	Intervention (n=18), mean (SD; 95% CI)	Control (n=18), mean (SD; 95% CI)	Mean difference (SD; 95% CI)	P value
Shared decision-making (7 items; %)	79 (18; 70 to 89)	64 (14; 57 to 71)	15 (16; 4 to 26)	.009
Down syndrome (2 items; %)	89 (21; 78 to 100)	78 (31; 62 to 93)	11 (27; -7 to 29)	.21
Ethics (7 items; %)	68 (21; 58 to 78)	69 (22; 59 to 80)	-1 (21; -16 to 13)	.85
Prenatal screening (4 items; %)	74 (13; 67 to 80)	79 (15; 71 to 86)	-5 (14; -14 to 5)	.32

Participants' Overall Impression of the Training

[Table 4](#) shows scores of satisfaction (with content, with trainers, and overall satisfaction), acceptability, perceived usefulness, and reaction to the pedagogical approach. Item scores for participants' impression of the training was based on a scale of 1 to 5. The mean score for acceptability of the training program was 4.6 (95% CI 4.4-4.8) in the intervention group and 4.3 (95%

CI 4.1-4.5) in the control group. The difference in acceptability of training between the 2 groups was statistically significant ($P=.02$). The mean score of reaction to the pedagogical approach was 4.7 (95% CI 4.5-4.8) in the intervention group and 4.4 (95% CI 4.2-4.5) in the control group (ie, the intervention group reacted more positively). This difference in reaction between the 2 groups was statistically significant ($P=.02$). The

between-group differences in scores of satisfaction and perceived usefulness were not statistically significant.

Table 4. Overall impression of the course (scale of 1-5).

	Intervention (n=18), Mean (SD; 95% CI)	Control (n=18), Mean (SD; 95% CI)	Mean difference (SD; 95% CI)	P value
Satisfaction				
Content	4.4 (0.9; 3.9 to 4.8)	4.2 (0.4; 4.02 to 4.4)	0.1 (0.7; -0.3 to 0.6)	.53
Trainers	4.6 (1.0; 4.1 to 5.02)	4.2 (0.4; 4.1 to 4.4)	0.3 (0.7; -0.2 to 0.8)	.21
Overall satisfaction	4.5 (1.0; 4.01 to 4.9)	4.2 (0.4; 4.05 to 4.4)	0.2 (0.7; -0.2 to 0.7)	.31
Acceptability	4.6 (0.4; 4.4 to 4.8)	4.3 (0.4; 4.1 to 4.5)	0.3 (0.4; 0.1 to 0.6)	.02
Perceived usefulness	4.6 (0.4; 4.4 to 4.8)	4.4 (0.5; 4.2 to 4.6)	0.2 (0.4; -0.1 to 0.5)	.13
Reaction (pedagogical aspects)	4.7 (0.4; 4.5 to 4.8)	4.4 (0.4; 4.2 to 4.5)	0.3 (0.4; 0.04 to 0.5)	.02

Written Comments

Overall, 17 participants (9 in the intervention group and 8 in the control group) provided feedback on the course. Most participants in the intervention group (6/9, 67%) described the training as excellent, perfect, practical, applicable, or relevant. One participant expressed comfort with the DA and the principle of SDM. One said that she would use the DA as soon as possible. Moreover, 2 participants emphasized the usefulness of the training, which they felt increased their knowledge and confidence and gave them the tools to better structure meetings with their patients:

I was a little uncomfortable bringing up this topic [talking about prenatal screening for Down syndrome]...this part of the information was more to discuss with the doctor...It will allow me to better structure my meetings and I feel much better equipped. [Participant 9]

However, 2 nurses pointed out that, in practice, they lack the time to use such tools and that the rapid sequence of steps leading to prenatal screening affords future parents little time for reflection:

I work in a local community health centre [CLSC] with 5 consultations per day, where there's little time allocated per client. For me it would be difficult to use this decision aid. However, if I had more time, I could, and I would find it practical and very useful. [Participant 25]

In the control group, although some participants (5/8, 63%) were happy to have had the opportunity to do this course and found it interesting, 2 of them pointed out the difficulty in understanding the person who was speaking on the PowerPoint narration videos because of their rapid speech, unclear pronunciation, and changes in intonation (control intervention only). In addition, 3 of them said that the length of the first module and the length of documents to be consulted made the course longer than 3 hours.

Discussion

Principal Findings

We assessed the impact of an SDM course on nurses' intention to use a DA with pregnant women facing the decision of prenatal screening for Down syndrome, as well as the nurses' overall impressions of the SDM training. We found no statistically significant difference in intention scores between the intervention arm (SDM course) and the control arm (course on the screening program only). However, we found a statistically significant difference in knowledge about SDM, acceptability, and reaction to the pedagogical approach between the 2 arms. In written comments, nurses identified lack of time as a barrier to the use of the DA in clinical settings. These results lead us to make the following observations.

First, there was no difference in intention scores between the intervention and control groups. This was a comparative effectiveness study [56], as both arms presented an active intervention. Although the control arm developed by nurse experts in prenatal screening excluded an SDM focus, it covered ethical aspects of the decision and information on the importance of adapting prenatal care to each pregnant woman, a core value in the nursing profession [57,58]. Consequently, it is possible that there was not enough difference between the study arms in terms of generic decision support for prenatal care. Indeed, previous research has shown that of all health professions, genetic counselors have the highest SDM scores during prenatal consultations, even in the absence of SDM training [59,60]. In addition, we observed a ceiling effect with the primary outcome at baseline, which may have limited our ability to observe the effect of the intervention. Similar ceiling effects were seen in a study assessing change in behavioral intention after CPD activities [48] and in another study assessing the impact of a patient-professional coproduced digital educational intervention [61]. Our initial high scores may also be because of the training that Canadian nurses had already received. Nursing programs emphasize fundamental knowledge of relational approaches that influence health outcomes for individuals, families, and communities [57]. In fact, the essence of nursing is based on a deep understanding of the biopsychosocial aspects of patients and on advocating for them [62]. Finally, participants may have been subjected to social pressure to state that they intended to

use a DA [49,63-65]. Thus, we do not have insight into the full set of factors that may have contributed to their intention (apart from the CPD-Reaction constructs), because the theories explain only part of the variance in intention [46].

Second, we found a statistically significant difference in scores for knowledge about SDM between the intervention and control groups but not for knowledge about the topics covered in both arms, such as prenatal screening and Down syndrome. Thus, the intervention arm (the SDM training program) did distinguish itself from transmitting knowledge about SDM. In addition, the intervention group found their course more acceptable and had a more positive reaction to its pedagogical approach than did the control group. This can be explained in part by the speakers, as participants in the control group expressed difficulties in understanding the speaker in their course. The course format may also have made a difference. The SDM course included a DA and a simulation video, which, especially in the context of web-based pedagogy and regardless of its content, may have been a more acceptable and effective format than the control course [37].

Third, we did not measure whether this high level of intention translated into behavior. Although intention is a strong predictor of behavior [46], the implementation of SDM in practice might depend on other external variables, such as organizational limitations [26]. Indeed, in their written comments, nurses mentioned that organizational barriers prevented them from using DAs in their clinical setting, regardless of their intention, and that they had little time to share decisions with their patients given the speed of lead up to prenatal screening procedures. Another organizational barrier that could defeat nurses' best intentions may be related to the role they are assigned in interprofessional teams or their ability to collaborate with other professionals to ensure that SDM occurs [28]. The organizational environment and care pathways need to be adapted so that pregnant women and nurses can engage fully in SDM, which is already a good fit with nurses' role in the health care system.

Limitations

This study has several limitations. First, in contrast with the planned study design, randomization allocation was not implemented. The private firm, unbeknownst to us, instead focused on ensuring a balanced number of participants in both arms by allocating them alternately to one group or the other. Nevertheless, the study was controlled and allowed us to compare the intervention and control groups. Second, nurses who agreed to participate in this trial may not be representative of all nurses involved in prenatal care in Quebec because of our web-based recruitment methods. For example, in this study, there was only 1 nurse practitioner who had a different scope of practice than other nurses. In addition, our findings may not be generalizable to nurses' engagement in SDM in other areas of their practice, such as disease management. Prenatal care does not usually involve disease management, as pregnancy itself is not an illness. Third, these results cannot be generalized to other health professionals involved in prenatal care in Quebec, as studies show that each approaches the topic of SDM in a different way [16,53]. Training nurses using an interprofessional approach to SDM might encourage interprofessional interaction and information exchange about SDM [28]. Exploration of an interdisciplinary DA model will be examined in future research.

Conclusions

This study focuses on the potential of web-based nursing education to support pregnant women's decision-making needs. We assessed nurses' intention to use a DA to support prenatal screening decisions among pregnant women and their overall impressions regarding the training. This study showed that nurses' intention to use a DA in prenatal care is already high, with or without training, but that their knowledge about SDM could be improved with training. Our results will inform future strategies for implementing SDM behaviors in this population. The study also suggested avenues for future evaluations of SDM training programs. The next steps will be to (1) update the program by incorporating the written comments received from the participants and (2) evaluate the impact of the course with all health professionals involved in prenatal care.

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Conflicts of Interest

The authors of this paper are also the developers of the intervention. APH, TTA, and FL participated in the creation of the training program in designing and conducting the study. The other authors have no conflicts to declare.

Multimedia Appendix 1

CONSORT-eHEALTH checklist (V 1.6.1).

[PDF File (Adobe PDF File), 1192 KB - [nursing_v5i1e31380_app1.pdf](#)]

Multimedia Appendix 2

Report of both programs according to the Template for Intervention Description and Replication items.

[PDF File (Adobe PDF File), 105 KB - [nursing_v5i1e31380_app2.pdf](#)]

Multimedia Appendix 3

Screenshots of the training content.

[PDF File (Adobe PDF File), 2108 KB - [nursing_v5i1e31380_app3.pdf](#)]

Multimedia Appendix 4

Data collection questionnaire after the training.

[PDF File (Adobe PDF File), 465 KB - [nursing_v5i1e31380_app4.pdf](#)]

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Abbreviations

CONSORT-EHEALTH: Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth

CPD: continuing professional development

DA: decision aid

PEGASUS: Personalized Genomics for Prenatal Abnormalities Screening Using Maternal Blood

SDM: shared decision-making

TIDieR: Template for Intervention Description and Replication items

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Original Paper

Investigating Psychological Differences Between Nurses and Other Health Care Workers From the Asia-Pacific Region During the Early Phase of COVID-19: Machine Learning Approach

YanHong Dong^{1*}, PhD; Mei Chun Yeo^{2*}, MTech, MEng; Xiang Cong Tham^{1*}, MPH; Rivan Danuaji^{3*}, MD; Thang H Nguyen^{4*}, MD; Arvind K Sharma^{5*}, MD; Komalkumar RN^{6*}, MD; Meenakshi PV^{7*}, MD; Mei-Ling Sharon Tai⁸, MD; Aftab Ahmad^{9*}, MD; Benjamin YQ Tan^{10,11*}, MBBS; Roger C Ho^{11,12*}, MD; Matthew Chin Heng Chua^{2*}, PhD; Vijay K Sharma^{10,11*}, MD

¹Alice Lee Centre for Nursing Studies, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore

²Institute of Systems Science, National University of Singapore, Singapore, Singapore

³Dr Moewardi Hospital Surakarta, Jawa Tengah, Indonesia

⁴Cerebrovascular Disease Department, 115 People's Hospital, Ho Chi Minh City, Vietnam

⁵Zydus Hospital, Ahmedabad, India

⁶Yashoda Hospital, Secunderabad, India

⁷Senthil Multi Specialty Hospital, Erode, India

⁸University of Malaya, Kuala Lumpur, Malaysia

⁹Department of Neurology, Ng Teng Fong General Hospital, Singapore, Singapore

¹⁰Division of Neurology, National University Hospital, Singapore, Singapore

¹¹Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore

¹²Department of Psychological Medicine, National University Hospital, Singapore, Singapore

* these authors contributed equally

Corresponding Author:

YanHong Dong, PhD

Alice Lee Centre for Nursing Studies

Yong Loo Lin School of Medicine

National University of Singapore

Clinical Research Centre

Block MD11, Level 2, 10 Medical Drive

Singapore, 117597

Singapore

Phone: 65 65168686

Email: nurdy@nus.edu.sg

Abstract

Background: As the COVID-19 pandemic evolves, challenges in frontline work continue to impose a significant psychological impact on nurses. However, there is a lack of data on how nurses fared compared to other health care workers in the Asia-Pacific region.

Objective: This study aims to investigate (1) the psychological outcome characteristics of nurses in different Asia-Pacific countries and (2) psychological differences between nurses, doctors, and nonmedical health care workers.

Methods: Exploratory data analysis and visualization were conducted on the data collected through surveys. A machine learning modeling approach was adopted to further discern the key psychological characteristics differentiating nurses from other health care workers. Decision tree-based machine learning models (Light Gradient Boosting Machine, GradientBoost, and RandomForest) were built to predict whether a set of psychological distress characteristics (ie, depression, anxiety, stress, intrusion, avoidance, and hyperarousal) belong to a nurse. Shapley Additive Explanation (SHAP) values were extracted to identify the prominent characteristics of each of these models. The common prominent characteristic among these models is akin to the most distinctive psychological characteristic that differentiates nurses from other health care workers.

Results: Nurses had relatively higher percentages of having normal or unchanged psychological distress symptoms relative to other health care workers (n=233-260 [86.0%-95.9%] vs n=187-199 [74.8%-91.7%]). Among those without psychological symptoms, nurses constituted a higher proportion than doctors and nonmedical health care workers (n=194 [40.2%], n=142 [29.5%], and n=146 [30.3%], respectively). Nurses in Vietnam showed the highest level of depression, stress, intrusion, avoidance, and hyperarousal symptoms compared to those in Singapore, Malaysia, and Indonesia. Nurses in Singapore had the highest level of anxiety. In addition, nurses had the lowest level of stress, which is the most distinctive psychological outcome characteristic derived from machine learning models, compared to other health care workers. Data for India were excluded from the analysis due to the differing psychological response pattern observed in nurses in India. A large number of female nurses emigrating from South India could not have psychologically coped well without the support from family members while living alone in other states.

Conclusions: Nurses were least psychologically affected compared to doctors and other health care workers. Different contexts, cultures, and points in the pandemic curve may have contributed to differing patterns of psychological outcomes amongst nurses in various Asia-Pacific countries. It is important that all health care workers practice self-care and render peer support to bolster psychological resilience for effective coping. In addition, this study also demonstrated the potential use of decision tree-based machine learning models and SHAP value plots in identifying contributing factors of sophisticated problems in the health care industry.

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KEYWORDS

COVID-19; psychological outcome; machine learning; nurses; health care workers

Introduction

In late 2019, well before COVID-19, the World Health Organization (WHO) declared 2020 as the “Year of the Nurse and Midwife” [1]. This was to recognize the vital role of nurses and midwives in health care and their inherent professional challenges, while commemorating the bicentenary of the birth of Florence Nightingale. When the pandemic hit the world in 2020, such recognition was like a fulfilled prophecy. The public are fully aware of the nature, dedication, and challenges of nursing professionals when they risk their lives, together with other health care workers, to fight against COVID-19.

Nurses have been on the frontline, fighting COVID-19, amidst an alarming failure in the global supply of protective gear and new coronavirus tests. Together with unprecedented overwork, global staff shortages have highlighted various vulnerabilities, acknowledged by WHO on the World Health Day.

Nurses play a central role in health care due to the close proximity and amount of time spent with patients. Consequently, they may disproportionately experience ongoing challenges, such as changes in clinical management, shortages of personal protective equipment, work overload, and extended shifts. They may also experience the fear of infection and the emotional toll related to supporting sick and dying patients and their families. As the pandemic evolves, these challenges may impose a significant psychological impact on nurses.

Nursing in 2020 is certainly to be remembered. With approximately 2 years and several COVID-19 waves, the battle against the pandemic seems endless. Health care professionals around the world have been working tirelessly to render support to the health care system embroiled by the pandemic. In particular, the backbone of any health care system—nurses—is enduring and persevering, with no real end of the pandemic in sight.

Several reviews have reported mental health outcomes of health care professionals working during the COVID-19 pandemic. These include stress, anxiety, depression, burnout, and sleep disturbances [2-5]. Particularly within the Asia-Pacific region, both medical and nonmedical health care workers experienced some levels of psychological distress [6]. However, it is unclear whether nurses in this study fared better or worse compared to other health care workers. Several studies have reported that the psychological impacts on nurses were similar to those on other health care workers [7-9]. However, these studies were conducted in China, the epicenter of the initial COVID-19 outbreak. It is unclear whether other Asia-Pacific countries have similar findings.

In view of the lack of evidence on the psychological impacts of COVID-19 on nurses, and to honor nurses and midwives, this study aims to investigate the following: (1) the psychological outcome characteristics of nurses in different Asia-Pacific countries and (2) psychological outcome differences between nurses, doctors, and nonmedical health care workers. This study utilized data from our previous study [10]. The findings may infer focused interventions necessary to address mental health problems amongst health care workers.

Methods

Study Population and Study Design

From April 29, 2020, to June 4, 2020, health care workers in major tertiary institutions in India, Indonesia, Malaysia, Singapore, and Vietnam were invited to take part in a survey. Participants included doctors, nurses, and nonmedical health care workers (eg, allied health workers, technicians, administrators). The participating institutions were involved in COVID-19 management during the survey period. The study was approved by the Domain Specific Review Board, National Healthcare Group (2020/00144) as well as the Research Ethics

Committee of Zydus Hospitals (2020/220520) and governed by ethical principles of the Declaration of Helsinki.

Screening Questionnaires

The survey questionnaires included demographic information, medical history, somatic symptoms of participants during the month prior to the study, the Depression Anxiety Stress Scale (DASS-21), and the Impact of Events Scale-Revised (IES-R). These questionnaires were adopted to assess the psychological impact on health care workers due to the COVID-19 outbreak [10].

Depression, anxiety, and stress are the 3 emotional states measured by DASS-21 [11]. DASS-21 is applicable to anyone regardless of their health conditions. Depression, anxiety, and stress scores were derived by adding the scores for questions relevant to each emotional state. DASS-21 comes with thresholds based on the multiplication of emotion scores by 2, which are unique for depression, anxiety, and stress, to categorize levels of severity. DASS-21 was found to have an internal consistency of 0.95 in a psychometric analysis among Chinese hospital workers [12].

Unlike DASS-21, the IES-R measures event-induced distress [13]. It consists of 22 test questions relevant for posttraumatic stress disorder (PTSD) symptoms, namely intrusion, avoidance, and hyperarousal. The score of each symptom was obtained by averaging the scores for relevant test questions. Psychometric analysis amongst Asian populations revealed a Cronbach α coefficient for the total scale as .96, while Cronbach α for the subscales of intrusion, avoidance, and hyperarousal was .94, .87, and .91, respectively, with a high degree of intercorrelation between the subscales ($r=0.52-0.87$) [14].

Study Outcomes

We compared the scores of DASS-21 and the IES-R amongst nurses, doctors, and nonmedical health care workers. Similarly, the differences in these scores within a subsample of nurses in different countries were compared. Finally, the most distinctive difference between nurses and other health care professionals was identified.

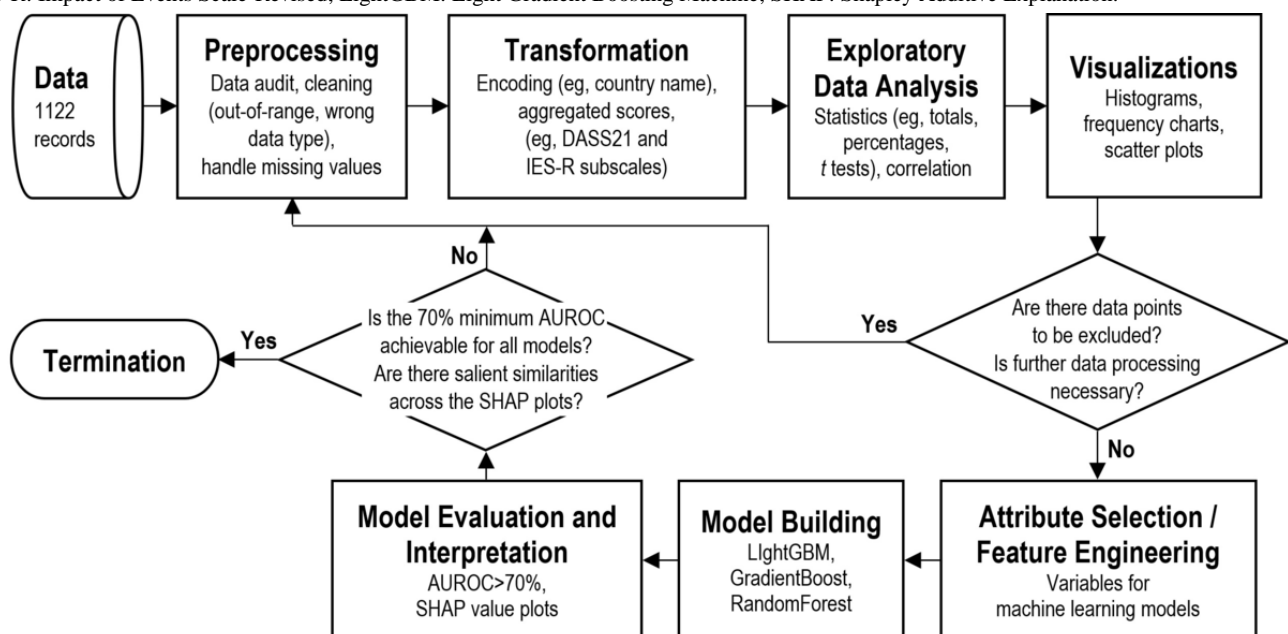
Statistical Analysis and Machine Learning Process

The diagram in Figure 1 depicts the flow of our analysis process.

During transformation (Figure 1), depression, anxiety, stress, intrusion, avoidance, and hyperarousal were expressed as an average value. In the subsequent stages, the average values were used to understand and investigate the psychological outcome characteristics of the various health care professionals and compare them with those of nurses in different countries.

In addition to deciphering useful information from numbers during the exploratory data analysis stage, a visual approach was adopted, as shown in the visualizations stage of the analysis process (Figure 1). Histograms, frequency charts, and scatter plots were used to analyze the spread of hyperarousal mean scores for nurses of each country. As the plots revealed a differing psychological response pattern with obviously higher hyperarousal mean scores for the nurses in India as compared to nurses in other countries, the preprocessing, transformation, exploratory data analysis, and visualizations stages were repeated to prepare another set of statistics excluding the data points for India.

Figure 1. Flow of the analysis process. AUROC: area under the receiver operating characteristic curve; DASS-21: Depression Anxiety Stress Scale; IES-R: Impact of Events Scale-Revised; LightGBM: Light Gradient Boosting Machine; SHAP: Shapley Additive Explanation.



The next step was to identify the critical psychological characteristics that distinguish nurses from other health care workers. Through modeling, the impacts of the psychological variables that made up the model could be discerned. Instead

of using traditional mathematical modeling approaches to build the models (eg, probability and statistical models, differential equations, logic models, game theoretic models), machine learning was adopted. Traditional methods are restricted by the

underlying theory and assumptions of mathematical models, as well as the need for a mathematician's expertise to devise the system of mathematical models and inject the model parameter values obtained from calculations. If the underlying mechanisms are misunderstood or incorrect assumptions are made, the derived parameter values will not give rise to adequate goodness of fit. It is a process that relies heavily on human judgement, whereas machine learning methods are not limited by theories and assumptions, and the model parameter values iteratively determined in the course of model training are usually able to produce models that are more accurate than mathematical models. In addition, the verification of mathematical models takes a much longer time as the goal is often to ascertain a worldly theory. Machine learning focuses on finding the association between inputs and outputs, which may not necessarily lead to a conclusion about the causal relationship. The validation of a machine learning model is often not as onerous as the mathematical model and is done right after model training to provide an assurance of the model performance in a timely manner [15-17]. More importantly, the machine learning method suits the objective of this study as the underlying relationships between nurses and their psychological characteristics during COVID-19 were unknown when we began the study. COVID-19 is a novel pandemic that humans have no prior knowledge of. Machine learning methods are commonly used to identify patterns to enhance our understanding of the phenomenon or make predictions about diseases [18].

To identify the most distinctive psychological characteristic of nurses, Shapley Additive Explanation (SHAP) values were extracted from 3 types of decision tree-based models. These steps correspond with the Model Building and Model Evaluation and Interpretation stages of the analysis process (Figure 1). Decision tree-based models were selected as less effort for data preprocessing is required. Normalization and scaling of data values are not necessary for decision tree-based models [19]. Missing values and outliers do not significantly affect the modeling process [19,20]. Even if there are variables that are highly correlated with each other, decision tree-based models are able to handle the multicollinearity [21]. Consideration was also given for their relatively high model accuracy for a small data set upon inherently taking in the interaction effects between variables (interaction terms have to be consciously handled for some model types, eg, regression) [22]. Acceptable models can therefore be quickly built from algorithms for decision tree-based models.

SHAP values are mathematically derived numbers of how much each variable contributes to any machine learning model. The models built were Light Gradient Boosting Machine (LightGBM), GradientBoost, and RandomForest, and they were used for predicting whether a set of psychological distress characteristics belongs to a nurse. A binary target or dependent variable of 1 represented nurses, and 0 represented other health care professionals. The independent variables were depression, anxiety, stress, intrusion, avoidance, and hyperarousal. The data set was balanced through oversampling to achieve equal distribution of data with targets of 1 and 0, before the balanced

data set was split into 2 for training and validation purposes in an 80:20 ratio. The parameters for model training were not key in the modeling process. The expectation was not to spend many hours tuning the models for their highest-possible performance but just for the models to be reasonably good for extracting useful information. To ensure that the models were adequately reliable, the target area under the receiver operating characteristic curve (AUROC) of each model, when applied on the validation data set (not requiring a large data set for only testing the AUROC), was set at above 70%. The models were able to converge within a few iterations with the training data set, even with the default algorithm settings. After each model was trained, the model was evaluated using the validation data set. The AUROC of the LightGBM, GradientBoost, and RandomForest models was 73.5%, 78.4%, and 74.0%, respectively. Subsequently, the rank of influence of each variable was concluded visually from the SHAP values for the training data set. The interpretations of the SHAP value plots are discussed in the Results section. The common-most influential variable across all the models, akin to the distinctive psychological outcome characteristic of nurses, as compared to other health care professionals, was established. This technique was used to discover the unique qualities of the K-Pop group Bangtan Boys (BTS) [23]. All analyses were performed in Python 3.7.3 with Anaconda Jupyter Notebook and SHAP version 0.37.0.

It is always necessary to review the steps taken in data preprocessing and transformation if the accuracy of models is not acceptable or no conclusion can be drawn from the SHAP value plots. The decision symbol connected to the Model Evaluation and Interpretation stage in Figure 1 depicts the feedback loop to initial stages. We did not observe consistencies in the SHAP value plots in our first attempt. We reperformed data preprocessing to remove data for India due to the differing psychological response pattern of the nurses in India, before we were able to observe an obvious similarity across all SHAP value plots.

Results

Participant Characteristics

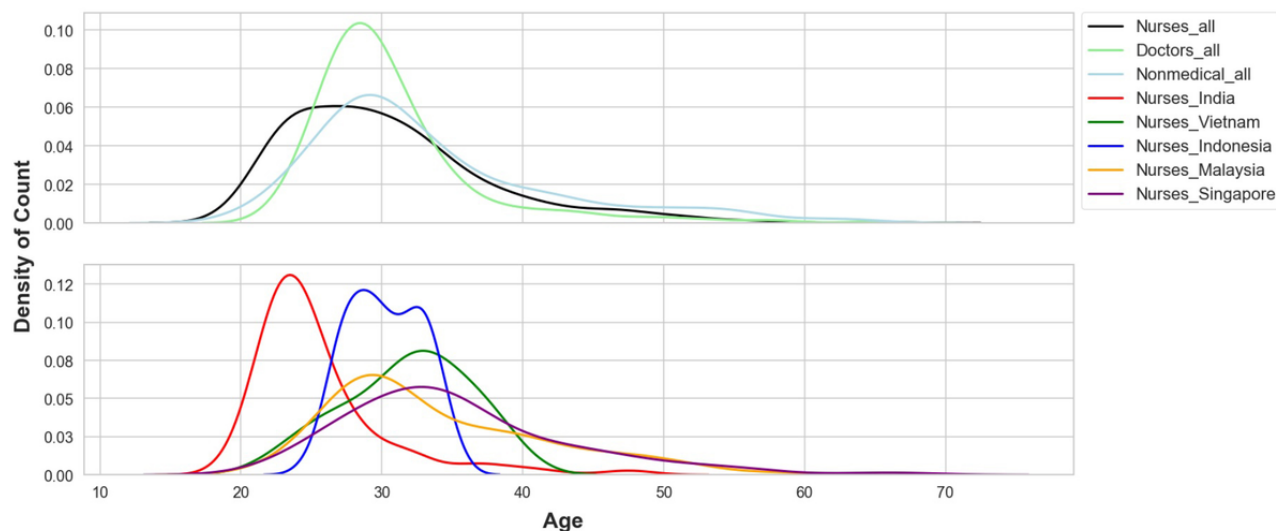
A total of 1122 participants, including doctors, nurses, and nonmedical health care workers, were recruited from India, Indonesia, Malaysia, Singapore, and Vietnam. Nurses comprised 39.0% (n=438) of the study population, followed by nonmedical health care workers (n=389, 34.7%) and doctors (n=295, 26.3%). The median (IQR) age was 30 (27-34) years, with most participants being female (n=732, 65.2%) and married (n=606, 54%). The majority of the participants were Indian (n=436, 38.9%); see Table 1. Amongst the nurses (n=438, 39.0%), there was a significantly higher proportion of female nurses as compared to male nurses (362 [82.6%] vs 76 [17.4%]); see Table 2. In addition, nurses were relatively younger than other health care professions due to the relatively lower median age (24 years) amongst nurses in India (Figure 2).

Table 1. Baseline characteristics of study participants (N=1122).

Characteristic	Value
Age (years), median (IQR)	30 (27-34)
Type of profession, n (%)	
Nurses	438 (39.0)
Doctors	295 (26.3)
Nonmedical	389 (34.7)
Country, n (%)	
India	384 (34.2)
Malaysia	175 (15.6)
Singapore	254 (22.6)
Indonesia	249 (22.2)
Vietnam	60 (5.4)
Sex, n (%)	
Female	732 (65.2)
Male	390 (34.8)
Ethnicity, n (%)	
Indian	434 (38.7)
Malay	211 (18.8)
Chinese	154 (13.7)
Others	323 (28.8)
Marital status, n (%)	
Married	606 (54.0)
Single	493 (44.0)
Divorced, separated, or widowed	23 (2.0)

Table 2. Baseline characteristics of nurses (N=438).

Characteristic	Value
Age (years), median (IQR)	29 (25.0-33.5)
Country, n (%)	
India	167 (38.1)
Malaysia	94 (21.5)
Singapore	93 (21.2)
Indonesia	64 (14.6)
Vietnam	20 (4.6)
Sex, n (%)	
Female	362 (82.6)
Male	76 (17.4)
Ethnicity, n (%)	
Indian	179 (40.9)
Malay	84 (19.2)
Chinese	43 (9.8)
Others	132 (30.1)
Marital status, n (%)	
Married	218 (49.8)
Single	211 (48.2)
Divorced, separated, or widowed	9 (2.0)

Figure 2. Age distribution (overall sample vs nurses subsample).

Psychological Characteristics of Nurses in Different Countries

Considering psychological distress characteristics of nurses only, except for hyperarousal and anxiety, all other psychological distress scores were highest among nurses in Vietnam. Nurses in India and Singapore exhibited highest levels of hyperarousal and anxiety, respectively (Table 3).

The mean distribution of hyperarousal scores in the nurses showed that their overall higher hyperarousal scores were mainly

due to the scores of nurses in India (Figures 3-5). A higher count density for hyperarousal mean values and 2 peaks of density (at mean values between 0.0 and 0.2 and between 0.6 and 1.0) in the distribution were observed in the nurses in India (more clearly shown in Figure 5). This was attributed to younger nurses in India (aged 20-24 years) having higher hyperarousal scores (Figure 6) relative to their same-age peers (ie, other health care workers or nurses) from other countries. Based on this observation, it became apparent that the nurses in India had a psychological response pattern that was different from the nurses in the other 4 countries.

Upon excluding the data for India, nurses in Vietnam had the highest scores for all psychological distress characteristics, except for anxiety. Nurses in Singapore showed the highest anxiety score (Table 3).

Table 3. Mean scores^a of psychological distress characteristics for nurses by country (all 5 countries, including India).

Country	Depression	Anxiety	Stress	Intrusion ^b	Avoidance ^b	Hyperarousal ^b
India	0.1566	0.1575	0.2439	0.2470	0.2869	0.4386
Indonesia	0.1273	0.1720	0.2278	0.3647	0.2798	0.1543
Malaysia	0.1596	0.1657	0.2234	0.2294	0.2424	0.1915
Singapore	0.2167	0.2320	0.2827	0.2984	0.2772	0.2460
Vietnam	0.3286	0.1930	0.3787	0.3984	0.4875	0.3625
Overall mean	0.1736	0.1788	0.2515	0.2783	0.2834	0.2997

^aThe average of mean scores or normalized mean scores.

^bNormalized values by multiplying by 3 and dividing by 4 were adopted for IES-R (Impact of Events Scale-Revised) subscales (ie, intrusion, avoidance, and hyperarousal). This was to make IES-R scores (0-4) to be in the same scale as DASS-21 (Depression Anxiety Stress Scale) (0-3).

^cNumbers in italics are the mean scores of nurses in different countries that are higher than their respective overall mean scores (last row of the table).

Figure 3. Hyperarousal of nurses by country (overlapping distribution plots). IES-R: Impact of Events Scale-Revised.

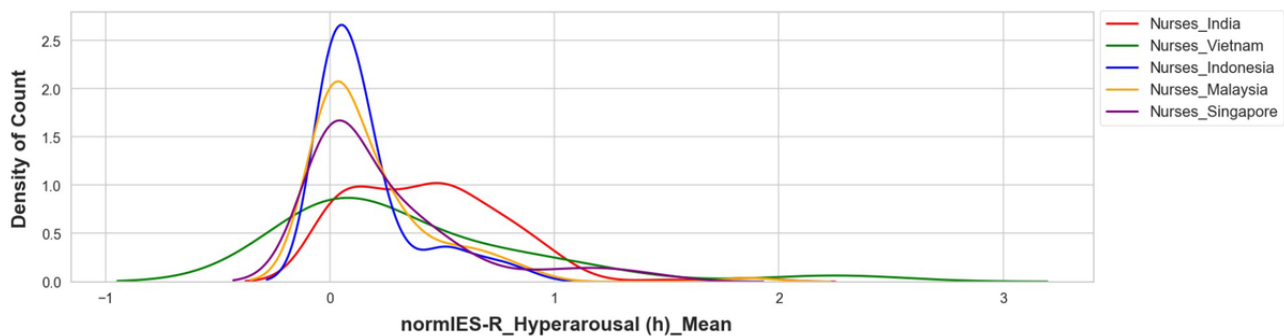


Figure 4. Hyperarousal of nurses by country (plots with the same y axis limit). IES-R: Impact of Events Scale-Revised.

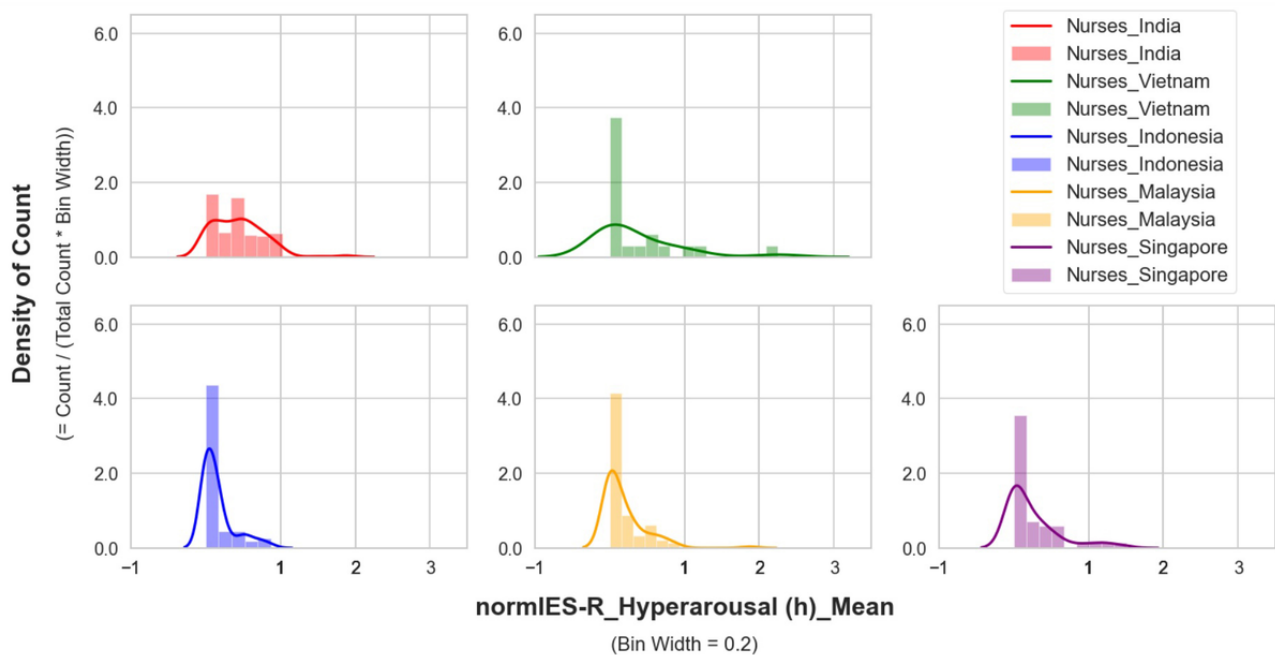


Figure 5. Hyperarousal of nurses by country (plots with different y axis limits). IES-R: Impact of Events Scale-Revised.

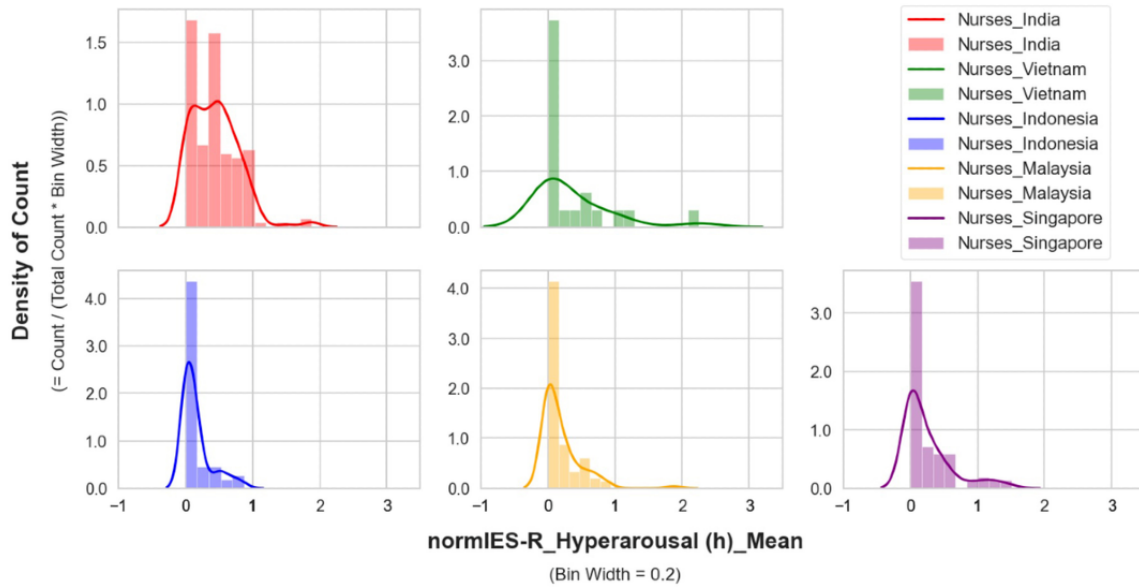
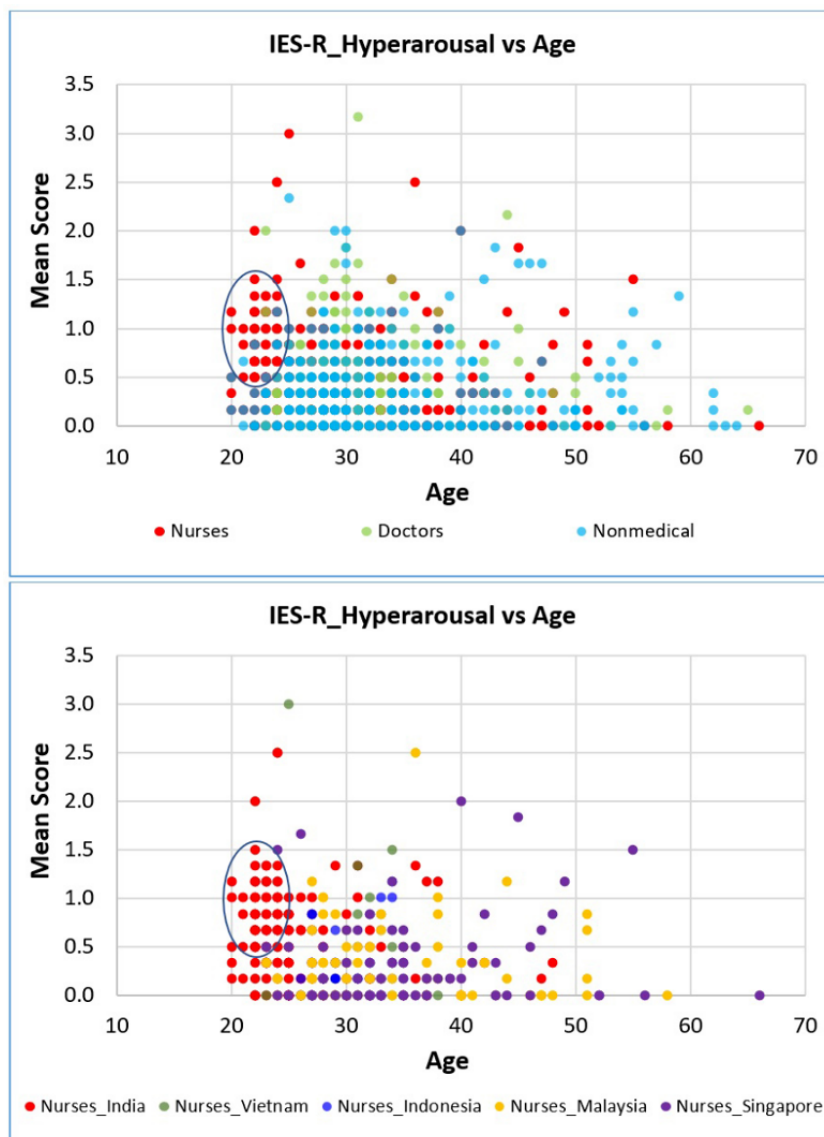


Figure 6. Hyperarousal versus age, by profession and by nurses of each country (dots inside circles represent younger nurses in India). IES-R: Impact of Events Scale-Revised.



Differences Between Nurses, Doctors, and Nonmedical Health Care Workers

As discussed in the previous section that the nurses in India exhibited a vastly different psychological response pattern, and the data for India were excluded from the subsequent analysis and building of machine learning models (analysis including the data points for India is provided in Tables S1 and S2 of [Multimedia Appendix 1](#), corresponding to [Tables 4](#) and [5](#) of this main paper, respectively). Upon excluding the nurses in India, the overall mean hyperarousal score of nurses reduced to 0.2140 (normalized), which was below the overall sample mean of 0.2463 (normalized); see [Table 4](#). This, in turn, placed the nurses' hyperarousal score to be the lowest. Similarly, the scores for depression, anxiety, stress, intrusion, and avoidance amongst nurses were below the respective overall sample mean ([Table 4](#)). The most severe levels of psychological distress were observed in nonmedical health care workers, with the highest scores for all psychological distress characteristics except for depression. Doctors were affected in terms of depression

(0.3200) and stress (0.4424) during the early COVID-19 phase ([Table 4](#)).

Regarding the clinical severity of psychological outcomes, most participants displayed normal or unchanged psychological distress characteristics (n=609-666, 82.5%-91.2%); see [Table 5](#). Nurses, however, had higher percentages of normal or unchanged characteristics compared to other health care workers: in nurses, avoidance was the lowest (n=233, 86.0%) and stress was the highest (n=260, 95.9%), while among other nonnurse workers, avoidance was the lowest (n=187, 74.8%) in nonmedical health care workers and hyperarousal was the highest (n=199, 91.7%) in doctors (see [Table 5](#)). Thus, nurses were least psychologically affected by COVID-19.

There were 482 participants who were normal or had no symptoms at all for all the 6 psychological distress characteristics. Among them, there were 194 (40.2%) nurses, followed by 146 (30.3%) nonmedical health care workers and 142 (29.5%) doctors.

Table 4. Mean scores^a of psychological distress characteristics by profession and *t* test results (4 countries, not including India).

Profession	Depression	Anxiety	Stress	Intrusion ^b	Avoidance ^b	Hyperarousal ^b
Scores by profession						
Overall	0.2546	0.2577	0.3775	0.3360	0.3363	0.2463
Nurses	0.1840	0.1920	0.2562	0.2975	0.2813	0.2140
Doctors	<i>0.3200^c</i>	<i>0.2792</i>	<i>0.4424</i>	0.3085	0.3020	0.2310
Nonmedical	<i>0.2743</i>	<i>0.3104</i>	<i>0.4526</i>	<i>0.4016</i>	<i>0.4256</i>	<i>0.2945</i>
Two-tailed <i>P</i> values of a two-sample <i>t</i> test for comparing mean values (Cronbach α=.05)						
Nurses vs doctors	<.001 (diff ^d)	.005 (diff)	<.001 (diff)	.75 (no diff ^d)	.57 (no diff)	.55 (no diff)
Nurses vs nonmedical	.009 (diff)	<.001 (diff)	<.001 (diff)	.004 (diff)	<.001 (diff)	.008 (diff)

^aThe average of mean scores or normalized mean scores.

^bNormalized values by multiplying by 3 and dividing by 4 were adopted for IES-R (Impact of Events Scale-Revised) subscales (ie, intrusion, avoidance, and hyperarousal). This was to make IES-R scores (0-4) to be in the same scale as DASS-21 (Depression Anxiety Stress Scale) (0-3).

^cNumbers in italics are the mean scores by profession that are higher than their respective overall mean scores (first row of the table).

^dIf the *P* value of the 2-sample *t* test was <.05, it represented that there was a difference in the mean scores or normalized mean scores (denoted by "diff"). Otherwise, there was no difference (denoted by "no diff").

Table 5. Psychological distress severity (4 countries, not including India).^a

Severity category	Depression, n (%)	Anxiety, n (%)	Stress, n (%)	Intrusion, n (%)	Avoidance, n (%)	Hyperarousal, n (%)
All (nurses, doctors, and nonmedical health care workers; N=738)						
Normal/not at all	638 (86.4)	614 (83.2)	673 (91.2)	627 (85.0)	609 (82.5)	666 (90.2)
Mild/a little bit, and above	100 (13.5)	124 (16.8)	65 (8.8)	111 (15.0)	129 (17.5)	72 (9.8)
Nurses (N=271)						
Normal/not at all	245 (90.4)	242 (89.3)	260 (95.9)	234 (86.4)	233 (86.0)	249 (91.9)
Mild/a little bit, and above	26 (9.6)	29 (10.7)	11 (4.1)	37 (13.6)	38 (14.0)	22 (8.1)
Doctors (N=217)						
Normal/not at all	178 (82.0)	173 (79.7)	193 (88.9)	191 (88.0)	189 (87.1)	199 (91.7)
Mild/a little bit, and above	39 (18.0)	44 (20.3)	24 (11.1)	26 (12.0)	28 (12.9)	18 (8.3)
Nonmedical health care workers (N=250)						
Normal/not at all	215 (86.0)	199 (79.6)	220 (88.0)	202 (80.8)	187 (74.8)	218 (87.2)
Mild/a little bit, and above	35 (14.0)	51 (20.4)	30 (12.0)	48 (19.2)	63 (25.2)	32 (12.8)

^aDASS-21 (Depression Anxiety Stress Scale) severity categories are based on 2 times of the sum of subscale scores: depression mild and above, ≥ 10 ; anxiety mild and above, ≥ 8 ; stress mild and above, ≥ 15 . IES-R (Impact of Events Scale-Revised) severity categories are based on the mean of subscale scores: intrusion, avoidance, and hyperarousal, a little bit and above, ≥ 1 .

Distinctive Psychological Distress Characteristics of Nurses

Due to the differing psychological response pattern of nurses in India, all data for India were excluded to build the 3 decision tree-based machine learning models (LightGBM, GradientBoost, and RandomForest) for predicting whether a health care worker is a nurse, based on the psychological scores. The SHAP values of these models were extracted to identify the distinctive psychological distress characteristics of nurses.

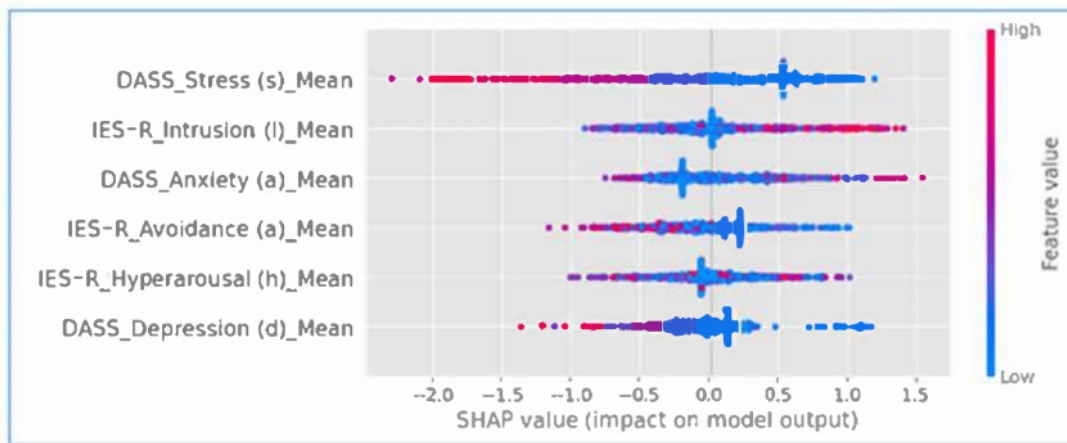
Figures 7a-7c represent the SHAP value plots. There is a corresponding SHAP value of each independent variable computed for all the data points, providing the local interpretation for understanding individual predictions. The magnitude of a SHAP value represents the impact of each independent variable in deviating the predicted values from the base value [24]. The base value is the average of the model outputs for the entire training data set. The sign of a SHAP value represents the directional force that increases (positive sign) or decreases (negative sign) the prediction away from the base value.

SHAP values can be plotted to provide a global interpretation of the model in understanding the general model behavior based on the model features. The red and blue dots, as shown in SHAP

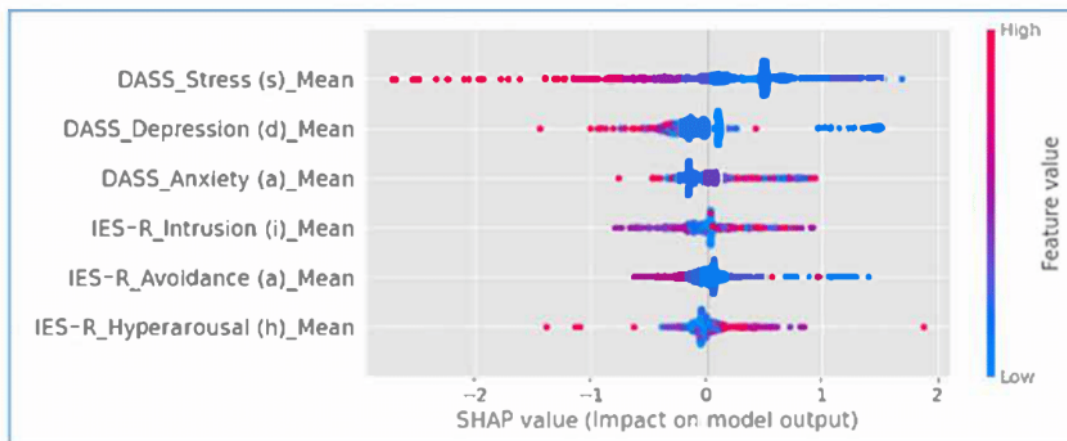
value plots (Figures 7a-7c), represent the higher and lower magnitude levels (referred to as feature values), respectively, as compared with the predicted values contributed by all individual data points. The amount of influence in both positive and negative directions of a variable is shown by the spread of the dots from the center. The variable with the widest spread of red dots (or appearing to have more red dots) than other variables is the most influential variable. As shown in the plots, variables are positioned from top to bottom sorted in the order of their importance.

Take Figure 7a for the LightGBM model as an example. Most of the red dots for DASS-21 stress scores are on the left side, which is the region for negative SHAP values, and are most spread out compared to other variables. This indicates that the DASS-21 stress item is the first variable on the list having the highest amount of influence over the LightGBM model, and stress has a negative relationship (the lower the stress, the higher the impact on the model prediction). Stress is placed right at the top in the plot corresponding with its rank of importance. This phenomenon about the stress of nurses was consistent in the SHAP value plots of all the 3 models. As shown in Table 6, stress in the negative direction was ranked first for all the models, and we could affirm that the most distinctive psychological characteristic of nurses was the lower stress level compared to doctors and nonmedical health care workers.

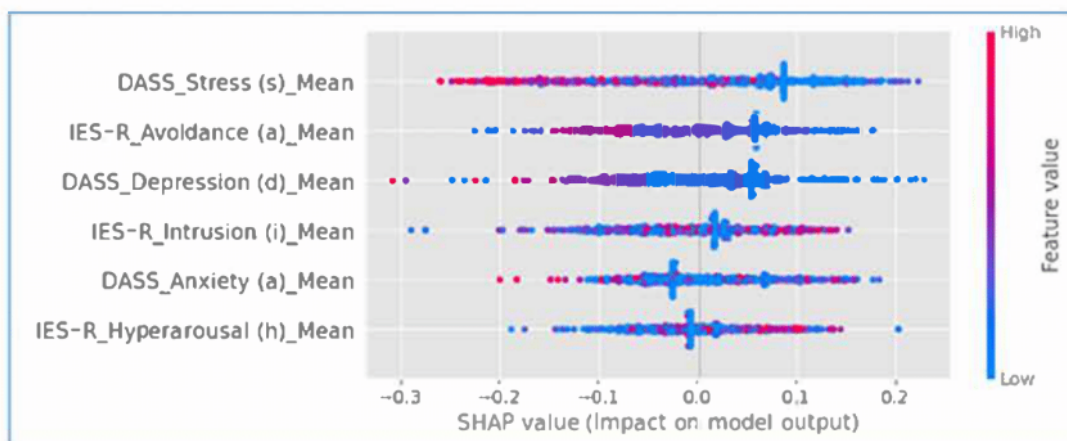
Figure 7. SHAP value plots: (a) LightGBM model, (b) GradientBoost model, and (c) RandomForest model. LightGBM: Light Gradient Boosting Machine; SHAP: Shapley Additive Explanation.



(a)



(b)



(c)

Table 6. Global interpretation of SHAP^a value plots.

Rank ^b of variable influence	LightGBM ^c model	GradientBoost model	RandomForest model
1	Stress (-) ^d	Stress (-)	Stress (-)
2	Intrusion (+) ^d	Depression (-)	Avoidance (-)
3	Anxiety (+)	Anxiety (+)	Depression (-)
4	Avoidance (-)	Intrusion (+)	Intrusion (+)
5	Hyperarousal (+)	Avoidance (-)	Anxiety (+)
6	Depression (-)	Hyperarousal (+)	Hyperarousal (+)

^aSHAP: Shapley Additive Explanation.

^bRank 1 is most influential. Variables of each model were ranked and filled in accordingly in the table. The variable with the widest spread of red dots was ranked 1.

^cLightGBM: Light Gradient Boosting Machine.

^dThe “-” and “+” represent the direction of force in value prediction and correspond with the right or left region, respectively, where most red dots fall within the SHAP value plots. The “-” and “+” signs of a variable are the same for all the models.

Discussion

Principal Findings

The principal findings of our study are twofold. First, during the early phase of COVID-19 in the Asia-Pacific region, nurses were least psychologically affected than other health care workers. This was evidenced by their relatively higher percentages of normal or unchanged psychological distress symptoms relative to other health care workers. Additionally, among health care workers with no psychological distress symptoms, nurses constituted a higher proportion than doctors and nonmedical health care workers. Notably, despite the most demanding job nature (ie, greater exposure and longer time with patients), nurses showed the lowest level of stress, which is the most distinctive psychological outcome characteristic compared to other health care workers. Second, nurses in Vietnam showed the highest level of depression, stress, intrusion, avoidance, and hyperarousal symptoms compared to those in Singapore, Malaysia, and Indonesia. Nurses in Singapore had the highest level of anxiety. The differing patterns of psychological outcomes among nurses are probably related to different contexts, cultures, and points in the pandemic curve.

Our finding that amongst health care workers, frontline nurses were least psychologically affected is consistent with a previous study [25]. Li et al [25] reported that frontline nurses had lower vicarious traumatization scores relative to nonfrontline nurses and the general public. Furthermore, our finding is also consistent with a previous study conducted during the SARS pandemic [26], which reported that doctors were 1.6 times more likely to experience psychiatric symptoms than nurses. The authors attributed higher rates of doctors' anxiety to the need for maintaining a prolonged hypervigilant state in diagnosing SARS cases. By comparison, a rapid review conducted during the early phase of COVID-19 suggested that nurses may be at a higher risk for adverse mental health outcomes than doctors [27]. However, the authors acknowledged that confounding factors in the studies were not robustly addressed. The reason why nurses were least psychologically affected could be explained by their job scopes. The nature of the nursing

profession in clinical settings requires teamwork. An integrative review suggested that positive teamwork has a significant correlation with mental resilience [28]. It is possible that despite the demanding workload during the pandemic, nurses have good mental resilience as they work in teams.

Although we believe that the differing patterns of psychological outcomes amongst nurses in various Asia-Pacific countries could be related to the magnitude of the pandemic in those countries, despite having the lowest volume of cases during the study period, nurses in Vietnam showed the highest level of depression, stress, intrusion, avoidance, and hyperarousal relative to nurses in Singapore, Malaysia, and Indonesia. This is in line with a previous study in Vietnam that reported a higher level of psychological distress in nurses than doctors, attributing the findings to their job nature and demands [29]. Singapore had the highest case volume, which might have contributed to the relatively higher anxiety level of nurses.

Although nurses in India showed the highest level of hyperarousal, the data for India were not accounted for in our conclusions due to the differing psychological response pattern exhibited amongst the nurses in India. The highest level of hyperarousal in nurses in India might be due to the larger proportion of younger nurses (two-third being <35 years old). A younger age is considered a risk factor for PTSD symptoms [30]. In view of fewer older and experienced nurses in India, younger nurses are likely to experience higher levels of hyperarousal due to the lack of supervision support, guidance, and leadership. It is also reported that a large number of female nurses across India are emigrants from states in South India, especially Kerala [31]. The emigrated nurses usually live alone in their cities of employment. With the lack of support from family members, they could not have psychologically managed themselves well in facing the work challenges posed by the COVID-19 pandemic.

During the early phase of the pandemic curve, relative to other health care workers, although nurses seemed to cope better psychologically, yet approximately three-fifth of the nurses reported some psychological distress. Notably, this proportion was lower than doctors (approximately three-fourth) and

nonmedical health care workers (two-third). This highlights significant psychological outcomes of COVID-19, for which effective coping strategies are essential to bolster psychological resilience in all health care workers, especially doctors and nonmedical health care workers.

During the early COVID-19 phase, health care workers had coped with the pandemic by holding on to their values. This is consistent with the meaning-making coping style postulated by Park and Folkman [32]. That is, health care workers coped by making meaning of their work with altruistic beliefs and goals in the battle against the pandemic. This led to psychological adaptation and personal growth to occur early and possibly within 2 weeks [33]. Nurses reported their personal growth under the crisis (eg, gratitude, a stronger sense of professional identity, and self-reflection). Such growth promoted positive emotions and psychological adaptation. Moreover, health care workers reported improved mood over the 2 weeks' duration, due to acquiring more knowledge about COVID-19 [33]. This seems to concur with the decline in the frequency of mental health problems of Chinese health care workers over time [34,35].

With almost 2 years into the pandemic, the International Council of Nurses found that 20% of National Nurses Associations reported increased rates of nurses leaving the profession in 2020, likely due to the pandemic [36]. Accordingly, a recent scoping review reported that nurses will be under an increased risk for stress, burnout, and depression during the pandemic, where younger female nurses, with less clinical experience, are more vulnerable to adverse mental health outcomes [37]. Catton and Iro [38], nurses in WHO and the International Council of Nurses (ICN), recently called for an investment in the augmentation of the nursing profession since the availability of adequate nursing staff can reduce inpatient admissions and hospital stays [39], a dire situation that most countries are currently facing.

In view of the aforementioned worrying trend, and the fact that health care workers prefer self-help rather than seeking professional help [40,41], we recommend self-care coping strategies, such as self-reflection, reinforcing internal values, aerobic exercises, and support from religious organizations, peers, and family. These strategies were helpful during the previous SARS and Ebola epidemics [42-45]. Similarly, digital interventions, such as computerized resilience training over a medium-long course duration (12-17 sessions), may be useful to build up health care workers' resilience [46]. Furthermore, peer-led cognitive behavioral therapy group programs may also assist health care workers to cope psychologically [47]. Moreover, a structured peer support program through caring mentorship and self-reflection practice would be practical and useful for health care workers to continue to strive in coping with the pandemic [48,49].

Strengths

The novelty of our study is twofold. First, we used machine learning techniques and visualizations to discover trends. This novel machine learning approach predicts whether a health care worker is a nurse from a set of psychological scores. Although versatile models (eg, decision tree, neural network) are desirable for accuracy, many hesitate to adopt them, as the model interpretation of the independent variables is challenging. In

our study, decision tree-based models were adopted based on the fact that SHAP could explain the models and pick out the most distinctive characteristic. The use of SHAP in unravelling distinctive characteristics manifests the power of the SHAP algorithm [50]. With SHAP, the advantages of decision tree-based machine learning models in requiring less data processing effort and a not too large data set can be widely applied in situations in which the underlying principles of the relationship between variables are unknown and a quick solution is required. These are the limitations that a traditional statistical approach cannot overcome. For example, the statistical *t* test will not lead to a correct conclusion if the assumptions of the *t* test are not present (eg, 1 of the assumptions is that data points should follow a normal distribution). The *P* value of the 2-sample *t* test for the DASS-21 stress item was the lowest among all psychological distress characteristics (ie, the highest level of difference) for the comparisons between nurses and doctors and between nurses and nonmedical health care workers (Table 4). This is consistent with our SHAP result, which shows a significant lower level of stress amongst nurses (Figures 7a-7c). The same result cannot be arrived at if the assumptions of the *t* test are not met. Like the *t* test (one-tailed), SHAP is capable of indicating the direction of influence (positive or negative) for each psychological distress characteristic. In addition, SHAP can present the level of contrast in graphical form. The notable advantage of SHAP is the model interpretation at both global and local levels, thus constituting a full suite of explanations for the gap between the overall average value and the model prediction. Such user-friendly interpretation style allows wide application of the SHAP technique in health care research. Second, to better understand the psychological outcomes of health care workers from a wider range of the Asia-Pacific region, we recruited a large sample from several countries. These health care workers have different occupational roles and were functioning in both medical and nonmedical roles during the early phase, which was the most stressful period of the pandemic. Understanding their psychological outcomes will help the health care industry to better prepare for future pandemics. In urgent situations like the current pandemic, where the presentations evolved rapidly, without any precedent case, machine learning can be a faster and efficient option to analyze data for identifying patterns and taking appropriate actions in a timely manner.

Limitations

Some limitations of our study merit acknowledgement. First, there are no similar mental health data prior to COVID-19 for comparison. This limited us to provide insight into the direct impact of COVID-19 on health care workers' psychological outcomes. Second, we used a cross-sectional survey with participant self-report questionnaires; hence, it was difficult to accurately assess mental health problems, due to a lack of specialist verification. Third, we did not have a follow-up study design, which could evaluate long-term mental health outcomes and coping. Future studies should include a better study design using clinical verification to further assess cases with significant psychological distress and follow them up to investigate the long-term psychological outcomes.

Conclusion

In conclusion, during the early phase of COVID-19, nurses were least psychologically affected as they have better teamwork compared to other health care workers. Different contexts, cultures, and points in the pandemic curve may have also contributed to differing patterns of psychological outcomes amongst nurses in various Asia-Pacific countries. With no real end in sight for the current pandemic, along with their multidisciplinary colleagues, nurses worldwide are persevering

to fight this war. Nurses require targeted psychological support dependent on regions, contexts, cultures, and points in the pandemic curve. Similarly, active outreach and targeted interventions should be provided to nonmedical health care workers and medical doctors to support their psychological well-being. To win this battle, it is crucial for all health care workers to hold on to their values, practice self-care, and render peer support to bolster psychological resilience for effective coping.

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Authors' Contributions

YHD conceptualized the study, was involved in analysis, and drafted the manuscript. MCY conducted the analysis and was involved in the writing and reviewing of the manuscript. XCT was involved in the writing and reviewing of the manuscript. RD, THN, AKS, KRN, MPV, MLST, AA, BYQT, and RCH were involved in data collection and writing and reviewing of the manuscript. MCHC was involved in conceptualization, analysis, and writing and reviewing of the manuscript. VKS was involved in conceptualization, data collection, analysis, and writing and critical review of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Supplementary materials: Tables S1 and S2.

[[DOCX File, 34 KB - nursing_v5i1e32647_app1.docx](#)]

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Abbreviations

- AUROC:** area under the receiver operating characteristic curve
- DASS-21:** Depression Anxiety Stress Scale
- IES-R:** Impact of Events Scale-Revised
- LightGBM:** Light Gradient Boosting Machine
- PTSD:** posttraumatic stress disorder
- SHAP:** Shapley Additive Explanation
- WHO:** World Health Organization

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Original Paper

Acceptance of an Internet-Based Team Development Tool Aimed at Improving Work-Related Well-being in Nurses: Cross-sectional Study

Sylvia Broetje¹, PhD, RN; Georg F Bauer¹, MD, DPH; Gregor J Jenny¹, PhD

Center of Salutogenesis, Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Zurich, Switzerland

Corresponding Author:

Sylvia Broetje, PhD, RN

Center of Salutogenesis

Epidemiology, Biostatistics and Prevention Institute

University of Zurich

Hirschengraben 84

Zurich, 8001

Switzerland

Phone: 41 446344854

Email: sylvia.libro@gmail.com

Abstract

Background: Workplace health interventions can produce beneficial health- and business-related outcomes. However, such interventions have traditionally focused on lifestyle behaviors of individuals, mostly not considering the role of working conditions. The wecoach intervention is an internet-based tool that combines both a digital and a participatory team development approach aimed at addressing critical job demands and resources as key aspects of health-promoting working conditions. Nursing staff are particularly affected by challenging working conditions and could potentially benefit greatly. Understanding the acceptance of novel workplace health promotion approaches is a critical precursor to their successful implementation and use.

Objective: This study aims to examine the factors influencing the acceptance of a digitally supported team development tool among nurse managers.

Methods: A sample of 32 nurse managers from 3 German-speaking countries tested wecoach and completed our online questionnaire. Hypotheses were based on the unified theory of acceptance and use of technology (UTAUT) and the organizational health development (OHD) model and were tested using multiple regression analyses.

Results: Our analyses found that merely capacities on the team level (CapTeam) significantly contributed to the acceptance of wecoach, although only after the other variables were excluded in the stepwise multiple regression analysis. The UTAUT predictors were unable to add significant variance explanation beyond that, and their inclusion masked the contribution of CapTeam.

Conclusions: For the acceptance of a digitally supported participatory tool, the fit with the team, its culture, and its motivation are of critical importance, while aspects proposed by traditional acceptance models, such as the UTAUT, may not be applicable.

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KEYWORDS

digital intervention; eHealth; nurses; online intervention; organizational health; technology acceptance; UTAUT; workplace health promotion; mHealth

Introduction

Workplace Health Interventions

Workplace health programs can produce beneficial health- and business-related outcomes [1-3]. Such interventions have traditionally focused on targeting lifestyle behaviors of individuals, supporting them, for example, in quitting smoking,

increasing their physical activity, or managing their stress levels. The role played by working conditions, however, has received little attention in the development of workplace health promotion programs [4]. A model well suited to studying and assessing the well-being-enhancing and well-being-diminishing aspects of work is the Job Demands-Resources model [5]. It proposes a dual pathway. Job resources, such as autonomy and social support, are linked to motivational outcomes, such as work

engagement, while high levels of job demands, such as work interruptions or role conflict, are linked to strain and health impairment. Its assumptions have found widespread support in empirical research [6]. Data collected during a large-scale stress management intervention conducted in Switzerland showed that a favorable ratio of job resources to job demands is associated with lower exhaustion and absenteeism as well as higher engagement and productivity of staff [7]. Reviews also indicate that at least some organization-level interventions aimed at improving working conditions can positively affect outcomes such as mental health, physical health, absenteeism, or staff turnover [8,9].

Teams are optimal units for workplace health promotion [10]. Leaders not only play an important role in the implementation of interventions [11], but teams and leaders are also the level on which many job demands and resources are created. Teams can apply the expertise about their workplace to develop measures that are tailored to their own situation, and the participation of the team in this process enhances ownership of the intervention and facilitates learning and communication.

At the same time, the ongoing megatrend of digitization has led to an increase in the delivery of interventions in digital format. The most common forms are health apps, wearables, and health portals [12]. Such approaches have been shown to improve mental health in general population samples [13] as well as in employees [14]. However, no digital interventions have, to the best of our knowledge, aimed to improve health and well-being in employees via the improvement of working conditions.

This presents a highly innovative form of workplace health intervention. Previous intervention research has focused on the effectiveness of workplace health interventions, with aspects of acceptance and implementation receiving little attention. This, however, is changing. Attention is now directed towards *realist* evaluations of interventions, acknowledging the entire intervention process [15] as well as aspects preceding the use of an intervention, as emphasized by the *adoption* dimension of the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework [16,17]. If digital workplace health interventions are to fulfill their potential, they not only must be effective and well implemented, supporting their internal and external validity, but also need to be accepted by potential users. According to Rogers [18], the adoption of innovations is a 5-step process, leading from (1) knowledge about the product to (2) persuasion of the product, (3) decision to adopt—or reject—the product to its (4) implementation and (5) confirmation that one has made the right decision. During the stage of persuasion, an opinion about the product is formed, which is influenced by different characteristics of the product. These characteristics stem from attributes of the product itself, as well as from relevant outside factors, such as current needs or compatibility with other products. In accordance with this model, we view acceptance as the phase of formation of attitudes and usage intentions that precedes the adoption of a product.

Health care is one of the industrial sectors with the highest levels of health risks. The sixth European working conditions survey

[19] names the health sector as the one with the highest work intensity index, measuring aspects such as quantitative demands, time pressure, interruptions, and emotional demands. It also reports that health sector workers have a substantially above average experience of adverse social behavior at work. Approximately one-third of nurses in Europe and the United States feel burned out [20], and 33% of nurses report wanting to leave their current employer within the next year due to job dissatisfaction, with 9% intending to leave the profession altogether [21]. Poor working conditions are at the root of this situation, with low pay, limited educational and career opportunities, unsafe workplaces, and lack of resources, contributing to nurse turnover and health impairment [22]. Although these challenges also need to be addressed on the societal and political levels, interventions on the level of the individual health care organization and even on the unit or team level can make a contribution to the improvement of working conditions [23].

The Wecoach Approach

In this study, we examine what affects the acceptance of wecoach, an internet-based tool that combines both a digital and a participatory team approach and guides team leaders through a health-oriented team development process. It is currently only available in German. When logging into wecoach, the team leader interacts with a chatbot, which advises the leader on which training session to complete next and presents training materials on work and health, self-assessments, and online tools to conduct team surveys and workshops, as well as self-evaluation of progress and effectiveness (see Figures 1 and 2). After the initial training sessions, the entire team is involved and team members complete a survey that assesses job demands and resources with validated scales, such as the Health and Safety Executive (HSE) Stress Management Standards [24], which have been found to be relevant across many industries. Afterward, a team workshop is conducted that builds on these results, developing measures to reduce demands or strengthen resources. The team workshop is moderated by the team leader, who has been provided with material on how to organize and conduct the workshop. Instructions on maintaining the effects of the intervention and a health-oriented team culture are also included. This sequence of sensitizing participants to the relationship between work and health, providing information and enhancing self-efficacy in team leaders, followed by assessments and team workshops, has been honed by our department in many on-site interventions, and these experiences built the foundation for the digitally supported wecoach intervention. The wecoach tool is based on a capacity-building approach, which the World Health Organization's International Classification of Health Interventions describes as "providing resources or initiating strategies to increase the ability of an organisation or community to address health issues by creating new structures, approaches or values in relation to patterns of behaviour that may affect psychological health and wellbeing" [10,25].

Figure 1. Screenshot of the wecoach main page.

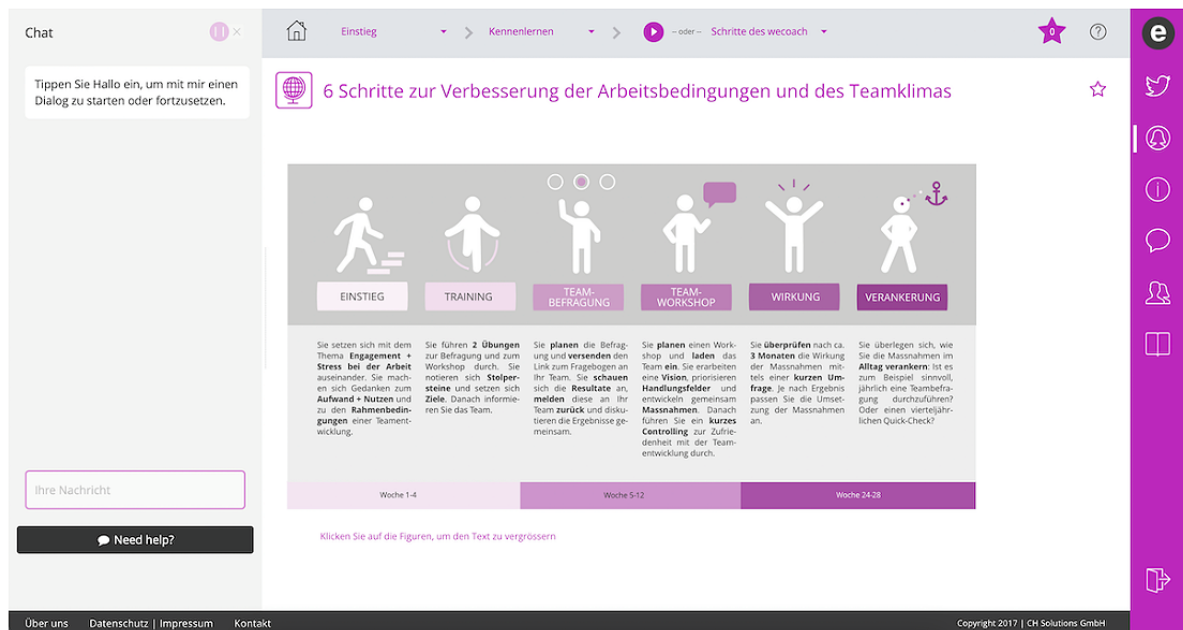
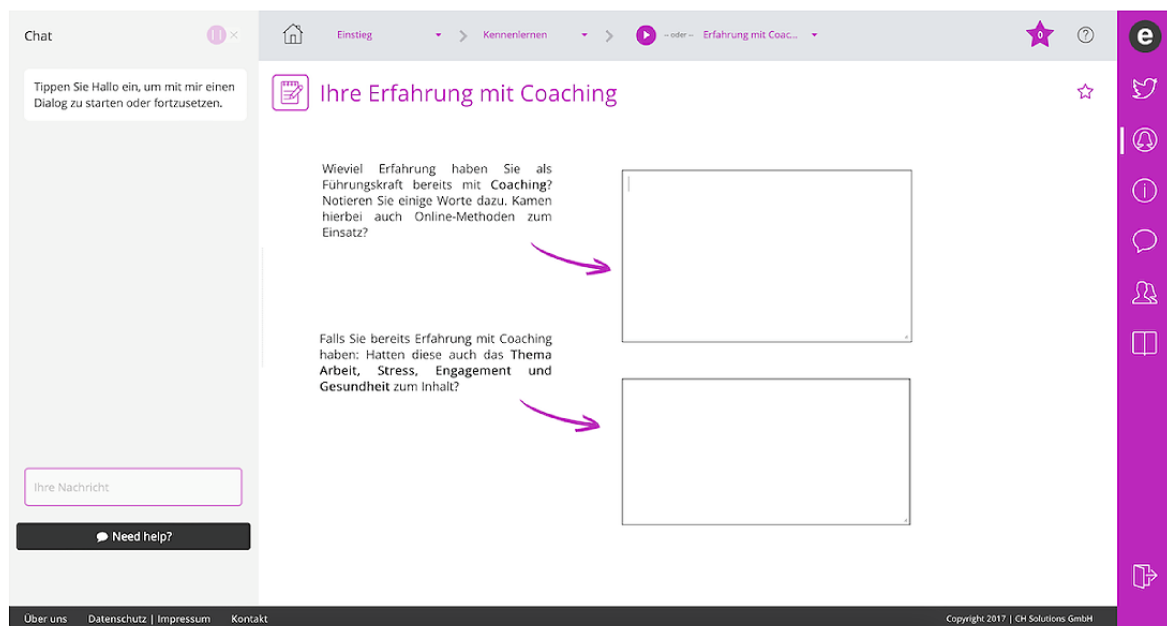


Figure 2. Screenshot of a wecoach interactive form.



Study Aim and Hypotheses

The aim of this study is to examine the factors determining the acceptance of wecoach among nurse managers in 3 German-speaking countries in order to make a contribution to the understanding on what factors can help promote the use of participatory, digitally supported workplace interventions that can help address working conditions in a challenging work environment such as health care. We based our hypotheses regarding its acceptance on 2 models: the unified theory of acceptance and use of technology (UTAUT) and the organizational health development (OHD) model to capture the complexity of wecoach, which is simultaneously a technological innovation as well as an innovative participatory team approach.

Unified Theory of Acceptance and Use of Technology

UTAUT [26] is 1 of the most widely used models of technology acceptance. It examines the factors that explain the intention to use new technologies, especially in organizational contexts. It was developed empirically and integrates elements from 8 established models, including traditional psychological theories such as the theory of reasoned action [27] and social cognitive theory [28,29], as well as other technology-related models, such as the technology acceptance model [30].

UTAUT proposes 4 predictors [26]. Performance expectancy describes the degree to which an individual believes that using the system will help them attain gains in job performance. Effort expectancy refers to the degree of ease associated with the use

of the system. Social influence is the degree to which an individual perceives that important others believe they should use the new system. Facilitating conditions refers to the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system. The model proposes 2 outcome variables that indicate acceptance of a new technology: (1) behavioral intention, which is the expressed intention to use the technology in the near future, and (2) use behavior, which indicates how often people, within a certain period after the technology rollout, actually use the technology, typically tracked by company logs. Based on the original 8 theories from which UTAUT was synthesized, gender, age, voluntariness, and experience were also included into the original model as moderators.

UTAUT has been applied in different contexts, especially to study the acceptance of online banking [31], general information technology [32], e-government services [33], or e-learning tools [34]. Among health care professionals, it has been used predominantly to examine factors influencing the acceptance of electronic medical records [35-37].

A meta-analysis of 74 studies by Khechine et al [38] confirmed the strength and robustness of UTAUT and corroborated findings from a previous meta-analysis by Taiwo and Downe [39]. All 4 predictors have been found to significantly predict behavioral intention and use behavior, respectively, with regression weights ranging from 0.4 to 0.5 [38]. Performance expectancy was the strongest predictor of behavioral intention, indicating that users will be keen to use a new technology when they believe that it would improve their productivity, efficiency, and effectiveness. The moderators proposed in UTAUT have rarely been examined in empirical studies [38,40] and were not considered in the meta-analysis. Venkatesh et al [40] also later distanced themselves from the inclusion of moderators in the model and suggested a focus on the main effects for enhanced parsimony.

As our study is exploratory in nature and we want to focus on the initial impressions potential users have of wecoach, we included only behavioral intention as an indicator of acceptance in this study. We expect all 4 predictors to be relevant to the

acceptance of wecoach as a new technology. Our first hypothesis (H1) thus states:

- H1a: Performance expectancy contributes to the intention to use wecoach.
- H1b: Effort expectancy contributes to the intention to use wecoach.
- H1c: Social influence contributes to the intention to use wecoach.
- H1d: Facilitating conditions contribute to the intention to use wecoach.

Organizational Health Development Model

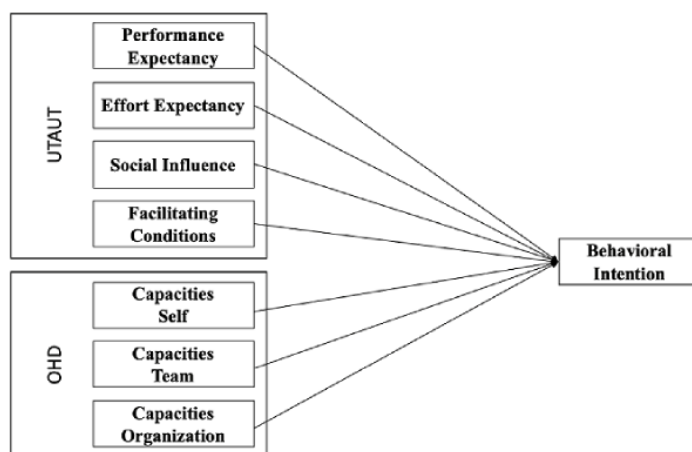
The wecoach tool is a complex intervention approach that is not only a new technology but also an innovative participatory approach that affects different organizational levels. For this reason, we considered it necessary to include additional predictors in our study. Attitudes or beliefs relating to the affected organizational levels may serve as the gateway to considering using such a tool, even before considering aspects such as usefulness or user-friendliness.

We included 3 variables from the OHD model [41]. The OHD model describes capacities on the individual and organizational levels that are needed to implement and sustain health interventions. For example, on the individual level, a leader needs to be competent and motivated to conduct an intervention and perceive it as fitting to their leadership style and values. These aspects should also be true for the members of their team. On the organizational level, resources should be available for the intervention and the intervention should fit with the goals and culture of the organization. Accordingly, we hypothesized that capacities on the individual leader's level (CapSelf), the team level (CapTeam), and the organizational level (CapOrg) will influence the intention to use wecoach. Our second hypothesis (H2) thus states:

- H2a: CapSelf contributes to the intention to use wecoach.
- H2b: CapTeam contributes to the intention to use wecoach.
- H2c: CapOrg contributes to the intention to use wecoach.

Figure 3 illustrates our proposed study model with predictors from UTAUT and the OHD model.

Figure 3. Proposed study model with predictors from UTAUT and the OHD model. OHD: organizational health development; UTAUT: unified theory of acceptance and use of technology.



Methods

Participants and Procedure

The participants in our study were nurse managers and nurse executives working in hospitals or nursing homes in Switzerland, Austria, and Germany. Nurses without leadership responsibilities were not included in the study. The rationale for this decision is that wecoach empowers team leaders to conduct a team development process, together with their staff, who do not directly interact with wecoach. Since nurse managers would be the primary users of wecoach, we were particularly interested in their acceptance of it.

Participants were identified by searching databases or publicly available lists of hospitals and nursing homes in all 3 countries. In some cases, an email address for the nursing director was directly available. In other cases, organization websites were listed, which were then searched for contact information of nursing directors, nurse managers, or other staff, such as human resource personnel, who might be in charge of team development or occupational health in nurses.

We contacted all the largest hospitals and nursing homes in all 3 countries. Additionally, using an online random generator, we also selected subsets of small and medium-size organizations in each canton or state. This varied slightly, based on the databases available for hospitals and nursing homes in each country; however, great efforts were undertaken to ensure that organizations of different sizes, from urban and rural areas and from all regions of each of the 3 countries, were included. The identified contacts were invited by email to participate in our study, and a flyer with further information was included. Participation in the study involved completing several modules of wecoach and then answering our online questionnaire (all in German; total time approximately 60-90 minutes). We sent out emails to 2269 recipients working in more than 500 organizations, deemed suitable for participating in or sharing the information about the study, such as nursing unit managers, nursing directors, or persons in charge of human resource development or occupational health and well-being. Persons interested in participating contacted the first author. To be included in the study, participants had to be working in a nursing leadership role with staff supervision responsibilities in either a hospital or a nursing home. Participants were asked to complete 4 modules of wecoach. The first module acquainted them with the technical interface, such as the chatbot and interactive forms. It also introduced them to general information

about work and stress and asked them about their current level of confidence in undergoing health-oriented team development. The second module deepened the understanding of work, stress, and engagement; introduced users to the Job Demands-Resources model [5]; and provided an introduction to the team survey. In the third module, users learned how the team survey works and analyzed their own work situation. In the fourth module, they learned about the team workshop approach and practiced developing measures for improving 1 of their own job resources and job demands. These 4 modules represent only a selection of the full wecoach tool and were chosen to provide participants with a good overview of the team development approach and the technology of wecoach, while not requiring too much time. However, participants were free to move around wecoach and go over different modules as they pleased.

As an incentive, participants retained access to their fully active wecoach account, which allowed them to conduct an entire team development process free of charge. In total, 105 persons registered to participate in the study; however, many did not complete the wecoach modules or the questionnaire. The emails we received indicated that this was mainly due to time constraints. To encourage participation, we later provided an incentive of a raffle of 5 gift certificates for an online store worth €50 each (approximately US \$54).

Ethical Considerations

No ethical review of the study was necessary under federal, state, university, or departmental rules. The study was conducted under strict observation of ethical and professional guidelines.

Measures

We assessed the variables of UTAUT by modifying the items used by Venkatesh et al [26]. We attempted to maintain the meaning of the original items, while adjusting them slightly for the purposes of our study. For example, we rephrased the statement *Using the system enables me to accomplish my tasks more quickly* to *I think that wecoach can enable me to more efficiently conduct team development*. The capacities for the team development approach were assessed with newly developed items based on the OHD model [41], with 3 items assessing each dimension. All UTAUT and OHD items are illustrated in Table 1. Participants responded to all of these on 7-point scales ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Additional data collected were demographics, work setting, leadership role, and voluntariness of testing wecoach.

Table 1. Items used to measure variables from UTAUT^a and the OHD^b model.

Variable	Items ^c
Behavioral intention	<ul style="list-style-type: none"> • I intend to use wecoach within the next 6 months. • I plan to use wecoach in the next 6 months. • I mean to use wecoach in the next 6 months.
Performance expectancy	<ul style="list-style-type: none"> • I find wecoach useful for conducting team development. • I think that wecoach would make it easier for me to conduct team development. • I think that wecoach can enable me to enhance the quality of team development. • I think that wecoach can enable me to more efficiently conduct team development. • I think that wecoach can convey the knowledge that I need to conduct team development.
Effort expectancy	<ul style="list-style-type: none"> • I find that wecoach does what I want it to without problems. • Operating wecoach is clear and easy to understand. • Using wecoach does not require a lot of mental effort. • I think that wecoach has intuitive user navigation. • Learning to operate the system is easy.
Social influence	<ul style="list-style-type: none"> • In general, I think that my organization would support the use of wecoach for team development. • My fellow managers would support the use of wecoach for team development. • My team would support the use of wecoach for team development. • I think upper management would endorse the use of wecoach for team development. • I would be more likely to use wecoach if my colleagues did so as well.
Facilitating conditions	<ul style="list-style-type: none"> • I have the resources necessary to use wecoach. • I have the technological know-how to be able to use wecoach. • The wecoach tool is compatible with other systems I use. • Assistance for using wecoach is available if I need it. • Using wecoach fits with my way of working. • Using wecoach fits with the human resource development strategy of our organization.
CapSelf ^d	<ul style="list-style-type: none"> • I have the necessary competencies to do such team development. • I am motivated to do such team development. • This team development approach fits with my leadership style.
CapTeam ^e	<ul style="list-style-type: none"> • Our team has the competences necessary to undertake such team development. • Our team is motivated to do such team development. • Such team development fits with our team culture.
CapOrg ^f	<ul style="list-style-type: none"> • The necessary resources (time, finances) are available, so one can conduct such team development. • Conducting such team development is in line with our organizational goals. • Such team development fits well with our organizational culture.

^aUTAUT: unified theory of acceptance and use of technology.

^bOHD: organizational health development.

^cRated on a scale from 1 to 7.

^dCapSelf: capacities on the individual leader's level.

^eCapTeam: capacities on the team level.

^fCapOrg: capacities on the organizational level.

Analysis

All statistical analyses were performed using SPSS Statistics version 24. To test our hypotheses, we conducted multiple linear regression analyses with all variables that were significantly correlated with our outcome variable, behavioral intention. First, we used the enter method, followed by another analysis using the stepwise method.

Results

Sample Characteristics

In total, 36 participants reviewed wecoach and completed our questionnaire. Of these, 4 (11%) were removed from the analysis for the following reasons: not having a leadership role, not working in a hospital or long-term care setting, or not registering for the study. Our final sample consisted of 32 persons. Descriptive data on our sample are presented in [Table 2](#).

Table 2. Sample characteristics (N=32).

Characteristic	Respondents
Age (years), mean (SD)	40.56 (7.76)
Gender, n (%)	
Female	23 (71.9)
Male	9 (28.1)
Work setting, n (%)	
Hospital	28 (87.5)
Long-term care	2 (6.3)
Other	2 (6.3)
Work country, n (%)	
Switzerland	12 (37.5)
Austria	12 (37.5)
Germany	8 (25.0)
Leadership level, n (%)	
Upper	6 (18.8)
Middle	22 (68.8)
Lower	4 (12.5)
Voluntariness of testing wecoach, n (%)	
Own motivation	24 (75.0)
Were advised to	8 (25.0)
Minutes spent in wecoach, mean (SD)	137.75 (103.21)

Preliminary Analyses

The internal reliabilities of our scales ranged from .72 to .92. All variables were examined for outliers based on 2.2 IQRs [42]. Two extreme low values were identified on the variable CapSelf and were winsorized by replacing them with the next lowest value that was not an outlier. Inspection of our outcome variable, behavioral intention, questioned its normal distribution, which was supported by a significant Shapiro-Wilk test ($P=.02$). Thus, we proceeded with our analyses using Spearman correlation analyses and the Kruskal-Wallis test for group comparisons.

We assessed group differences on the predictor and outcome variables based on sex, age, country, leadership level, and

voluntariness of testing wecoach. No significant group differences were found in any of these. Note that no group comparisons were performed for work setting, since 28 (87.5%) of our final 32 participants worked in hospitals, while only 2 (6.25%) worked in long-term care and 2 (6.25%) in psychiatric acute care.

The variable of greatest interest to us was behavioral intention as an indicator of acceptance. Its mean level can be described as moderate. Of all assessed variables, it showed the highest degree of variability among participants. Table 3 displays the mean scores and SDs for behavioral intention and all predictors, their correlations, and internal reliabilities.

Table 3. Scores on UTAUT^a and OHD^b variables, correlations, and internal reliabilities^c (N=32).

Variable	Mean ^d (SD)	Correlation (<i>P</i>)							
		Behavioral intention	Performance expectancy	Effort expectancy	Social influence	Facilitating conditions	CapSelf ^e	CapTeam ^f	CapOrg ^g
Behavioral intention	4.40 (1.94)	.92	N/A ^h	N/A	N/A	N/A	N/A	N/A	N/A
Performance expectancy	5.57 (0.99)	.49 ⁱ	.92	N/A	N/A	N/A	N/A	N/A	N/A
Effort expectancy	5.57 (0.88)	.36 ^j	.25	.81	N/A	N/A	N/A	N/A	N/A
Social influence	4.78 (1.03)	.53 ⁱ	.50 ⁱ	.48 ⁱ	.79	N/A	N/A	N/A	N/A
Facilitating conditions	4.65 (0.98)	.52 ⁱ	.59 ^k	.53 ⁱ	.78 ^k	.72	N/A	N/A	N/A
CapSelf	5.81 (0.67)	.29	.39 ^j	.50 ⁱ	.37 ^j	.37 ^j	.81	N/A	N/A
CapTeam	4.80 (1.15)	.61 ^k	.52 ⁱ	.46 ⁱ	.67 ^k	.60 ^k	.44 ^j	.93	N/A
CapOrg	4.45 (1.36)	.34	.38 ^j	.32	.65 ^k	.57 ⁱ	.40 ^j	.63 ^k	.87

^aUTAUT: unified theory of acceptance and use of technology.

^bOHD: organizational health development.

^cInternal reliabilities are reported in the diagonal.

^dRated on a scale from 1 to 7.

^eCapSelf: capacities on the individual leader's level.

^fCapTeam: capacities on the team level.

^gCapOrg: capacities on the organizational level.

^hN/A: not applicable.

ⁱ $P < .01$.

^j $P < .05$.

^k $P < .001$.

Findings

To test our hypotheses, the predictors that were significantly correlated with the outcome variable, behavioral intention, namely performance expectancy, effort expectancy, social influence, facilitating conditions, and CapTeam, were entered into a multiple regression model. The assumptions for linear regression were tested and all met, with the possible issue of multicollinearity between social influence and facilitating conditions, which correlated at .776 ($P < .001$). Examination of the collinearity statistics found the lowest tolerance for facilitating conditions at .27 (with a variance inflation factor of

3.66) and social influence at .28 (with a variance inflation factor of 3.58). Depending on the chosen cut-off, these values can still be considered tolerable.

We began by simultaneously including all 5 predictors using the enter method. This allowed us to examine the overall predictive power of the model as well as examine the respective β weights of the predictors in conjunction. The model explained 43.9% of the variance in behavioral intention (adjusted $R^2 = .331$). As Table 4 illustrates, none of the predictors reached significance. CapTeam was the strongest predictor, followed, in declining order, by performance expectancy, social influence, facilitating conditions, and, lastly, effort expectancy.

Table 4. Contributions to behavioral intention: multiple regression analysis using the enter method.

Variable	Unstandardized coefficient B	SE	Standardized β	<i>P</i> value	95% CI
(Constant)	-.3013	2.240	N/A ^a	.19	-7.617 to 1.591
Performance expectancy	.441	0.345	.226	.21	-.268 to 1.150
Effort expectancy	.015	0.450	.007	.97	-.817 to .847
Social influence	.405	0.525	.215	.45	-.674 to 1.484
Facilitating conditions	.129	0.554	.065	.82	-1.011 to 1.268
CapTeam ^b	.485	0.349	.288	.18	-.232 to 1.203

^aN/A: not applicable.

^bCapTeam: capacities on the team level.

Overlaps in explained variance may have caused the lack of any of the individual predictors reaching significance. To identify the most useful one(s), we also conducted stepwise multiple regression analysis. CapTeam was retained as the only predictor that uniquely contributed to behavioral intention with

a standardized β of .582 ($P < .001$). This model explained 33.8% of the variance (adjusted $R^2 = .316$) in behavioral intention. All other variables were excluded from the model. These findings are illustrated in Table 5.

Table 5. Contributions to behavioral intention: stepwise multiple regression analysis.

Variable	Unstandardized coefficient B	SE	Standardized β	P value	95% CI
Model 1					
(Constant)	-.313	1.235	N/A ^a	.80	-2.835 to 2.209
CapTeam ^b	.981	0.250	.582	<.001	0.469-1.492
Excluded variables					
Performance expectancy	.283	N/A	N/A	.094	N/A
Effort expectancy	.093	N/A	N/A	.582	N/A
Social influence	.324	N/A	N/A	.105	N/A
Facilitating conditions	.285	N/A	N/A	.130	N/A

^aN/A: not applicable.

^bCapTeam: capacities on the team level.

A post hoc power analysis using G*Power (Faul, Erdfelder, Buchner, and Lang) [43] estimated the power of our regression analyses at .96, which is good and indicates that despite our limited sample size, our findings are interpretable.

Our findings were not able to confirm any of our hypotheses regarding the predictors of UTAUT (H1). None of the four predictors (ie, performance expectancy, effort expectancy, social influence, and facilitating conditions) significantly contributed to the acceptance of wecoach, indicated by behavioral intention. Of the 3 levels of capacities derived from the OHD model (H2), only CapTeam was found to be a significant predictor, although only after the other variables were excluded in the stepwise multiple regression analysis. Neither CapSelf nor CapOrg significantly contributed to behavioral intention. In summary, only H2b was partially confirmed.

Discussion

Principal Findings

The aim of our study was to examine factors that predict the acceptance of wecoach. In total, 32 nurse managers in Switzerland, Austria, and Germany tested several introductory modules of wecoach and completed our questionnaire, which assessed predictors from UTAUT [26] and the OHD model [41]. Although we hypothesized that all 7 would yield a significant influence on behavioral intention, our analyses found that merely CapTeam significantly contributed to the acceptance of wecoach, although only in the absence of the other predictors.

The level of behavioral intention to use wecoach was moderate, while both performance expectancy and effort expectancy were quite high. This suggests that although users perceived wecoach as rather useful, they also perceived it as requiring some effort.

Our findings raise the question of whether UTAUT was an appropriate model to determine acceptance in our study. We see findings similar to ours in a study by Apolinário-Hagen et

al [44] in their examination of the acceptance of a stress management app. Their strongest predictor was attitudes about the use of health apps for stress management, and like in our study, no additional significant contribution by the UTAUT predictors was found. They concluded that attitudes “may be a more relevant initial precondition of acceptance than elaborated cognitive beliefs on usefulness or usability” [44]. Another, albeit smaller, significant predictor in their study was stress symptoms, alluding to the importance of the perceived need for the intervention.

This critique has been brought up repeatedly against models of technology acceptance. The use of a technology is not an end of its own, determined by how useful and user-friendly, but also by the perceived need for it, that is the task-technology fit [45,46]. According to Fülleman et al [47], an awareness for employee health is not yet present in many organizations, and hence, there may not have been a perceived need for an intervention to address this issue. The same is also implied in the Rogers [18] theory of innovation, which for the stage of attitude formation specifies that attributes not only inherent to but also external to the innovation, such as the need for it or its compatibility with other tools, are of relevance. The concept of fit is recognized in the intervention literature as well. Randall and Nielsen [48] proposed person-intervention fit and environment-intervention fit as 2 dimensions that acknowledge the complex social environment in which interventions occur and that provide a possible answer to why the same intervention sometimes succeeds and sometimes fails.

Given the participatory nature of wecoach, it makes sense that factors relating to the fit on the team level strongly contributed to its acceptance. CapTeam was the strongest contributor to acceptance in our regression analysis and reached significance in the absence of other predictors. The availability of resources on the organizational level and alignment with organization goals, as indicated by CapOrg, however, did not seem immediately relevant for the acceptance of wecoach, although

it could be speculated that those, alongside the facilitating conditions, might gain salience in the actual implementation.

The 3 items of the CapTeam scale assessed competence, motivation, and identity, and a closer inspection of the items revealed that 2 of them (*Our team is motivated to do such team development* and *I think that such team development fits well with our team culture*) correlated highly with behavioral intention, while the third one (*Our team has the competences necessary to undertake such team development*) did not. It can be assumed then that the perceived motivation as well as fit with the team climate were the main drivers of intention to use wecoach. Note that these aspects relate entirely to the procedural aspect of wecoach, not the technological one. This could be particularly relevant in a highly collaborative work environment, such as nursing.

Consisting of not only a novel technological approach but also a novel approach to leadership and team development, wecoach may be too complex a tool to be suitably assessed with technology-related variables of UTAUT alone. Indeed, the intervention aspect of wecoach may have been more salient to the participants than the technology aspect of it. It would be interesting to further examine how users perceive and frame wecoach along these 2 dimensions.

As interventions become more sophisticated and more complex, especially in the work context, it is important to acknowledge the limitations of UTAUT and to recommend careful and deliberate selection of variables matched to the level at which innovations occur in order to better understand acceptance. Such fit-related aspects, informed by implementation science and intervention research, may serve as a gateway that determine acceptance before aspects such as usefulness or user-friendliness are even relevant. UTAUT may thus still be a suitable, although not a sufficient model, to understand the acceptance of complex technologies, and enhancing models with carefully selected variables can support researchers and practitioners in detecting the appropriate level to address facilitators of and barriers to their acceptance.

Limitations and Outlook

Several limitations need to be considered in interpreting our findings. First, our sample of 32 was small and represented only a tiny fraction of the persons we invited to participate. This

means that our findings are difficult to generalize to a broader population of nurse managers, despite the satisfactory post hoc power analysis. This also increases the likelihood that our sample was biased and already interested in or open to workplace health promotion or digital interventions. Furthermore, although substantial efforts were undertaken to include staff working in nursing homes, only 2 (6.25%) participants did, limiting the conclusions that can be drawn about that setting. As with any study attempting predictions, longitudinal data would have allowed us to strengthen causal assumptions between the assessed variables. The inclusion of moderators might have also enhanced the predictive power of our model. However, although they contributed substantial variance explanation in the original UTAUT publication study [26], their inclusion may no longer be the most feasible approach [40]. In addition, in our study, sample size limitations did not permit their inclusion. Being an exploratory study examining the acceptance of a complex online-based leadership and team development intervention, qualitative data could yield valuable additional insights into the drivers of the different predictors, especially an in-depth exploration of the perceived motivation on the team level and fit with team culture. It would also be interesting to further understand in what terms users framed wecoach—whether they perceived it more as technology or a team development method.

Conclusion

Our study found that CapTeam is the only significant predictor of the intention to use wecoach. This implies that for successful dissemination of such a digitally supported participatory tool, the fit to the team, its culture, and its motivation are of much greater relevance than its technological aspects.

UTAUT has previously been 1 of the dominant models to determine acceptance of new technologies. Our findings suggest that in the case of complex technologies, this may not be the most appropriate model. As new technologies and digital interventions become more complex, it is important to supplement acceptance models through the careful selection of variables matched to the level at which the innovations occur. This can help researchers and practitioners identify the appropriate level to more fully understand acceptance and to address related barriers and facilitators to implementation and use of innovations.

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Authors' Contributions

The data analysis and manuscript were prepared by SB, with support from GFB and GJJ. All authors critically reviewed and contributed to the manuscript and approved the final version.

Conflicts of Interest

GFB and GJJ are board members of the company that distributes wecoach.

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Abbreviations

- CapOrg:** capacities on the organizational level
- CapSelf:** capacities on the individual leader's level
- CapTeam:** capacities on the team level
- OHD:** organizational health development
- UTAUT:** unified theory of acceptance and use of technology

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Original Paper

Digital Health Literacy During the COVID-19 Pandemic Among Health Care Providers in Resource-Limited Settings: Cross-sectional Study

Mohammedjud Hassen Ahmed¹, MPH; Habtamu Alganah Guadie², MPH; Habtamu Setegn Ngusie¹, MPH; Gizaw Hailiye Teferi³, MPH; Monika Knudsen Gullsllett⁴, PhD; Samuel Hailegebreal⁵, MPH; Mekonnen Kenate Hunde⁶, MSc; Dereje Oljira Donacho⁷, MPH; Binyam Tilahun⁸, PhD; Shuayib Shemsu Siraj⁹, MPH; Gebiso Roba Debele⁹, MPH; Mohammedamin Hajure¹⁰, MSc; Shegaw Anagaw Mengiste¹¹, PhD

¹Department of Health Informatics, College of Public Health and Medical Sciences, Mettu University, Mettu, Ethiopia

²School of Public Health, College of Medicine and Health Sciences, Bahir Dar University, Bahir Dar, Ethiopia

³Department of Health Informatics, College of Medicine and Health Science, Debre Markos University, Debre Markos, Ethiopia

⁴Faculty of Health and Social Science, University of South-East Norway, Drammen, Norway

⁵Department of Health Informatics, College of Medicine and Health Science, Arba Minch University, Arba Minch, Ethiopia

⁶Department of Social Sciences, Mettu University, Mettu, Ethiopia

⁷Department of Health Informatics, Mettu University, Mettu, Ethiopia

⁸Department of Health Informatics, University of Gondar, Gondar, Ethiopia

⁹Department of Public Health, Mettu University, Mettu, Ethiopia

¹⁰Department of Psychiatry, Mettu University, Mettu, Ethiopia

¹¹Department of Management Information Systems, University of South East Norway, Drammen, Norway

Corresponding Author:

Shegaw Anagaw Mengiste, PhD

Department of Management Information Systems

University of South East Norway

Dalegårdsveien 24 C

Drammen, 3028

Norway

Phone: 47 31009832

Email: Shegaw.Mengiste@usn.no

Abstract

Background: Digital health literacy is the use of information and communication technology to support health and health care. Digital health literacy is becoming increasingly important as individuals continue to seek medical advice from various web-based sources, especially social media, during the pandemics such as COVID-19.

Objective: The study aimed to assess health professionals' digital health literacy level and associated factors in Southwest Ethiopia in 2021.

Methods: An institution-based cross-sectional study was conducted from January to April 2021 in Ethiopia. Simple random sampling technique was used to select 423 study participants among health professionals. SPSS (version 20) software was used for data entry and analysis. A pretested self-administered questionnaire was used to collect the required data. Multivariable logistic regression was used to examine the association between the digital health literacy skill and associated factors. Significance value was obtained at 95% CI and $P < .05$.

Results: In total, 401 study subjects participated in the study. Overall, 43.6% ($n=176$) of respondents had high digital health literacy skills. High computer literacy (adjusted odds ratio [AOR] 4.43, 95% CI 2.34-5.67; $P=.01$); master's degree and above (AOR 3.42, 95% CI 2.31-4.90; $P=.02$); internet use (AOR 4.00, 95% CI 1.78-4.02; $P=.03$); perceived ease of use (AOR 2.65, 95% CI 1.35-4.65; $P=.04$); monthly income of >15,000 Ethiopian birr (>US \$283.68; AOR 7.55, 95% CI 6.43-9.44; $P<.001$); good knowledge of eHealth (AOR 2.22, 95% CI 1.32-4.03; $P=.04$); favorable attitudes (AOR 3.11, 95% CI 2.11-4.32; $P=.04$); and perceived usefulness (AOR 3.43, 95% CI 2.43-5.44; $P=.02$) were variables associated with eHealth literacy level.

Conclusions: In general, less than half of the study participants had a high digital health literacy level. High computer literacy, master's degree and above, frequent internet use, perceived ease to use, income of >15,000 Ethiopian birr (>US \$283.68), good knowledge of digital health literacy, favorable attitude, and perceived usefulness were the most determinant factors in the study. Having high computer literacy, frequent use of internet, perceived ease of use, perceived usefulness, favorable attitude, and a high level of education will help to promote a high level of digital health literacy.

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KEYWORDS

digital, health; literacy; COVID-19; professionals; Ethiopia; health professionals; digital literacy; skills; knowledge; perception; use; education; training

Introduction

Information and communication technologies (ICTs) greatly reduce health disparities through promoting health, preventing disease, and supporting clinical care for all [1-3]. Moreover, the development of ICTs for patient and consumer health apps has been exploding in the past decade, with thousands of websites, hundreds of mobile apps, and dozens of special purpose devices targeted at the health care markets [4-6]. These ICTs enhance the digitalization of health and diversify the use of digital health around the globe; ultimately, it leads to the accessibility of high-quality, cost-effective health care service delivery through improving the communication of health professionals [7-11].

Public health emergencies such as COVID-19 need up-to-date health information for prevention, tackling of the disease, and the protection of the community from long-lasting economic and societal impacts. Digital health is the use of emerging ICT, mainly the internet, to improve health that emphasizes the roles that digital technologies play in facilitating health care, health information delivery and storage, and health-related social support [7,12,13]. However, electronic health tools provide little value if the intended actors of health care systems, such as patients and health professionals, lack the skills to engage them effectively. This makes the skills to search, select, appraise, and apply web-based health information and health care-related digital apps increasingly important in the health care area [5,14,15]. These skills are called digital health literacy or eHealth literacy [16-18].

Digital health literacy is a congregate set of 6 basic skills (traditional literacy, health literacy, information literacy, scientific literacy, media literacy, and computer literacy) [15]. On the other hand, digital health literacy not only requires the ability to search for health-related information, understand the information, and apply it appropriately but also indicates advanced technology that involve patient empowerment and involvement, sharing information, and social networking [19,20]. In the context of digitization, it needs to be emphasized that users are not just passive recipients but rather active participants in the communication process by interacting with existing content or by sharing their own health-related information [21]. In this regard, health care professionals should be able to identify and use reliable health care information sources from the internet and other relevant sources of information to make evidence-based medical decisions as well as to improve health care service delivery [10,15,22,23].

Ethiopia is at a pivotal moment in its efforts to strengthen the health status of its population. As Ethiopia has made progress in reaching the health-related Millennium Development Goals, the government has realized that these advances need to be accelerated if targets in the areas of maternal and child mortality and infectious diseases are to be achieved.

Even the interaction between technology and health care has a long history, as the embracing of digital health is slow because of limited infrastructural arrangements, capacity, and political willingness [7]. Regardless of the escalating number of internet users and mobile phone penetration around the globe, the implementation of digital health systems continues to be challenging, especially in resource-limited countries [24-26]. Ethiopia is in the process of putting in place a digital health program to improve the delivery of health care services. In line with this, the Ethiopian government has implemented a strategy that focuses on digitalizing the health system [27-30]. However, the low internet penetration in Ethiopia—less than 2%, [31]—and the skills needed to find and evaluate web-based resources remain a challenge for the sustainability of digital health programs [32].

Literature has depicted that digital health literacy positively influences health-promoting behaviors and people's health-related quality of life. Digital health literacy is also influenced by educational background, motivation for seeking the information, the technologies used, frequent internet use, computer literacy, digital health training, knowledge regarding the availability and importance of health information, perceived usefulness, having higher internet efficacy, and attitude toward using web-based health information resources [32-40]. Most of the previous studies conducted in Ethiopia did not examine the potential factors of digital health literacy skill. Some of them focused on digital health strategies, web-based health information source, and the application of ICT and use of computer in the health care area.

Addressing these problems will have a practical benefit for improving the quality of health and health care services. Moreover, evaluating health professionals' digital health literacy skills would allow the government to identify a variety of literacy levels and hindering factors to generate a proper response accordingly. Therefore, this study was aimed at assessing the digital health literacy skill and associated factors among health professionals working at public health facilities in the Illubabor and Buno Bedele zones, Ethiopia.

Methods

Study Design and Setting

The cross-sectional study was conducted from January to April 2021 at selected public hospitals in the Illubabor and Buno Bedele zones, Oromia Regional state, Ethiopia. Currently, the Illubabor zone has 14 woredas and 1 administrative town, as well as 41 health centers and 2 hospitals (1 referral hospital and 1 primary hospital). Mettu Karl Referral Hospital and Darimu Hospital provide primary and advanced health care service for the Illubabor zone. The Buno Bedele zone has 10 woredas and 1 administrative town, as well as 3 hospitals called Buno Bedele General Hospital, Dambi Hospital, and Chora Hospital. The health systems of both zones include hospitals, health centers, and health posts.

Population

The source population were all health professionals working at the public hospitals of the 2 zones [41]. All selected health professionals working at the public health hospitals of the 2 zones and available during data collection time were included in the study. Health professionals who have less than 6 months working experience from the 2 zones were excluded from this study [41].

Sample Size and Sampling Procedure

The sample size was calculated using a single population proportion formula by considering the following assumptions.



Therefore, 423 participants were included for this study.

Data Collection and Data Quality Control

The design and development of the self-administered structured questionnaire for this study was guided by literature reviews. Questions were adapted from other studies [17,33,39,42-45]. The questionnaires gathered information about the participants' sociodemographic characteristics, computer skills, attitude, access, and technology-related factors. Data were collected using a self-administered questionnaire that was prepared in English. A total of 4 degree-holding health professionals and 8 health professionals participated in the data collection process as supervisors and data collectors, respectively.

To ensure the quality of data, a pretest was conducted at Jimma University, which has a similar population to our study setting, by taking 10% of respondents from the total sample size. Subsequently, the necessary correction was completed based on the pretest finding. The validity of the questionnaire was determined based on the view of experts, and the reliability was obtained by calculating the Cronbach α (.7) [41]. The scale evidenced high internal consistency (overall Cronbach α = .87). Data collecting material was checked for spelling errors and its completeness and code before the actual data collecting date.

The data were also checked daily by the supervisor and the investigator for its consistency and completeness.

A 2-day training was given to data collectors about the purpose of the study, the content of the questionnaires, and all the study

protocols to be followed throughout the data collection. Health facilities were assigned to each data collector so as to increase the response rate. Supervisors conducted regular supervision. Data backup activities such as storing data in different places and duplicating hard and soft copies of data were performed to prevent data loss. Before running the logistic regression model, assumptions were checked for outliers, multicollinearity, and independent error terms. Multicollinearity was tested by running a false linear regression iterating the independent variables as the independent variable, and the result showed the entire variance inflation factor value as less than 3 and tolerance as greater than 0.7, which demonstrated the absence of multicollinearity [41]. The data were also checked for outliers by a box plot, and no outshining outlier effect was observed. The model's goodness of fit was also checked.

We used omnibus tests of model coefficients for the overall (global) fitness of the model and a Hosmer-Lemeshow test for the fitness of the data to the model. Consequently, the omnibus test result was significant with a P value $<.05$, and the Hosmer-Lemeshow test showed a good model fit with a P value of .61.

Data Management and Analysis

The data was entered using Epi Info (version 7; Centers for Disease Control and Prevention), and analysis was done using SPSS (version 20; IBM Corp) software. Frequency and descriptive statistics were used to describe respondents' characteristics.

Binary logistic regression analysis was conducted to assess the effect of selected variables on digital health literacy skill. Variables having a P value $<.2$ on the bivariate analysis were entered into a multivariable logistic regression analysis to check for confounding effects on the association from bivariate analysis. The strength of association was described at 95% CI, and a P value $<.05$ was considered significant. Odds ratios were used to determine the strength of association. Multicollinearity was checked between independent variables.

Ethics Approval

All methods of the study were carried out in accordance with relevant guidelines and regulations. All experimental protocols were approved by the ethical review board of Mettu University (approval ARCSV/161/2013). A permission letter was received from each hospital. After the objective of the study was explained, informed consent was obtained from all study participants. Moreover, privacy and the confidentiality of information were strictly guaranteed by all data collectors and investigators. The information retrieved was used only for the study. Thus, the names of participants and other personal identifiers were not included in the data collection tool.

Result

Participants

In total, 401 study subjects were included in the study. The response rate was 94.8% (401/423). The mean age of the participants was 32.13 (SD 11.2) years. Of the 401 participants, 217 (54.1%) were aged <30 years and 248 (61.8%) were male. Almost half ($n=206$, 51.4%) of the participants had a monthly

income of <5000 Ethiopian birr (<US \$94.56), and only 35 (8.7%) had a monthly income of 10,000-15,000 Ethiopian birr (US \$189.12-283.68). Regarding education, 119 (54.6%) participants had a diploma and only 46 (11.5%) had a master's degree and above. Additionally, 211 (52.6%) health professionals had <5 years of working experience and only 48 (12%) had >10 years of working experience. Among the participants, 124 (30.9%) were nurses and 107 (26.7%) were physicians, as shown in [Table 1](#).

Table 1. Sociodemographic characteristics of health professionals.

Variable, category	Participant (N=401), n (%)
Age (years)	
<30	217 (54.1)
30-39	94 (23.4)
40-49	49 (12.2)
>49	41 (10.2)
Gender	
Female	153 (38.2)
Male	248 (61.8)
Monthly income (Ethiopian birr)	
<5000 (<US \$94.56)	206 (51.4)
5000-10,000 (US \$94.56-189.12)	114 (28.4)
10,000-15,000 (US \$189.12-283.68)	35 (8.7)
>15,000 (>US \$283.68)	46 (11.5)
Educational status	
Diploma	219 (54.6)
Bachelor's degree	136 (33.9)
Master's degree and above	46 (11.5)
Experience (years)	
<5	211 (52.6)
5-10	142 (35.4)
>10	48 (12)
Professional category	
Nurse	124 (30.9)
Physician	107 (26.7)
Midwifery	98 (24.4)
Laboratorian	49 (12.2)
Others	23 (5.7)

Digital Health Literacy Level

The median digital health literacy score was 27.4 (SD 8.3). Scores less than the median value were labeled as low digital health literacy level, and scores greater than or equal to the median value were labeled as high digital health literacy level.

From the total, 43.6% (175/401; 95% CI: 40.7-54.12) had high digital health literacy skills during the pandemic. Associated factors with a *P* value <.2 from the bivariate analysis were included in the final multivariable logistic regression model to control the effect of confounding as shown in [Table 2](#).

Table 2. Digital health literacy level questions among health professionals (N=401).

Items	Strongly disagree, n (%)	Disagree, n (%)	Neutral, n (%)	Agree, n (%)	Strongly agree, n (%)
Digital health literacy skills					
The internet is useful in helping you make decisions about your health	123 (30.7)	113 (28.2)	48 (12)	67 (16.7)	50 (12.5)
The internet is important for you to be able to access health resources	121 (30.2)	115 (28.7)	45 (11.2)	71 (17.7)	49 (12.2)
I know what COVID-19-related health resources are available on the internet	43 (10.8)	55 (13.8)	81 (20.2)	121 (30)	101 (25.2)
I know where to find helpful health resources on the internet	41 (10.2)	47 (11.7)	91 (22.7)	119 (29.7)	103 (25.7)
I know how to find helpful COVID-19 pandemic resources on the internet	6 (1.4)	56 (14)	78 (19.5)	181 (45.1)	80 (20)
I know how to use the internet to answer my questions about the COVID-19 pandemic	4 (1)	52 (13)	75 (18.7)	179 (44.6)	91 (22.7)
I know how to use the health information about the COVID-19 pandemic I find on the internet to help me	8 (2)	54 (13.5)	70 (17.4)	175 (43.6)	94 (23.5)
I have the skills I need to evaluate the COVID-19-related resources I find on the internet	11 (2.7)	48 (12)	69 (17.2)	172 (42.9)	101 (25.2)
I feel confident in using information from the internet to make COVID-19-related decisions	8 (2)	70 (17.5)	54 (13.5)	147 (36.6)	122 (30.4)

Internet Use

Overall, of the 401 respondents, 49.3% (n=198) reported that they used the internet and 203 (50.6%) reported that they have never used the internet. Of the 198 internet users, about one-half (n=99, 50%) accessed the internet or email on a daily basis. Most (304/401, 75.8%) health professionals had access to the internet from home.

Factors Associated With Digital Health Literacy Level

All variables were entered into the binary logistic regression model. Computer literacy, marital status, educational status, monthly income, place of residence, self-efficacy, perceived ease of use, perceived usefulness, attitude and knowledge, and the frequency of internet use were significant factors associated with digital health literacy from the bivariable analysis. All variables were entered into the multivariable logistic regression model. Computer literacy, educational status, monthly income, place of residence, self-efficacy, perceived ease of use, perceived usefulness, attitude and knowledge, and the frequency of internet use were significant factors associated with eHealth literacy from the multivariable analysis. Accordingly, those having high computer literacy were 4.43 (95% CI 2.34-5.67; $P=.01$) times more likely to have a high eHealth literacy level than those who have low computer literacy. Similarly, respondents who have a master's degree and above were 3.42 (95% CI 2.31-4.90;

$P=.02$) times more likely to have a high eHealth literacy level than those who have a bachelor's degree or diploma. Health professionals who used the internet daily were 4.00 (95% CI 1.78-4.02; $P=.03$) times more likely have a high eHealth literacy level than those who used less than 1 day per week. Similarly, respondents who perceived eHealth as being easy to use were about 2.65 (95% CI 1.35-4.65; $P=.04$) times more likely to have a high eHealth literacy level than respondents who perceived eHealth as not being easy to use. Respondents who earn a monthly income of >15,000 Ethiopian birr (>US \$283.68) were 7.55 (95% CI 6.43-9.44; $P<.001$) times more likely to have a high eHealth literacy level than respondents who received income of <15,000 Ethiopian birr (<US \$283.68). Those who have good knowledge of eHealth were 2.22 (95% CI 1.32-4.03; $P=.04$) times more likely to have a high eHealth literacy level than respondents with low knowledge of eHealth. Attitude was also found to be a significant factor that affected the level of eHealth literacy; respondents with favorable attitudes about eHealth were about 3.11 (95% CI 2.11-4.32; $P=.04$) times more likely to have a high level of eHealth literacy than health professionals who had unfavorable attitude toward eHealth. Additionally, health professionals who perceived usefulness were about 3.43 (95% CI 2.43-5.44; $P=.02$) times more likely to have a high eHealth literacy level than respondents who did not perceived usefulness, as shown in [Table 3](#).

Table 3. Bivariable and multivariable analysis of factors associated with digital health literacy among health professionals.

Variables	Digital literacy level, n		COR ^a (95% CI)	AOR ^b (95% CI)	P value
	High	Low			
Computer literacy					
High computer literacy	84	88	5.10 (2.43-7.65)	4.43 (2.34-5.67)	.01
Low computer literacy	190	39	1	1	
Marital status					
Married	211	98	1.40 (1.12-2.99)	1.21 (0.98-2.31)	.07
Not married	69	23	1	1	
Educational Status					
Diploma	145	74	1	1	
Bachelor's degree	101	35	1.50 (1.21-3.4)	1.49 (0.97-2.54)	.11
Master's degree and above	41	5	4.18 (2.51-6.54)	3.42 (2.31-4.90)	.02
Monthly income (Ethiopian birr)					
<5000 (<US \$94.56)	50	156	1	1	
5000-10,000 (US \$94.56-189.12)	56	58	3.01 (2.11-5.04)	1.90 (0.96-4.11)	.09
10,000-15,000 (US \$189.12-283.68)	19	16	3.70 (3.21-5.03)	2.96 (2.55-4.04)	.01
>15,000 (>US \$283.68)	34	12	8.84 (5.44-11.65)	7.55 (6.43-9.44)	<.001
Frequency of internet use					
Less than 1 day per week	55	101	1	1	
Several days per week	67	48	2.56 (1.89-3.94)	2.31 (1.76-3.88)	.03
Daily	76	54	2.58 (1.81-3.81)	4.00 (1.78-4.02)	.03
Knowledge					
Good knowledge	190	56	2.39 (1.51-4.80)	2.22 (1.32-4.03)	.04
Poor knowledge	91	64	1	1	
Attitude					
Favorable attitude	210	56	3.38 (2.41-4.80)	3.11 (2.11-4.32)	.04
Unfavorable attitude	71	64	1	1	
Perceived ease of use					
Easy	147	80	2.73 (1.51-4.74)	2.65 (1.35-4.65)	.04
Not easy	70	104	1	1	
Perceived usefulness					
Useful	158	69	4.35 (2.76-6.89)	3.43 (2.43-5.44)	.02
Not useful	60	114	1	1	

^aCOR: crude odds ratio.

^bAOR: adjusted odds ratio.

Discussion

Principal Findings

This study attempted to describe and assess the digital health literacy of health professionals and significant factors. Digital health literacy is the major barrier to access updated health information for health professionals, specifically during public health emergencies. Overall, the findings from this study suggested that the digital health literacy level was low (43.6%;

95% CI 40.7-54.12), which was consistent with previous findings [32,38,46-48]. At the same time, our result was lower than the study findings in the Netherlands (76%) [17], Pakistan (54.3%) [42], and Iran (54.4%) [48]. Likewise, a study in Chicago reported that one-quarter of health professionals had low digital health literacy [49]. This variation could be due to the fact that our study was focused on the resource-limited country setting of Ethiopia, in which the internet penetration was very low. Surprisingly, our finding was lower than those of the studies conducted in Northwestern Ethiopia, which

reported that 60% [36] and 69.3% [50] of respondents possessed high digital literacy. This could be due to infrastructure differences in the selected health care facilities.

In contrast, our finding was higher than that of the study conducted in Korea, where digital health literacy was 38.8% [51]. These different findings may be related to the difference between the target populations of these studies. In this study, the participants were health professionals, whereas the study conducted in Korea was among nursing students.

Digital health literacy level is interlinked with sociodemographic, behavioral, and technological factors. Our finding implies that the computer literacy level of health professionals had a direct relationship with digital health literacy level. The professionals who had a high computer literacy level were 4.43 (95% CI 2.34-5.67) times more likely to have higher digital health literacy, which was supported by a previous study [52]. This finding was due to the fact that computer literacy, which is the knowledge and ability to use computer-related technology, made the interaction of health professionals with digital health applications easier.

Professionals who had a master's degree were 3.42 (95% CI 2.31-4.90) times more likely to have a high level of digital health literacy than health professionals who were only diploma holders. This finding is supported by studies conducted elsewhere [38,45,53] and could be due to the fact that higher education makes one more proficient with digital tools use and web-based resources. This finding strengthens the concept that higher education is interlinked with higher use of the internet for health purposes [54].

Similar to previous finding elsewhere [33,38,50,55,56], this study revealed that health professionals who had a higher monthly income were more likely to have a high digital health literacy level, which was 2.96 (95% CI 2.55-4.04) and 7.55 (95% CI 6.43-9.44) times higher for health professionals who had a monthly income of 10,000-15,000 Ethiopian birr (US \$189.12-283.68) and >15,000 Ethiopian birr (>US \$283.68) than health professionals who earned <5,000 Ethiopian birr (<US \$94.56), respectively. This finding might be due to high-earning health professionals having the necessary digital tools such as computer, smart phone, and tablets. However, this study was in contrast with a previous study in Northwest Ethiopia, which reported that a higher monthly income lowers digital health literacy level [32]. This difference might be due to the study setting and participants' sociodemographic characteristics.

Health professionals who used the internet daily were 4.00 (95% CI 1.78-4.02) times more likely to have digital health competency than those who did not use the internet at least one day per week. This finding is in line with previous studies conducted in different areas [38,49,52,57,58] and could be due to the fact that the internet is the precondition for using digital health tools.

The result of this study indicates that health professionals who were knowledgeable on health information sources were about 2.22 (95% CI 1.32-4.03) times more likely to have higher digital health literacy than who had poor knowledge, and this result

was supported by previous studies [50,59,60]. The possible explanation for this finding could be that digital health-related knowledge builds the competency and skill for using web-based health information sources, and knowledgeable health professionals can look up what and how to do a skill or task.

Health professionals who had a favorable attitude were 3.11 (95% CI: 2.11, 4.32) times more likely to have higher digital health literacy. This result was consistent with previous studies [37,38,50,60]. The explanation for this result could be that the attitude of health professionals helps them be more committed, since they do not consider it to be wasting their time when using digital health tools. Having a favorable attitude indicates an understanding of the relevance and use of digital health tools that could lead to a high literacy level by creating motivated health professionals. Moreover, the change in attitude might lead the overall technological and cultural change.

Regarding the perceived ease of use, this study implied that health professionals who perceived using digital health tools as being easy were 2.65 (95% CI 1.35-4.65) times more likely to have a higher digital health literacy level than their counterparts. This finding could be due to the fact that health professionals who consider using digital tools as being easy were more confident when practicing and building their literacy, and it is known that the perceived ease of use could influence health professionals' acceptance of digital health information technologies [61].

Health professionals who perceive digital tools as useful were 3.43 (95% CI 2.43-5.44) times higher in digital health literacy. This finding is in line with a previous study in Northwest Ethiopia [36] and might be due to the perceived benefit from using digital health tools that enhanced health professionals' attitude, which ultimately leads to sustainably practicing the use of the tools.

Limitations

First, the study was a facility-based cross-sectional study, which could not be used to identify causal inference. Second, the study was conducted at health facilities and might not be generalizable to all administrations of the country. In addition, the study was not able to include health professionals working at private health facilities. Finally, we recommend repeating our study in different parts of the country to determine the level of eHealth literacy, including health professionals from private hospitals.

Conclusions

In general, less than half of the study participants had a high digital health literacy level. High computer literacy, master's degree and above, frequent internet use, perceived ease of use, monthly income of >15,000 Ethiopian birr (>US \$283.68), good knowledge of digital health, favorable attitudes, and perceived usefulness were the most determinant factors associated with digital health literacy skills. Having a high computer literacy, frequent use of internet, perceived ease of use, perceived usefulness, favorable attitude, and high level of education will help promote the level of digital health literacy. However, the level of digital health literacy among health professionals in this study area was relatively low. Thus, an attempt needs to be taken to fill the gap in digital health literacy among health

professionals that will help them increase their productivity and increase the relevance of digital health to their day-to-day tasks.

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Data Availability

The data sets generated and/or analyzed during the current study will be available upon reasonable request from the corresponding author.

Authors' Contributions

All authors made substantial contributions to conception and design, the acquisition of data, or the analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Conflicts of Interest

None declared.

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Abbreviations

AOR: adjusted odds ratio

ICT: information and communication technology

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Original Paper

Understanding Whole-Person Health and Resilience During the COVID-19 Pandemic and Beyond: A Cross-sectional and Descriptive Correlation Study

Sripriya Rajamani¹, MBBS, MPH, PhD, FAMIA; Robin Austin¹, DNP, RN-BC, PhD, FAMIA, FNAP; Elena Geiger-Simpson¹, RN, PHN, DNP, PMHNP-BC, APRN; Ratchada Jantraporn¹, RN, MSN; Suhyun Park¹, RN, MSN; Karen A Mosen¹, RN, PhD, FAMIA, FNAP, FAAN

University of Minnesota, Minneapolis, MN, United States

Corresponding Author:

Sripriya Rajamani, MBBS, MPH, PhD, FAMIA
University of Minnesota
5-140 Weaver-Densford Hall; 308 Harvard St SE
Minneapolis, MN, 55455
United States
Phone: 1 6512787426
Email: sripriya@umn.edu

Abstract

Background: The COVID-19 pandemic has prompted an interest in whole-person health and emotional well-being. Informatics solutions through user-friendly tools such as mobile health apps offer immense value. Prior research developed a consumer-facing app MyStrengths + MyHealth using Simplified Omaha System Terms (SOST) to assess whole-person health. The MyStrengths + MyHealth app assesses strengths, challenges, and needs (SCN) for 42 concepts across four domains (My Living, My Mind and Networks, My Body, My Self-care; eg, *Income, Emotions, Pain, and Nutrition*, respectively). Given that emotional well-being was a predominant concern during the COVID-19 pandemic, we sought to understand whole-person health for participants with/without *Emotions* challenges.

Objective: This study aims to use visualization techniques and data from attendees at a Midwest state fair to examine SCN overall and by groups with/without *Emotions* challenges, and to explore the resilience of participants.

Methods: This cross-sectional and descriptive correlational study surveyed adult attendees at a 2021 Midwest state fair. Data were visualized using Excel and analyzed using descriptive and inferential statistics using SPSS.

Results: The study participants (N=182) were primarily female (n=123, 67.6%), aged ≥ 45 years (n=112, 61.5%), White (n=154, 84.6%), and non-Hispanic (n=177, 97.3%). Compared to those without *Emotions* challenges, those with *Emotions* challenges were aged 18-44 ($P<.001$) years, more often female ($P=.02$), and not married ($P=.01$). Overall, participants had more strengths (mean 28.6, SD 10.5) than challenges (mean 12, SD 7.5) and needs (mean 4.2, SD 7.5). The most frequent needs were in *Emotions, Nutrition, Income, Sleeping, and Exercising*. Compared to those without *Emotions* challenges, those with *Emotions* challenges had fewer strengths ($P<.001$), more challenges ($P<.001$), and more needs ($P<.001$), along with fewer strengths for *Emotions* ($P<.001$) and for the cluster of health-related behaviors domain concepts, *Sleeping* ($P=.002$), *Nutrition* ($P<.001$), and *Exercising* ($P<.001$). Resilience was operationalized as correlations among strengths for SOST concepts and visualized for participants with/without an *Emotions* challenge. Those without *Emotions* challenges had more positive strengths correlations across multiple concepts/domains.

Conclusions: This survey study explored a large community-generated data set to understand whole-person health and showed between-group differences in SCN and resilience for participants with/without *Emotions* challenges. It contributes to the literature regarding an app-aided and data-driven approach to whole-person health and resilience. This research demonstrates the power of health informatics and provides researchers with a data-driven methodology for additional studies to build evidence on whole-person health and resilience.

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KEYWORDS

Omaha System; whole-person health; strengths; resilience; assessment; app; health information technology; health informatics; nursing; health care; mobile health; health application; mHealth; health data; health community; digital health

Introduction

With more than 460 million cases of COVID-19 and more than 6 million deaths globally due to the pandemic as of March 2022 [1], along with the physical, financial, and emotional toll on the population, there is a critical need to renew focus on whole-person health and emotional well-being [2]. Whole-person health aims to help and empower individuals to improve their health in biological, behavioral, social, and environmental areas that are interconnected [3]. This whole-person health approach shifts the clinical and public health paradigms from limited transactional and disease-specific treatments to assessing and fostering overall health and promoting resilience [3].

This is known as strengths-based care, where the focus is on solutions and possibilities based on strengths (poststructuralist) models, with a shift away from deficit/pathology (structuralist) models that focus on problems and causes [4]. Strengths are defined as skills, capacities, actions, talents, potential, and gifts in each individual, family, and community [5]. The resilience of an individual is the ability to persevere, heal, and transform in the face of challenges, setbacks, and conflicts [6,7], and is dynamic across the life span [8], is applicable to mental health [9], and can be characterized using their strengths [7]. Movement toward a model that emphasizes talents and preferences is likely to benefit all persons, especially marginalized populations as the focus is on strengths [10], instead of deficits, and may help in decreasing stigmatization and improving engagement.

Informatics solutions through user-friendly tools such as apps for data collection and standards for data representation are useful for whole-person health assessments. A standardized terminology, Simplified Omaha System Terms (SOST), captures all of health in four domains: environmental, psychosocial, physiological, and health-related behaviors [11]. The Omaha System has been used as a strengths-based data capture model [12] and to operationalize resilience. It is mapped to clinical terminologies such as Systemized Nomenclature of Medicine—Clinical Terms (SNOMED CT) [13] and Logical Observation Identifiers Names and Codes, and is embedded within electronic health records (EHRs). In health care, strengths data should be considered in the context of problems so that the data is meaningful and adds value to improving health and health outcomes [14]. These tools with standardized data facilitate the integration of a consumer's whole-person strengths, challenges, and needs (SCN) data within nursing and interprofessional care [15] as well as population health measurement, accelerating the movement toward strength-oriented care and recognizing resilience.

Prior research has led to the development of a consumer-facing app MyStrengths + MyHealth (MSMH) [16] to standardize SCN data capture from a whole-person perspective using SOST [17-19]. Within MSMH and SOST, the integrity and rigor of the structure and concepts of the Omaha System are retained.

The Omaha System is a multidisciplinary health terminology [11] that includes three components, the Problem Classification Scheme and related signs/symptoms, the Intervention Scheme, and the Problem Rating Scale for Outcomes. The 42 problem concepts in the Omaha System are organized within four domains (environmental, psychosocial, physiological, and health-related behaviors). These were simplified in SOST as My Living, My Mind and Networks, My Body, and My Self-care (Textbox 1).

The Omaha System Problem Classification Scheme defines the 42 concepts, each of which has 3 to 18 unique taxonomically assigned signs/symptoms/challenges (Figure 1). The Problem Rating Scale for Outcomes enables measurement of strengths across all concepts. A user rates each concept using the Likert-type ordinal scale, where 1 is very bad and 5 is very good (Figure 1). A rating of 4 (minimal challenges) or 5 (no challenges) is defined as a strength. The Intervention Scheme classifies needs (actions) to address all concepts: surveillance (check-ins); treatments and procedures (hands-on care); teaching, guidance, and counseling (info/guidance); and case management (care coordination). In the MSMH app, needs are expressed in four categories: info/guidance (I could use more information about this or some guidance in deciding what to do), hands-on care (hands-on care or help), check-ins (someone to check in with me); and care coordination (help managing my appointments and connections). A screenshot of SCN assessments for the *Exercising* concept is portrayed in Figure 1, and Textbox 2 presents the connections across the SOST domains, concepts, strengths, challenges, and needs.

The MSMH is freely available to researchers, educators, and clinicians, and is licensed through the university [16]. MSMH data are housed in a secure computing network from which license holders may download their complete data. Studies based on the MSMH app have detailed the development and pilot testing [18], analyzed women's cardiovascular health using the app [20], described whole-person health of older adults [21], and examined local data on whole-person health and opioids in the community [22]. Recent research has analyzed MSMH data for resilience at the community level [7] and examined the feasibility of using MSMH-aided consumer-generated data for knowledge discovery [23]. Researchers have used the Omaha System data to understand whole-person health [15], characterize strengths of older adults with chronic illness [24], and examine relationships between social determinants and health disparities [25].

With the growing interest in whole-person health, emotional well-being, and strengths-based care, there is a need to build a body of evidence to demonstrate the value of informatics tools such as the MSMH app. The objectives of this research were to use visualization techniques and data from attendees at a Midwest state fair to examine SCN overall and by groups with/without *Emotions* challenges and explore the resilience of participants.

Textbox 1. MyStrengths + MyHealth domains and concepts.

My Living

- Income
- Cleaning
- Home
- Safe at home and work

My Mind and Networks

- Connecting
- Socializing
- Role change
- Relationships
- Spirituality or faith
- Grief or loss
- Emotions
- Sexuality
- Caretaking
- Neglect
- Abuse
- Growth and development

My Body

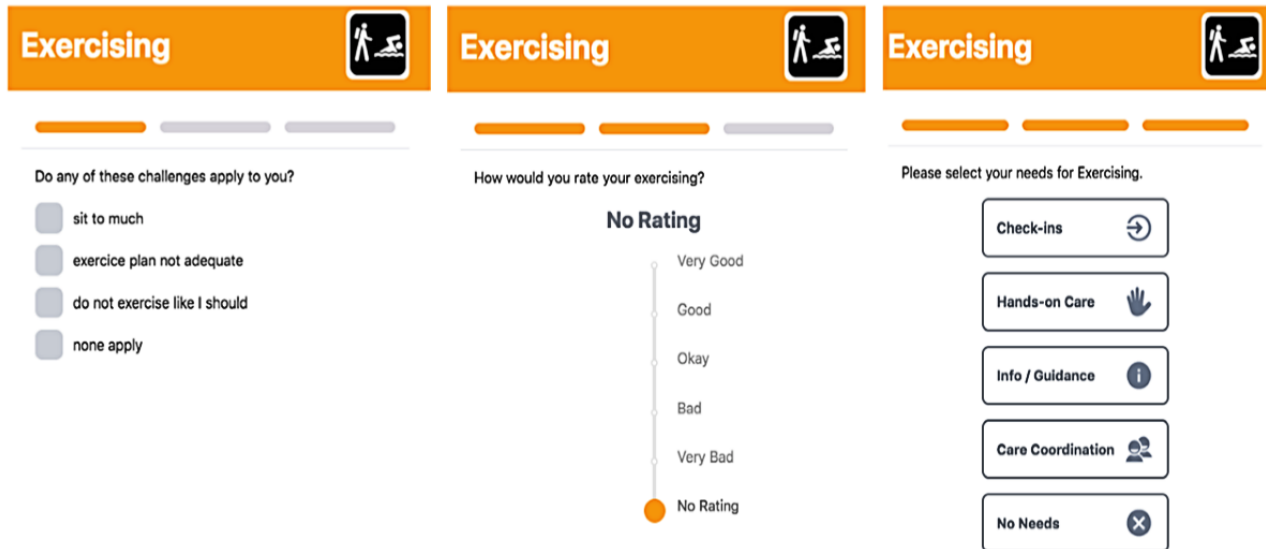
- Hearing
- Vision
- Speech and language
- Oral health
- Thinking
- Pain
- Consciousness
- Skin
- Moving
- Breathing
- Circulation
- Digesting
- Bowels
- Kidneys or bladder
- Reproductive health
- Pregnancy
- Postpartum
- Infections

My Self-care

- Nutrition
- Sleeping
- Exercising
- Personal care

- Substance use
- Family planning
- Health care
- Medications

Figure 1. MyStrengths + MyHealth app screenshots with challenges, strengths, and needs for exercising.



Textbox 2. Connecting domains, concepts, strengths, challenges, and needs in MyStrengths + MyHealth app.

Domains and number of concepts (total number of concepts: 42)

- My Living (4 concepts)
- My Mind and Networks (12 concepts)
- My Body (18 concepts)
- My Self-care (8 concepts)

Strengths (42 strengths possible/person)

- Each concept is rated on a scale of 1-5, with a 4 or 5 rating noted as a strength

Challenges (335 challenges possible/person)

- Each concept has 2-18 list of challenges

Needs (168 needs possible/person)

- Each concept has 4 needs: check-ins, hands-on care, info/guidance, and care coordination

Methods

Ethics Approval

The cross-sectional visualization survey study received approval from the university's institutional review board (approval number: #STUDY00009465). Researchers collected deidentified data using the SOST and MSMH app.

Study Setting: Midwestern State Fair

Data collection occurred at a popular Midwest state fair event that is held over 12 days and attracts attendance of more than 2 million annually. This study was conducted in August and

September 2021. Participants self-selected to participate in the study. Participation was restricted to adults (18 years or older) who could complete the MSMH app in English. An informed consent was displayed in the app; participants agreed to reuse their anonymous data for research prior to completing the assessment. They completed the MSMH assessment on university-owned iPads. Participants were given a university-branded drawstring backpack (US \$1.79 value) as an incentive for participation. At the end of the assessment, a unique code was displayed that participants could use to download a summary of their responses. The link to download the summary along with the participants' unique code was provided to each participant in a business card format.

Appropriate COVID-19 protocols were followed: masks were mandatory, iPads were sanitized after every use, and hand-sanitizing lotions were available in multiple places.

Study Tool: MSMH App

As displayed in [Figure 1](#), the MSMH app presents SCN for each concept as previously described using the SOST [21,23]. If all concepts are rated, there would be a total of 42 strengths, 335 challenges, and 168 needs. Of these, 37 concepts were chosen for analysis based on the study objectives and the setting/sample, excluding 5 concepts that did not apply to the majority of participants (*Pregnancy, Postpartum, Family Planning, Consciousness, and Growth and Development*). The total time to complete the assessment was approximately 15 minutes per user.

Study Approach and Data Analysis

Data were stored in a secure computing environment hosted by the university. Data were analyzed using visualization techniques in Excel (Microsoft Corporation), and descriptive and inferential statistics were analyzed using SPSS (IBM Corp).

For aim 1, the overall SCN were examined for all participants using descriptive statistics and parallel coordinates visualization techniques [7,26]. Two cohorts were then formed for participants with one or more *Emotions* challenges and those without *Emotions* challenges. SCN were compared using independent sample *t* tests and parallel coordinates visualization techniques. In examining whole-person health and the *Emotions* concept using data visualization techniques, a novel cluster of

health-related behaviors domain concepts (*Sleeping, Nutrition, and Exercising*) were uncovered and were examined in detail. In addition, bubble charts were created to visualize relationships among SCN across the four domains (My Living, My Mind and Network, My Body, and My Self-care).

For aim 2, to examine resilience, a correlational analysis was conducted on the strengths of participants with and without *Emotions* challenge. Co-occurrences of various strengths across the 37 study concepts were analyzed using the Pearson correlation coefficient. The resulting correlation matrix was conditionally formatted in Excel with blue (most correlated), white (midrange), and red (least correlated).

Results

Overview

The study participants (N=182) were primarily female (n=123, 67.6%), aged ≥ 45 years (n=112, 61.5%), White (n=154, 84.6%), and non-Hispanic (n=177, 97.3%). Almost half of the respondents indicated their marital status as married (n=84, 46.2%). The demographics of participants by age, gender, race, ethnicity, and marital status with and without *Emotions* challenges are presented in [Table 1](#). Compared to those without *Emotions* challenges, those with *Emotions* challenges were aged 18-44 years ($P<.001$), more often female ($P=.04$), and not married ($P=.02$). The *Emotions* challenges identified by participants are highlighted in [Table 2](#), with tired (n=69) and hard to manage my stress (n=46) identified as the top two challenges.

Table 1. Demographics of participants: overall and by group with and without an emotions challenge.

Sample characteristic	Sample (N=182), n (%)	Without an <i>Emotions</i> challenge, n (%)	With an <i>Emotions</i> challenge, n (%)	Difference by characteristic and the emotions challenge	Chi-square (df)	P value
Age (years)				14.49 (1)		<.001
18-44	70 (38.5)	18 (9.9)	52 (28.6)			
45 to ≥ 65	112 (61.5)	61 (33.5)	51 (28.0)			
Gender				4.17 (1)		.04
Female	123 (67.6)	47 (25.8)	76 (41.8)			
Male/other	59 (32.4)	32 (17.6)	27 (14.8)			
Race				1.71 (1)		.19
White	154 (84.6)	70 (38.5)	84 (46.2)			
All other	28 (15.4)	9 (4.9)	19 (10.4)			
Ethnicity				0.02 (1)		.88
Non-Hispanic/ non-Latinx	177 (97.3)	77 (42.3)	100 (54.9)			
Hispanic/Latinx	5 (2.7)	2 (1.1)	3 (1.6)			
Marital status				5.12 (1)		.02
Married	84 (46.2)	44 (24.2)	40 (22.0)			
Other marital categories	98 (53.8)	35 (19.2)	63 (34.6)			

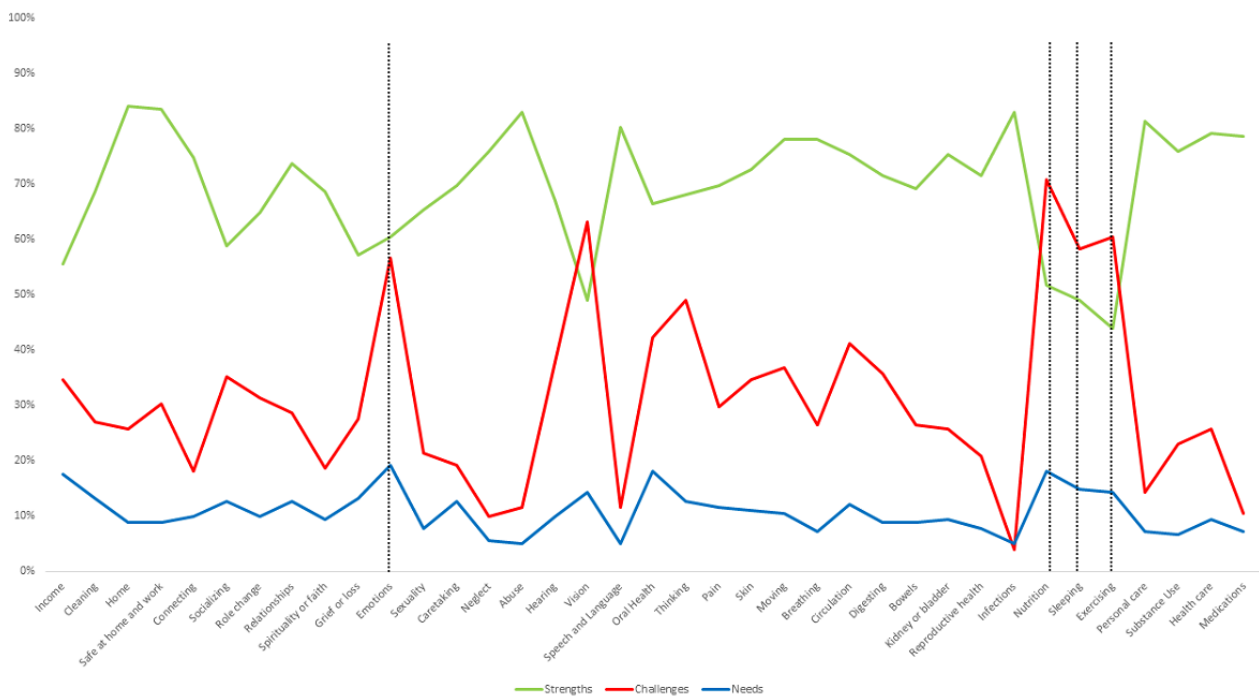
Table 2. Emotions challenges identified by participants.

Emotions challenges in participants	Participants, n
Tired	69
Hard to manage my stress	46
Hard to concentrate	31
Nothing excites me	27
Mood swings	23
Very sad, hopeless	16
Not interested in taking care of myself	16
Fearful	14
Hard to not repeat things I do	13
Strongly annoyed and acting out	11
Angry	8
Flashbacks	7
Hard to understand real life	6
See or hear things that others cannot	4
I think about killing myself or others	5
Self-harm	5

Aim 1: Overall Strengths, Challenges, Needs, and With/Without Emotions Challenges

Figure 2 presents the overall SCN of participants.

Figure 2. Overall strengths, challenges, and needs.



Strengths

Participants had an average of 28 strengths (mean 28.6, SD 10.5). *Home* (n=152, 83.5%) and *Safe at Home and Work* (n=152, 83.5%) were the two concepts with the most strengths.

Challenges

Participants had an average of 12 challenges (mean 12, SD 7.5). Common challenges were *Nutrition* (n=129, 70.9%), followed by *Exercising* (n=109, 60.4%) and *Sleeping* (n=106, 58.2%). Figure 2 displays the challenges (red line) exceeding the

strengths (green line) for this cluster of health-related behaviors domain concepts. Over half (n=103, 56.6%) of the participants had one or more challenges in the *Emotions* concept.

Needs

Participants had an average of 4 needs (mean 4.2, SD 7.5). The *Emotions* concept had the most needs, with info/guidance being the common need for this concept (Figure 3). One out of five (n=35, 19.2%) participants identified a need related to *Emotions*. Overall, the top five needs were in *Emotions*, *Nutrition*, *Income*, *Sleeping*, and *Exercising* (Figure 3).

Overall, participants had more strengths than challenges and needs (Table 3). Compared to those without *Emotions* challenges, those with *Emotions* challenges had fewer strengths, more challenges, and more needs than those without *Emotions* challenges (P<.001 for all; Table 3).

The analysis of strengths across concepts and by group with/without *Emotions* challenge showed that the group without *emotions* challenge (indicated in green in Figure 4) had more strengths across all concepts. Compared to those without *Emotions* challenges, those with *Emotions* challenges had fewer strengths for *Emotions* (P<.001) and for the cluster of health-related behaviors domain concepts: *Sleeping* (P=.002), *Nutrition* (P<.001), and *Exercising* (P<.001).

Figure 5 displays the analysis of challenges across the two groups, with higher challenges across all concepts for those in

the *Emotions* challenge group (indicated by the red line). The group with the *Emotions* challenge had more challenges. Compared to those without *Emotions* challenges, those with *Emotions* challenges had more challenges on the cluster of health-related behaviors domain concepts: *Sleeping* (P=.003), *Nutrition* (P<.001), and *Exercising* (P<.001).

The analysis of needs showed more needs for all concepts in the group with *Emotions* challenges (Figure 6). Compared to those without *Emotions* challenges, those with *Emotions* challenges had more needs for *Emotions* (P<.001), and health-related behaviors domain concepts: *Sleeping* (P=.002), *Nutrition* (P<.001), and *Exercising* (P<.001).

Additional visual analysis was conducted across the four MSMH domains to understand whole-person health by domain and concept using bubble charts (Figure 7) in which larger bubble size indicated more challenges; being on the left end of the x-axis showed fewer strengths and on the higher end of the y-axis showed greater needs. This is much more pronounced for the group with *Emotions* challenges (red bubbles) as shown in Figure 7. The combined patterns of location on the two axes and the bubble size show pronounced difference by problem: bubble size and location were notably larger, higher, and more left for *Income* in the My Living domain; *Emotions* and *Socializing* in the My Mind and Networks domain; *vision* and *thinking* in My Body; and *Sleeping*, *Nutrition*, and *Exercising* in My Self-care.

Figure 3. Most frequent needs by concepts.

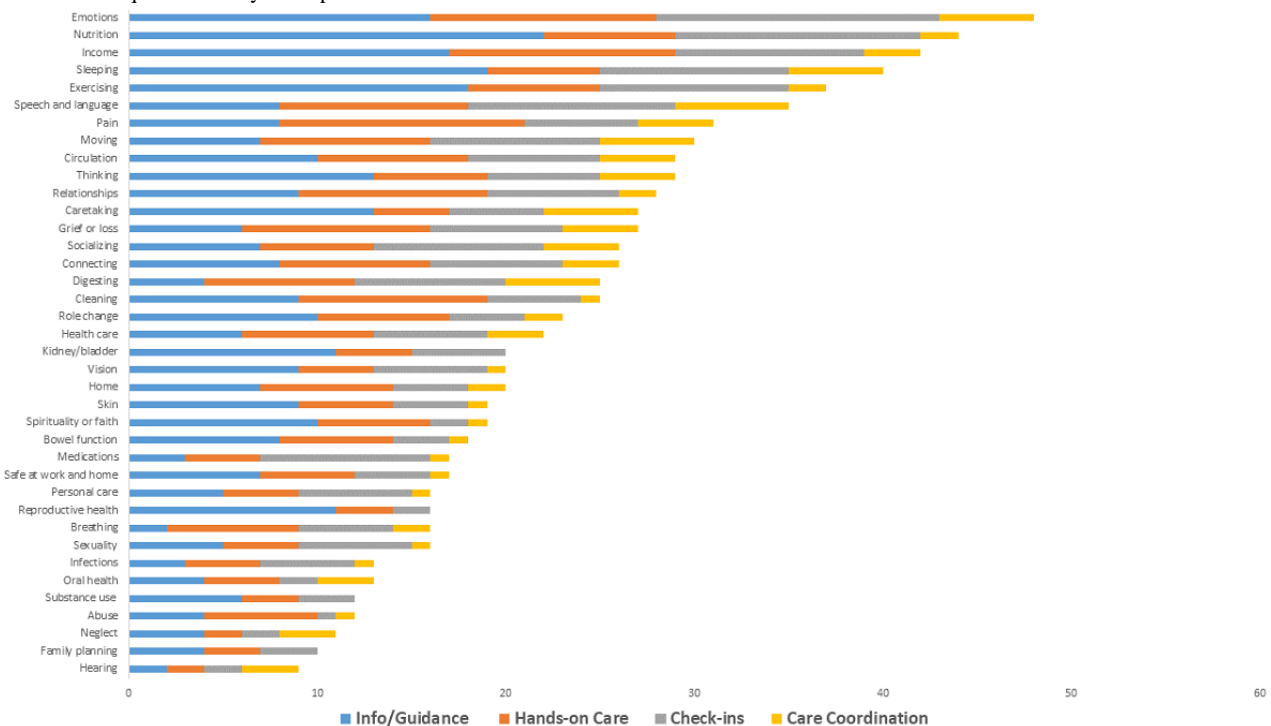


Table 3. Strengths, challenges, and needs: overall and by group with and without an emotions challenge.

Variable	Overall (N=182), mean (SD)	Without an <i>Emotions</i> challenge (n=79), mean (SD)	With an <i>Emotions</i> challenge (n=103), mean (SD)	P value
Strengths	28.6 (10.5)	32 (9.6)	26 (10.4)	<.001
Challenges	12 (7.5)	6.7 (3.9)	16.2 (7.0)	<.001
Needs	4.2 (7.5)	1.4 (2.4)	6.3 (9.2)	<.001

Figure 4. Strength by concept and by group with and without an Emotions challenge.

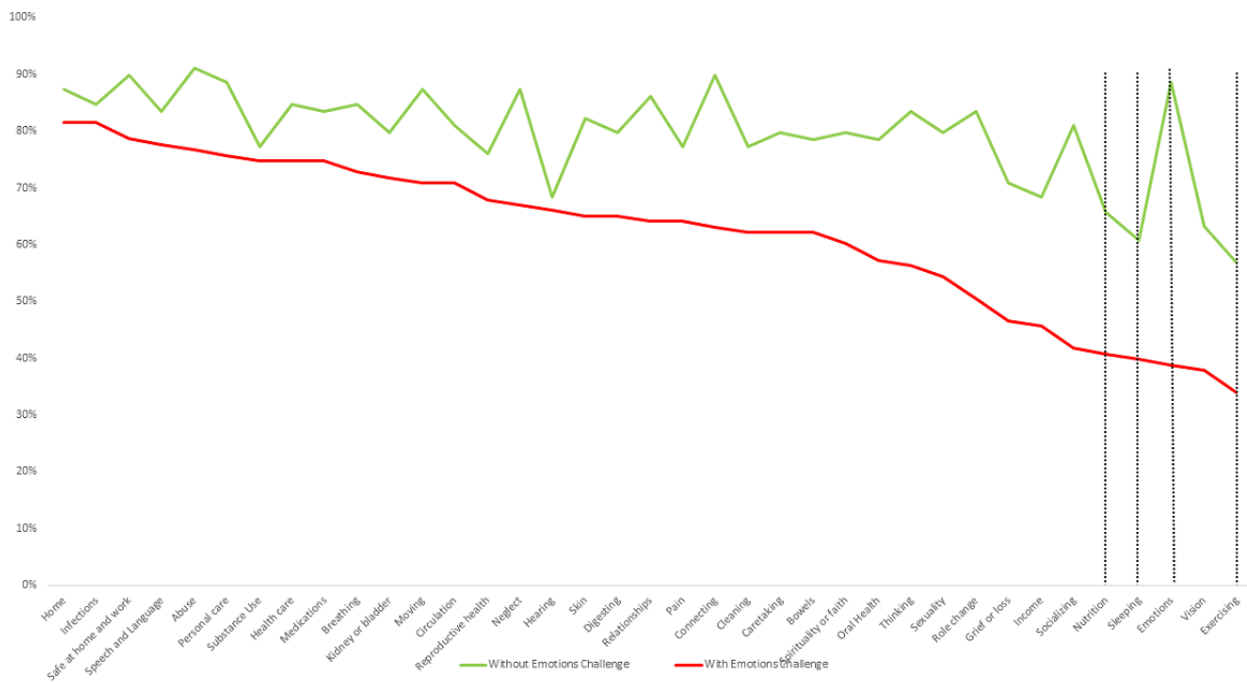


Figure 5. Challenges by concept and by group with and without Emotions challenges.

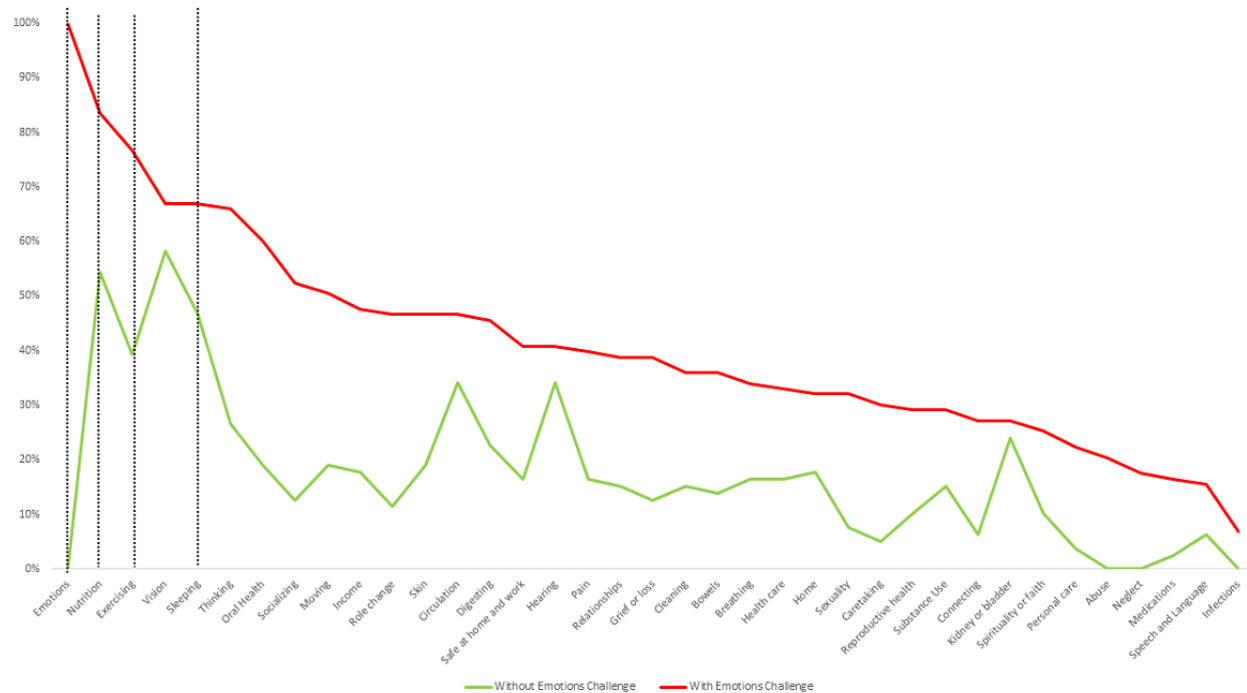


Figure 6. Needs by concept and by group with and without Emotions challenges.

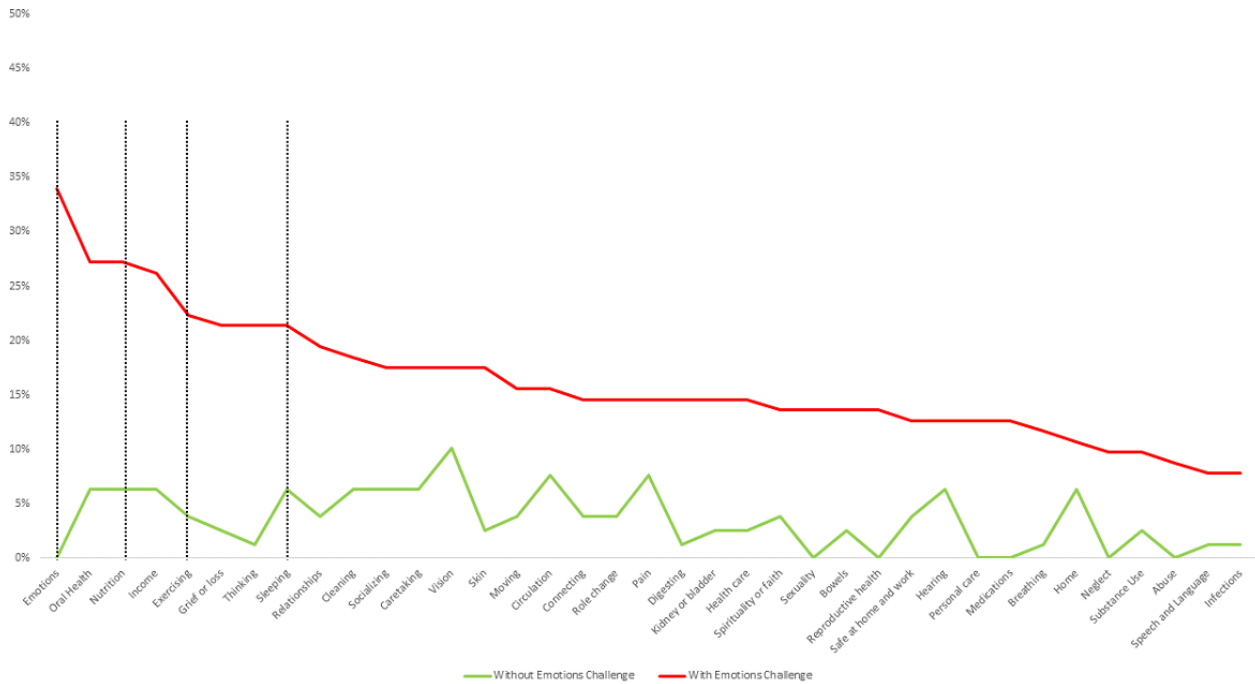
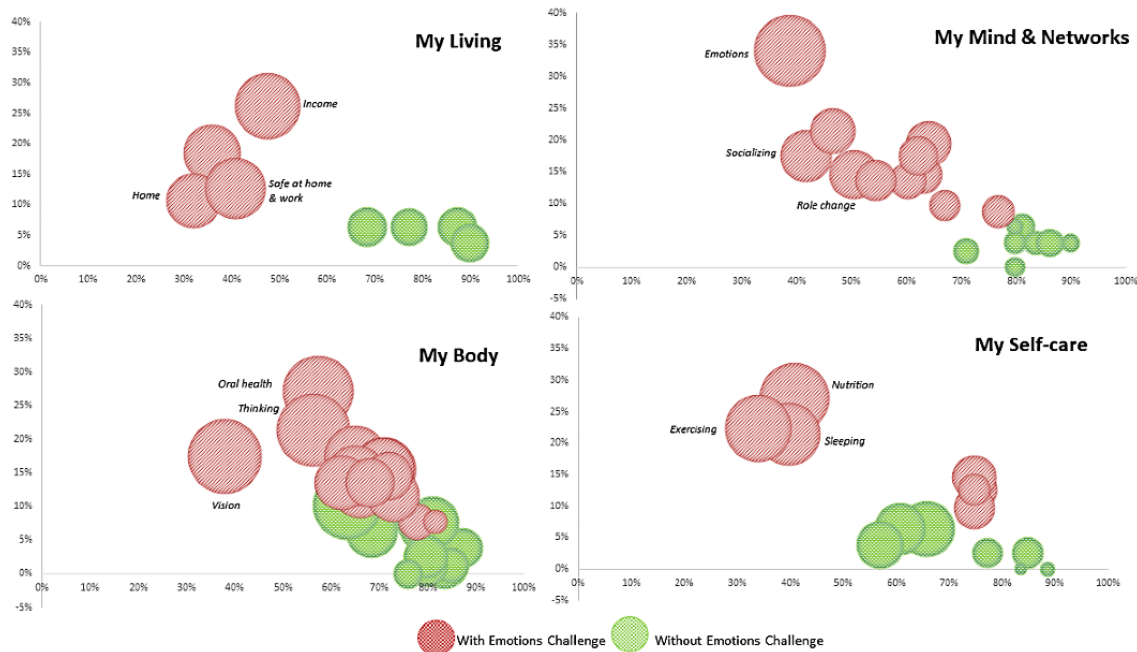


Figure 7. Strengths, challenges, and needs by domain, with and without Emotions challenges.



Aim 2: Characterize Resilience for Groups With and Without an Emotions Challenge

The correlational analysis to identify associations in strengths for participants with and without *Emotions* challenges are presented in **Figures 8** and **9**, respectively. A higher correlation indicates co-occurrence of strengths [7,27]. A total of 666 boxes are displayed for strength correlations with *Emotions* challenges and likewise for without *Emotions* challenges. A red box is an indicator of less correlation and a blue box is an indicator of high correlation, with the white box being in between. For those

with *Emotions* challenges, 22.5% (n=150) are blue boxes out of the total of 666 boxes, and for those without *Emotions* challenges, 51.7% (n=344) are blue boxes. As shown in **Figures 8** and **9**, the correlations among concepts are less strong for those with *Emotions* challenges (more red boxes) and stronger for those without *Emotions* challenges (more blue boxes indicating more and greater positive correlations). The correlation matrix for the group without an *Emotions* challenge depicts strengths that extend across concepts/domains as indicated by the blue boxes that span horizontally and vertically.

challenges and needs across all concepts underscores the importance of a whole-person health perspective. Further research is needed to understand nuances related to SCN across and among these concepts in respect to whole-person health.

The finding that more than half of the participants had challenges in the *Emotions* concept underscores the impact and emotional toll of the pandemic. This aligns with the evidence that emotional issues such as depression, anxiety, and suicidal thoughts have increased since 2020 [2]; for example, the number of US adults who reported symptoms of anxiety or depression in January 2021 increased 4 times compared to June 2019 [2]. The How Right Now communications campaign by the Centers for Disease Control and Prevention [2] aims to promote and strengthen the emotional well-being and resilience of people affected by stress, grief, and loss during the COVID-19 pandemic. Data on whole-person health such as those offered by this study has the potential to provide a quantitative data perspective to add to the qualitative lived experiences/narratives being shared as part of this initiative.

The finding that those with *Emotions* challenges also had many strengths is promising; and it is important to identify these as a tool to help understand and potentially bolster resilience. These findings align with prior strength-oriented studies [14,15,33-35]. Strengths can be used as tools to counter challenges, as an individual who has strength in *Socializing* or *Spirituality* or *Faith* is more likely to use social support systems to mitigate challenges related to concepts such as *Emotions*, *Relationships*, or *Grief* or *loss* and use these as their mechanisms to preserve and heal and, hence, build resilience [36,37].

The finding that those with *Emotions* challenges have fewer strengths and more challenges and needs across all four domains compared to those without *Emotions* challenges aligns with the literature regarding the impact of mental health on all of health [38,39]. Results align with prior studies that health and disease are a dynamic interconnected state with a ripple effect on other aspects of health [3,40]. Tools such as SOST and MSMH can provide a whole-person assessment and identify areas of strengths to leverage and help boost resilience. The SOST terminology within the MSMH app enabled comparisons across communities and clinical data [7,22], and has been used to analyze community-level resilience [7]. Given the potential for assessment at the individual and community level, powerful tools such as SOST and the MSMH app should be adopted within EHRs and personal health records to generate meaningful data for population health management.

This aligns with the current National Institutes of Health Bridge2AI Initiative that aims to build and leverage robust multidimensional data sets [41]. By tapping into increasing computing power along with machine learning, artificial intelligence, and transformative analytic techniques, these data sets can be used to draw insights on factors that facilitate whole-person health and resilience. Apps such as MSMH leverage the power of terminology standards and health informatics, and provide options for addressing the recommendations of the National Academies of Sciences, Engineering, and Medicine on design and use of health information technology for whole-person health [42].

Strengths and Limitations

This research demonstrates the power of health informatics, standardized data, and technology to assess, visualize, and test individual- and community-level data. It demonstrates a data-driven methodology for additional studies to build evidence on whole-person health and resilience. Furthermore, such research offers a starting point for initiating conversations about whole-person health with individuals and communities regarding their strengths, challenges, and needs, beginning a shift from a deficit model of health toward whole-person health.

Some limitations were noted. Recruitment challenges due to COVID-19 were considerable, given limited attendance at the state fair and the fact that participants needed to participate indoors and wear a mask inside the research building. The sample may have been biased by these pandemic conditions, as fair attendees in 2021 may be unique in some way that is not known. Lastly, the survey took 15 to 20 minutes to complete, which was a deterrent to some potential participants.

Conclusions

This study examined standardized whole-person data using an app-aided and data-driven approach, quantifying SCN of individuals across all of health (environmental, psychosocial, physiological, and health-related behaviors domains). Examining SCN data for groups with and without *Emotions* challenges revealed patterns in overall health and for important health-related behaviors concepts. This study lays a foundation for numerous research opportunities, such as metric development to measure resilience and the use of SOST and MSMH in clinical care settings to reframe health care encounters in a whole-person perspective.

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Conflicts of Interest

None declared.

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Abbreviations

EHR: electronic health record

MSMH: MyStrengths + MyHealth

SCN: strengths, challenges, and needs

SNOMED CT: Systemized Nomenclature of Medicine–Clinical Terms

SOST: Simplified Omaha System Terms

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Original Paper

Acceptability of an mHealth Family Self-management Intervention (myFAMI) for Pediatric Transplantation Families: Qualitative Focus

Stacey Marie Lerret^{1*}, PhD; Erin Flynn², BA; Rosemary White-Traut³, PhD; Estella Alonso⁴, MD; Alisha M Mavis^{5*}, MD; M Kyle Jensen^{6*}, MD; Caitlin G Peterson⁷, DO; Rachel Schiffman⁸, PhD

¹Division of Pediatric Gastroenterology, Hepatology, and Nutrition, Department of Pediatrics, Medical College of Wisconsin, Milwaukee, WI, United States

²Cincinnati Children's Hospital Medical Center, Cincinnati, OH, United States

³Department of Nursing Research, Children's Wisconsin, Milwaukee, WI, United States

⁴Division of Pediatric Gastroenterology, Hepatology, and Nutrition, Ann & Robert H Lurie Children's Hospital, Northwestern University Feinberg School of Medicine, Chicago, IL, United States

⁵Division of Gastroenterology, Hepatology, and Nutrition, Department of Pediatrics, Duke University School of Medicine, Raleigh, NC, United States

⁶Division of Pediatric Gastroenterology, Department of Pediatrics, University of Utah, Salt Lake City, UT, United States

⁷Division of Nephrology, Department of Pediatrics, University of Utah Health, Salt Lake City, UT, United States

⁸College of Nursing, University of Wisconsin-Milwaukee, Milwaukee, WI, United States

*these authors contributed equally

Corresponding Author:

Stacey Marie Lerret, PhD

Division of Pediatric Gastroenterology, Hepatology, and Nutrition

Department of Pediatrics

Medical College of Wisconsin

8701 West Watertown Plank Road

Milwaukee, WI, 53226

United States

Phone: 1 414 266 3944

Email: slerret@mcw.edu

Abstract

Background: Around 1800 pediatric transplantations were performed in 2021, which is approximately 5% of the annual rate of solid organ transplantations carried out in the United States. Effective family self-management in the transition from hospital to home-based recovery promotes successful outcomes of transplantation. The use of mHealth to deliver self-management interventions is a strategy that can be used to support family self-management for transplantation recipients and their families.

Objective: The study aims to evaluate the acceptability of an mHealth intervention (myFAMI) that combined use of a smartphone app with triggered nurse communication with family members of pediatric transplantation recipients.

Methods: This is a secondary analysis of qualitative data from family members who received the myFAMI intervention within a larger randomized controlled trial. Eligible participants used the app in the 30-day time frame after discharge and participated in a 30-day postdischarge telephone interview. Content analysis was used to generate themes.

Results: A total of 4 key themes were identified: (1) general acceptance, (2) positive interactions, (3) home management after hospital discharge, and (4) opportunities for improvement.

Conclusions: Acceptability of the intervention was high. Family members rated the smartphone application as easy to use. myFAMI allowed the opportunity for families to feel connected to and engage with the medical team while in their home environment. Family members valued and appreciated ongoing support and education specifically in this first 30 days after their child's hospital discharge and many felt it contributed positively to the management of their child's medical needs at home. Family members provided recommendations for future refinement of the app and some suggested that a longer follow-up period would be beneficial. The development and refinement of mHealth care delivery strategies hold potential for improving outcomes for solid organ transplantation patients and their families and as a model to consider in other chronic illness populations.

Trial Registration: ClinicalTrials.gov NCT03533049; <https://clinicaltrials.gov/ct2/show/NCT03533049>

KEYWORDS

mHealth; pediatric patients; transplantation; family self-management; qualitative

Introduction

Background

Around 1800 pediatric transplantations were performed in 2021, which is approximately 5% of the annual rate of solid organ transplantations carried out in the United States [1]. With successes in achieving high patient and graft survival for pediatric transplantation recipients, focused efforts and the related metrics of quality of care have shifted toward psychosocial patient outcomes. Measures of family experience and outcomes are notably absent [2]. Effective family self-management, the ability and processes used by families to purposefully incorporate health-related behaviors into the family's daily functioning to prevent or attenuate illness or facilitate the management of complex health regimens, is a key consideration for posttransplantation outcomes [3-5].

Successful outcomes of transplantation require effective family self-management [5,6]. The first 30 days following hospital discharge is a critical time for families to self-manage the additional stressors associated with posttransplantation care including managing the child's medical schedule (laboratory/clinic appointments, medication administration), impact on family life, and worry about transplantation complications [7-10].

The use of mobile health (mHealth) technology, particularly to deliver self-management interventions, is a strategy that can be used to support family self-management for transplantation recipients [11,12]. Within an mHealth intervention, including monitoring health and adhering to the medical regimen, self-management strategies improved for adult lung transplantation patients [13]. Furthermore, transplantation recipients have reported that they are largely in favor of utilizing mHealth interventions to aid in their recovery [12,14].

The innovative use of mHealth emphasizes the importance of an interactive partnership between families and nurses [12], an essential component of surveillance and care coordination for the transition from hospital to home in complex patient populations [15-20]. The use of mHealth technology in the postdischarge period allows for ease of access by an additional means of communication between families and the medical team, offering the opportunity for outreach and proactive intervention. mHealth technology offers a low-cost and efficient strategy to provide focused health-related messaging [21-23] and reciprocal communication between the nurse and family. The ability to identify factors associated with difficulty managing the child's illness provides an opportunity to develop effective individualized family-centered interventions that have

significant implications for care decisions, complications, and health care use.

Our team has previously conducted a pilot study of the implementation of a family self-management intervention (*myFAMI*) for families of pediatric heart, kidney, or liver transplantation recipients [24]. The effectiveness of interventions is tied to successful implementation [25]. Our initial evaluation of the intervention included quantitative assessments of feasibility, acceptability, and efficacy [26]. Family member use of the app was feasible in our study as 100% (21/21) of primary family members completed the app at least one day after discharge. More specifically, 81% (17/21) of primary family members used the app at a high frequency by completing the app at least 24/30 days after hospital discharge. Acceptability was evident with high nurse response rate (99%, 133/134) to family member trigger alerts within 2 hours. Improvements in patient outcomes of postdischarge coping, family quality of life, self-efficacy, and utilization of health care resources were in the expected direction [24]. The purpose of this analysis was to explore acceptability of *myFAMI* through an in-depth analysis of family member experiences with the *myFAMI* intervention. This exploration provides information for improving the intervention for use in future studies with pediatric transplantation families.

myFAMI App Description

The mHealth intervention, *myFAMI*, included the use of a smartphone app and nurse response (video or telephone) to support family self-management for family members after their child's transplantation. *myFAMI* promoted daily communication initiated by an in-app notification and completed by the participating family member for 30 days after discharge. Specifically, family members received an in-app notification at 8:00 AM reminding them to answer the 8 daily questions within 2 hours (ie, by 10 AM); 5 of the 8 questions were symptom-based (fever, vomiting, diarrhea, pain, other illness) and 3 were self-management-based (coping, medication administration, and medical appointments). Preidentified triggers for each question resulted in an alert to the research nurse who subsequently contacted the family to discuss any of the symptom(s) and self-management issues within 2 hours of receiving the alert. The preidentified triggers were defined as follows: (1) an answer of "yes" or "don't know" for the 5 symptom-based questions and (2) an answer of 3 or greater using a scale of "0" (no difficulty) to "10" (great difficulty) for the self-management questions. Figure 1 provides a summary of the app workflow and Figures 2 and 3 illustrate 2 of the 8 survey question pages [27]. Further details regarding *myFAMI*, study workflow, and app screenshots are available in our protocol manuscript [28] and app development manuscript [27].

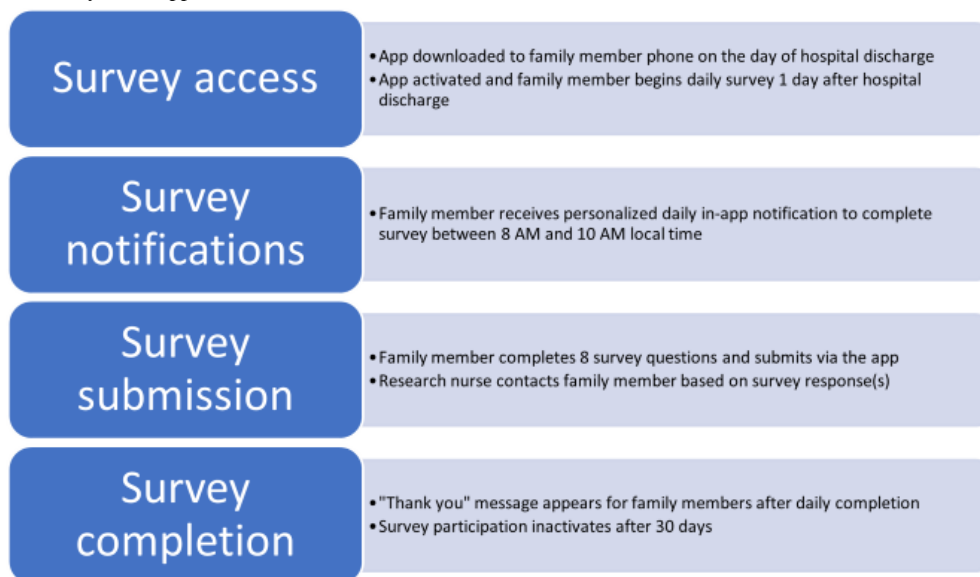
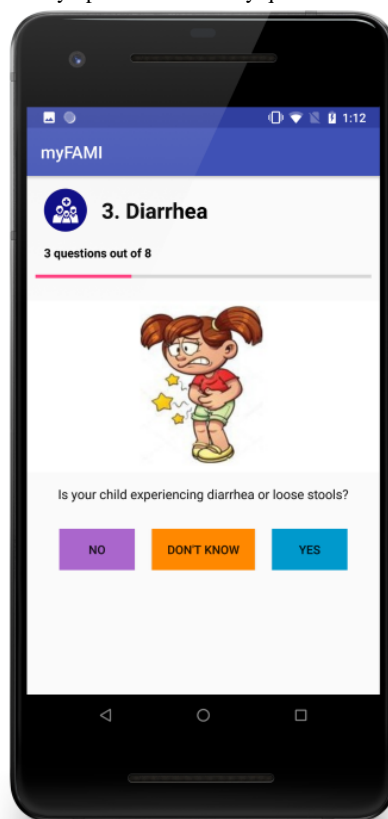
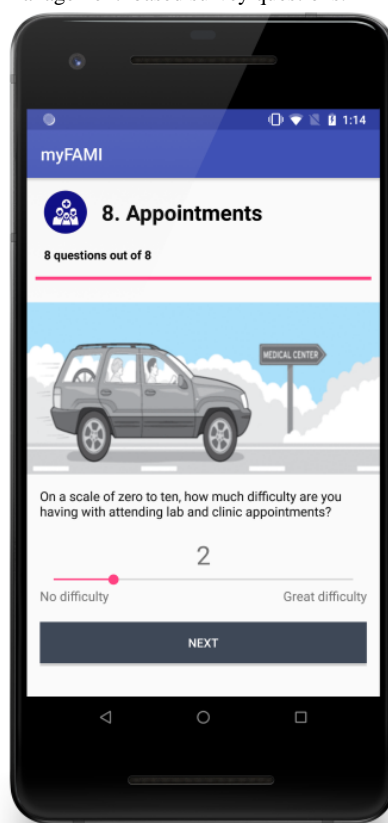
Figure 1. Summary of the myFAMI app workflow.**Figure 2.** myFAMI app screenshot displaying one of the symptom-based survey questions.

Figure 3. App screenshot displaying one of the self-management–based survey questions.



Methods

Design

This study involves an evaluation of the acceptability of an mHealth intervention (myFAMI) as experienced by the intervention family members participating in a randomized controlled trial comparing myFAMI with standard postdischarge follow-up care [24]. The main pilot study was a randomized controlled trial that evaluated the efficacy of myFAMI [24]. The data for this report include qualitative data from family members who reported their experiences of participating in the mHealth intervention to discern strengths and uncover opportunities for improving the acceptability and outcomes of myFAMI.

Participants

A convenience sample of family units of pediatric heart, kidney, and liver transplantation recipients was enrolled. For this report, a family unit is defined as one of the following: (1) a primary family member only or (2) a primary and secondary family member. This may include a variety of family unit combinations such as mother/father, mother/aunt, father/grandmother, mother/grandmother. Over a 17-month period, family units were enrolled at 4 major pediatric transplantation programs in the United States. Participants were deemed eligible to participate if they were (1) 18 years of age or older; (2) English speaking; and (3) had a child (<18 years of age) who received a heart, kidney, or liver transplantation with expected discharge to home

from the hospital [24]. Likewise, family members were deemed ineligible to participate (1) if they had communication or cognitive impairment that limited their ability to complete the myFAMI questionnaires or (2) if the child had a prior transplantation that would minimize the potential for an experiential effect. A family unit was *not* excluded if only 1 family member (primary family member) was interested in participation.

Procedure

After receiving institutional review board approval at each of the 4 study sites, eligible family members and their child were identified and approached for voluntary participation and informed consent/assent was obtained. On the day of hospital discharge, family units were randomized to the control or intervention (myFAMI) group.

The qualitative data used for this analysis were provided by family members who were assigned to the myFAMI app and participated in a 30-day postdischarge telephone interview. One component of the telephone interview consisted of open-ended questions focused on the overall experience of using the app (Table 1). Overall, 5-10 minutes was devoted to this qualitative component for the myFAMI group. To ensure consistency of interview questions, interviews were conducted by a single interviewer from the Pediatric Translational Research Unit at the main study site using a semistructured interview guide. The interviews were audio-recorded and transcribed by the single interviewer who also verified the accuracy of the transcription and corrected as needed.

Table 1. Qualitative questions in the 30-day follow-up interview.

Description	Questions
Challenges	<ul style="list-style-type: none"> Tell me about any challenges you had with using the app? Technical challenges with the app itself maybe something we can improve for future use.
Functionality	<ul style="list-style-type: none"> Tell me if you feel the app helped you after discharge? Helped you to manage your child at home? How much time did it take you to complete the app every day? Did the time spent with the app seem too long, too short, or just right?
Overall experience	<ul style="list-style-type: none"> Can you tell me more about your experience with using the app? Did you think it was easy or hard to use? Why?
Use of the app	<ul style="list-style-type: none"> Did you answer the app every day for 30 days? If not, what were some of the reasons why you did not complete the app? (ie, technical problems with the app or app did not work, forgot that day)
Call experience	<ul style="list-style-type: none"> Did you receive a call from the research nurse? If yes, what went well? What did not go well?
Recommendations	<ul style="list-style-type: none"> What recommendations do you have for improving the app? Would you recommend using the app for other families?

Data Analysis

This qualitative approach was guided by content analysis, a systematic and rigorous means of describing the family member experience [29]. The systematic coding of responses was an iterative process leading to emerging themes that portrayed each family's perspectives on, acceptance of, and recommendations for myFAMI [29]. Two experienced qualitative researchers (SL and EF) independently reviewed the interview transcripts and coded data into categories of responses. The 2 reviewers then worked together to systematically compare the coded responses and develop initial themes. Through an iterative process, transcripts and themes were reevaluated to generate the final themes. Rigor was assured by use of an audit trail documenting development of final themes. Differences in coding in the independent review phase were resolved by discussion and consensus between the 2 reviewers.

Ethics Approval

The study was approved by the Institutional Review Board at the Children's Hospital of Wisconsin (IRB approval number 1183697) and at each individual enrolling transplantation center.

Results

Demographics

A total of 21 family units (primary family member only or primary and secondary family members of the transplanted child) had 30-day postdischarge interview data available for analysis. The final sample consisted of 32 primary and secondary family members. The majority of this sample comprised family members of children who received liver transplantations (13/21, 62%). An overwhelming majority of the children (20/21, 95%) and family members (30/32, 94%) were White. The child age spanned from infant to adolescent (range 30 days to 17 years). The age range for family members was 25-63 years. Additional demographic data are listed in [Table 2](#).

Table 2. Demographics.

Characteristics	Values
Family member age (n=32), years, median (IQR)	36.5 (32-46)
Family member gender (n=32), n (%)	
Female	20 (62)
Male	12 (38)
Family member race (n=32), n (%)	
White	30 (94)
Asian	2 (6)
Marital status (n=32), n (%)	
Married	24 (75)
Single	8 (25)
Relationship to child (n=32), n (%)	
Mother	18 (56)
Father	11 (34)
Grandmother	1 (3)
Other	2 (6)
Child age (n=21), years, median (IQR)	8 (3-10.5)
Child gender (n=21), n (%)	
Female	10 (48)
Male	11 (52)
Child race (n=21), n (%)	
White	20 (95)
Asian	1 (5)
Child transplantation type (n=21), n (%)	
Heart	6 (29)
Kidney	2 (10)
Liver	13 (61)

General Acceptance

In the 30-day follow-up interview, nearly all participants (31/32, 97%) reported that the app was easy to use. In discussing certain features, 41% of family members (13/32) specifically mentioned that design features made the app easy to use. Question setup and phrasing were mentioned as a good part of the app design (4/32, 13%). One participant mentioned liking the pictures that were added with the questions, while 3 participants stated the notifications/reminders to complete the survey were good features. For example, a participant stated, "It sent notifications; reminders were helpful; simple and easy to use". Another parent stated, "Easy to use, being able to click yes or no". When asked about time spent with the app, the majority of family members (29/32, 91%) said it took 2 minutes or less to complete the app daily, and that time spent in the app was "just right."

Family members who did not complete the app every day reported various reasons for missing days, including that they forgot (2/32, 6%), were away from the child (1/32, 3%), or were not sure (2/32, 6%). One parent stated, "2 or 3 times I wasn't

able to answer, days I may have gone home and wasn't next to him [child], didn't want to provide inaccurate information". One other family member stated, "I believe I missed one day, can't remember why".

When asked about their experience with the app, family members indicated high levels of general acceptance, with 88% (28/32) recommending use of the app for future candidates. Supporting the theme of acceptance, a family member reported, "Yes [they would recommend it to other families], great to have the psychological safety net", while another reported that they "highly recommend [use of the app]". One family member did not recommend the app without explanation and another said s/he would recommend the app clarifying that "would recommend if it [the app] was geared towards helping people understand symptoms of infection and rejection".

Positive Interactions

Overall, among the 32 participating primary and secondary family members, 163 triggers were generated based on answers provided in the app. When a trigger alert was generated, the

family member received a call from the research nurse to discuss reason for the alert. The nurses responded to 99.3% (162/163) of the trigger alerts within 2 hours. In all, 23/32 (72%) family members who were interviewed reported receiving a call from the research nurse; 21/23 (91%) of these family members stated that the calls with the research nurse were positive interactions (Table 3) and that the interactions with the research nurse were helpful (5/23, 22%). One family member supported this by saying, “Helped with adjustments in the beginning; she [the nurse] was very nice”, while another family member stated,

“Received quick calls and they were beneficial”. Others who responded complimented the research nurses beyond the point of stating that it was a helpful interaction, that is, “Very positive and thorough; very caring, genuinely helpful”. The family members who used a video call reported a positive experience and stated, “the Zoom interaction worked well; the ability to share real time was best”. When asked what did not go well with the research nurse, only 1 participant (4%) answered by stating “Nice if a ‘5’ would constitute a trigger versus a ‘3’”.

Table 3. Themes and exemplar family member quotes.

Theme/category	Family member response
General Acceptance	<p><i>Easy to use, multiple choice was helpful</i></p> <p><i>Reminders were handy</i></p> <p><i>Super easy and fast</i></p> <p><i>Easy, and I'm not that tech savvy</i></p> <p><i>Easy, straight forward, within minutes someone would call us; reassuring as we had problems with diarrhea secondary to potassium levels</i></p> <p><i>Easy to use, repetitive in nature helped with awareness</i></p>
Positive Interactions (with the research nurse)	<p><i>Interactions were great</i></p> <p><i>Direct calls with RNs went well</i></p> <p><i>Went well [conversation with nurse], friendly and open to conversation, beneficial</i></p> <p><i>Research nurses were good, positive interactions</i></p> <p><i>RNs were good and knowledgeable</i></p> <p><i>Everyone [nurses] were informative and supportive, positive experience</i></p> <p><i>Got better talking with nurses because of the app</i></p>
Home Management: Helped Manage After Discharge	<p><i>Yes, I can get a hold of nurse; helped me become less anxious</i></p> <p><i>I think it helped initially to focus in on potential rejection symptoms; helped reassure that someone would call and talk through</i></p> <p><i>The 'difficulty' questions weren't particularly helpful, but didn't hurt, might be valuable to some users</i></p> <p><i>Nice to know that is there was a problem they would call back right away</i></p> <p><i>Awareness versus management, didn't take symptoms for granted</i></p> <p><i>It keeps you cognizant of what to look for</i></p> <p><i>Yes, couple of times we had difficulty with taking medications and nurse provided suggestions that helped</i></p> <p><i>The app helped to take inventory of what was going on</i></p> <p><i>If we had questions about the PICC line, the team was able to respond with direct feedback</i></p>
Opportunities for Improvement	<p><i>Good app, I liked it, possibly be able to open it back and do a follow-up note. It would be nice to have access to an ongoing record</i></p> <p><i>Maybe change your parameters, I thought a '3' was a good score so why did it cause a trigger? After than I put a '2' and didn't get a call</i></p> <p><i>Continue beyond the 30-day mark</i></p>

Home Management

The majority of participants (23/32, 72%) stated that the app allowed them to better manage their child's medical-related care after hospital discharge. The family members noted that the app helped them to be aware of symptoms and monitor the child for rejection. They specifically identified the value of access to the nurse for managing problems and resolving difficulties with their child's treatments. The app and response by the nurse provided support, reassurance, and help with managing emotions, as one participant stated, “if I put in an illness the nurse called, it helped me manage” and another

participant stated, “it helped me focus on getting him [child] better”. As many as 5 participants (16%) reported that the app did not help in managing the child (ie, “not really” or “didn't add much value”). Specifically, 1 family member stated, “Not really manage, more of an assist”.

Opportunities for Improvement

Although there were high levels of general acceptance, 25% of participants (8/32) also reported challenges, most frequently (4/8) technology-related challenges. Specifically, 1 participant stated, “In the beginning, the app didn't work well on the phone; a study team member helped to get it working”. Two other

participants reported feeling uncertain while using the app. For example, 1 participant stated, “When it talked about bowel movements, I’d question whether I should say ‘yes’ or ‘no’; if it changed a little, I wasn’t sure how to record”. Two participants stated that their only challenge was remembering to do the daily questions. One family member said, “No challenges other than remembering to complete it at times” and another parent stated, “the biggest challenge was remembering to complete it”.

In considering potential challenges, themes emerged from participant responses regarding recommendations to improve the app. In this, a few themes regarding ideas for improvement developed. First, 5 of the 32 family members recommended having the questions presented in a different order each day and with varying pictures. One participant supported this theme by stating, “switch up some of the questions.” Second, 4 participants recommended adding a space for extended feedback within the daily survey, that is, “Suggest adding a comments option. More chances for feedback...”. Four others recommended having more flexibility in calls with nurses. For example, “... the ability to leave a time to call back”. Lastly, 2 participants indicated that extending the use of the survey beyond 30 days would be beneficial, making a suggestion for, “longer, maybe out to the three-month mark”.

Table 3 lists additional family member responses for each of the 4 main themes.

Discussion

Principal Findings

The use of mHealth is an innovative approach that complements medical management for supporting the transition from hospital to home-based family self-management for medically complex children. This study aimed to understand parent perspectives and acceptability of a family self-management intervention (myFAMI) for the first 30 days after the child’s heart, kidney, or liver transplantation. It was important to learn the family perspective on acceptability of myFAMI to more fully understand how to further improve this mHealth app to promote successful family self-management during this high-acuity time [30]. The themes emerging from family member responses to use of myFAMI provide insight into the usability and acceptability of a delivery model for postdischarge continuation of surveillance, support, and care management using an mHealth app combined with triggered nurse responses to support family self-management.

Family members reported overwhelmingly positive perceptions of acceptability of the app. The high acceptability for an mHealth smartphone intervention has been similarly reported by adult liver transplantation recipients who stated that an app would help with their transplantation recovery [14]. mHealth has also been reported as an accessible and effective way to provide medical care and psychosocial support to adolescent and young adult lung transplantation recipients, engaging them in their own health care [31]. Further, a study with a platform similar to the one used in this study utilized SMS text messaging with adolescent solid organ transplantation recipients. The high acceptance rate (68%) supported mHealth technology as an

acceptable means of communicating with the clinical care team [32]. The widespread use of technology offers unique opportunities for the use of patient-nurse interfaces to efficiently support patients and families at home.

Family members reported appreciation for the positive interactions during direct conversations with the nurse (video or telephone) in response to triggers from the app, describing the nurses as knowledgeable and supportive. Adolescent heart, liver, and kidney transplantation recipients reported similar benefit to participating in an mHealth SMS text messaging intervention. More specifically, the adolescents reported appreciation for receiving SMS text messages and knowing someone is checking in as enhancing their health care experience [32]. Adult liver transplantation recipients prefer to use virtual video visits and SMS text message options to facilitate a fast response to questions especially early in the transplantation recovery process [14]. This immediate posttransplantation recovery phase was the focused time frame for myFAMI. Each family member received individual attention specific to the needs identified in his/her answers to the 8 daily questions. The importance of individualized care was also reported by lung transplantation recipients during the COVID-19 pandemic [31].

myFAMI is an individualized family self-management intervention that leveraged mHealth to facilitate timely and effective patient-nurse communication [24]. Family engagement is an important aspect of the posttransplantation recovery process and highlights the significance of developing and fostering a mutually beneficial partnership between families and the health care team [17]. Parents of transplantation recipients have reported the importance of seeking out information to participate in the medical discussion and decision making [8]. This supports how family members were engaged in the intervention by answering the daily questions in the app and talking to the nurse if a trigger alert was generated.

Families valued the support from medical experts in addition to their primary transplantation team. Parents of transplanted children reported that they were worried about complications, documented stress and worry in the first 3 weeks after hospital discharge, and indicated that support from the medical team had a positive influence on their ability to cope [9]. The additional layer of surveillance or monitoring was also positively received by family members in this study. Caregivers of adult lung transplantation recipients identified the need for and importance of additional education from the transplantation team [33]. Providing ongoing nursing support and education is an opportunity to promote effective family self-management in the home environment. The myFAMI nurses overwhelmingly provided ongoing support and education during their conversations with the family members in this study.

Recommendations for improvement to the app were functional and included extending the time frame for communication beyond 30 days following discharge. The 30-day time frame for this study was chosen based on hospital quality indicators for readmission [34,35]; however, family needs may not follow this specific schedule. Family members also suggested variability in the app, including presenting the questions in different order each day and using a variety of pictures to make

the tool more engaging. An opportunity to schedule times to speak with the nurse may meet individual family member priorities including extended hours. With this qualitative design, distinct recommendations from the end user (family member) can be considered for future versions of myFAMI. Incorporation of enhancements can support an improved experience for family members utilizing myFAMI in the future.

Study limitations exist. The study questions focused on the experience with and acceptability of myFAMI and did not address other opportunities for support or identify other family member needs. Non-English speaking families were excluded in this pilot study and future research with this population is indicated. The racial breakdown of the myFAMI group was predominantly White, indicating a clear lack of racial diversity. Future research can target diverse populations to identify racial or ethnic disparities experienced after transplantation and unique opportunities to support family self-management [36,37].

A strength of this study was identifying the family experience for different family structures including mom/aunt, mom/dad, and mom/grandmother. While the sample size was small and limited robust statistical analyses, it was sufficient to reach

saturation with commonality reported by family member experiences. However, future studies would benefit from larger samples sizes that would allow for differentiation of the unique perspectives of each type of family member.

Conclusions

This is the first study to qualitatively explore family member perceptions on the acceptability of a family self-management intervention for family members of pediatric heart, kidney, or liver transplantation recipients. Family members value and appreciate ongoing support and education specifically in the first 30 days after their child's hospital discharge. myFAMI allowed for the opportunity for families to feel connected to the medical team while in their home environment. A fully powered clinical trial to determine outcomes of myFAMI is indicated to extend the knowledge for use of mHealth to promote successful family self-management. The use of mHealth in a transitional care delivery model that also includes nurse-patient interaction initiated through the mHealth app may be an effective way to improve overall outcomes for solid organ transplantation patients and their families and a model to consider in other chronic illness populations.

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Conflicts of Interest

None declared.

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Abbreviations

mHealth: mobile health

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Original Paper

Normalizing Telemonitoring in Nurse-Led Care Models for Complex Chronic Patient Populations: Case Study

Kayleigh Gordon^{1,2}, PhD; Katie N Dainty^{1,3}, PhD; Carolyn Steele Gray^{1,4}, PhD; Jane DeLacy⁵, MHSc; Amika Shah^{1,2}, MScCH; Emily Seto^{1,2}, PhD, PEng

¹Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, ON, Canada

²Centre for Global eHealth Innovation, Techna Institute, University Health Network, Toronto, ON, Canada

³North York General Hospital, North York, ON, Canada

⁴Bridgepoint Collaboratory for Research and Innovation, Lunenfeld-Tanenbaum Research Institute, Sinai Health System, Toronto, ON, Canada

⁵William Osler Health System, Brampton, ON, Canada

Corresponding Author:

Kayleigh Gordon, PhD

Institute of Health Policy, Management and Evaluation

University of Toronto

155 College St 4th Floor

Toronto, ON, M5T 3M6

Canada

Phone: 1 416 978 4326

Email: kayleigh.gordon@mail.utoronto.ca

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Abstract

Background: The implementation of telemonitoring (TM) has been successful in terms of the overall feasibility and adoption in single disease care models. However, a lack of available research focused on nurse-led implementations of TM that targets patients with multiple and complex chronic conditions (CCC) hinders the scale and spread to these patient populations. In particular, little is known about the clinical perspective on the implementation of TM for patients with CCC in outpatient care.

Objective: This study aims to better understand the perspective of the clinical team (both frontline clinicians and those in administrative positions) on the implementation and normalization of TM for complex patients in a nurse-led clinic model.

Methods: A pragmatic, 6-month implementation study was conducted to embed multicondition TM, including heart failure, hypertension, and diabetes, into an integrated nurse-led model of care. Throughout the study, clinical team members were observed, and a chart review was conducted of the care provided during this time. At the end of the study, clinical team members participated in qualitative interviews and completed the adapted Normalization Measure Development questionnaires. The Normalization Process Theory guided the deductive data analysis.

Results: Overall, 9 team members participated in the study as part of a larger feasibility study of the TM program, of which 26 patients were enrolled. Team members had a shared understanding of the purpose and value of TM as an intervention embedded within their practice to meet the diverse needs of their patients with CCC. TM aligned well with existing chronic care practices in several ways, yet it changed the process of care delivery (ie, interactional workability subconstruct). Effective TM normalization in nurse-led care requires rethinking of clinical workflows to incorporate TM, relationship development between the clinicians and their patients, communication with the interdisciplinary team, and frequent clinical care oversight. This was captured well through the subconstructs of skill set workability, relational integration, and contextual integration of the Normalization Process Theory.

Conclusions: Clinicians successfully adopted TM into their everyday practice such that some providers felt their role would be significantly and negatively affected without TM. This study demonstrated that smartphone-based TM systems complemented the routine and challenging clinical work caring for patients with CCC in an integrated nurse-led care model.

KEYWORDS

telemonitoring; TM; nurse practitioner; NP-led care; models of care; integrated care; disease care model; disease; nurse; nurse-led implementation; complex chronic conditions; CCC; clinical team; mobile phone

Introduction

In Canada, the prevalence of complex chronic conditions (CCC) is increasing nationwide, affecting 12% to 52% of individuals [1-4]. Patients with CCC include both those with multimorbidity and those who also face clinical complexities and challenges such as clinical or psychosocial vulnerability [5]. Growing evidence suggests that multimorbidity and complexity are driven not only by the nature of aging but also by lower socioeconomic status and social marginalization [3,5,6]. Polypharmacy, increasing medication dosages, and high dosage frequency are also associated with high rates of adverse events, poor adherence, and high treatment burden on the patient [7-10], advancing routine care needs. Negative outcomes related to multimorbidity occur beyond merely a summed effect of single conditions as conditions interact with each other, mutually enhancing their negative effects, leading to new clinical issues and unanticipated care trajectories that do not align with existing care guidelines [11].

Case management has emerged as a strategy to better integrate the care for complex patients [12], involving one central contact between the patient and their providers [13,14]. However, the results of integrated care are mixed [8,11], in part because of often inconsistent clinical interactions and numerous providers who fulfill the most responsible clinician role. Nurse-led care models involving advanced nurse practitioners (NPs) are emerging as a more distilled iteration of case management. Such models have been found to be effective [15-18] in part because of a more person-centered approach, inherent in nursing epistemology. The nursing approach is holistic, considering the broader context of psychosocial and sociocultural influences [19]. In Ontario, NPs have the legal authority to diagnose, prescribe, and treat patients, enabling immediate decision-making and clinical action [20]. As NPs are generally salaried providers versus fee-for-service, they are able to spend more time with patients who require additional support, incorporating different strategies to facilitate comprehensive and complete care [21]. Without appropriate monitoring routines or technologies, additional clinical efforts may be limited in their potential effect.

Digital interventions such as telemonitoring (TM) aim to support chronic disease self-management through routine and timely data transmission, enabling clinicians to identify symptom exacerbations early and intervene [22,23]. Several studies and systematic reviews have shown that TM can improve clinical communication and coordination as well as support patient self-management [23,24]. Although the implementation of TM has been clinically successful in single conditions [25-30], some studies have shown mixed results in areas of all-cause mortality after 365 days and 30-day readmission rates [31,32]. Mixed results could be because of the challenges associated with implementing new technologies without a clear understanding

of existing workflows or an appropriate care model. In addition, there is limited research on TM for patients with CCC [33-35], which focuses on clinical workflows and care.

Implementing new models of care at scale is challenging [36], particularly in the context of clinical teams already working at capacity [37]. Normalization Process Theory (NPT) was used as a guide to determine the mechanisms (ie, conceptual or tangible) that contributed to or inhibited the process of embedding TM for CCC in an integrated nurse-led care model. NPT is a theory of implementation that focuses on the *work* involved to embed new interventions in their social context, detailing the mechanisms of coherence, cognitive participation, collective action, and reflexive monitoring [38-41]. Because of the importance of nurses' role in the delivery of care in this model, it was important to understand their perspectives on implementing and using multicondition TM systems over 6 months and identify any barriers or facilitators. The feasibility and patient adherence to TM in nurse-led care, as well as the characteristics of the patients who used the TM app in the model have already been published [42].

The objective of this study is to better understand the perspective of the clinical team during a 6-month implementation of TM for complex patients in a nurse-led clinic model. Our research question was as follows: "Can TM be successfully implemented in an integrated-nurse-led model within the context of everyday clinical practice for patients with CCC?"

The research subquestions included the following:

1. Does the intervention make sense to clinical staff?
2. Are team members willing to engage with the intervention?
3. How can TM be successfully embedded into the clinical workflow of a nurse-led care model?
4. What can be learned about the overall implementation to increase the spread of TM-enabled nurse-led models of integrated care for patients with CCC?

Methods

Study Setting

In 2018, an NP-led integrated model of care for complex patients was established at a large ambulatory facility in Southern Ontario. The NP-led team of colocated interdisciplinary clinicians included an undergraduate-prepared registered nurse (RN), a pharmacist, a social worker, a kinesiologist, and a dietician. Specialists were also available for referrals based on patient's previous care connections and new needs. Patients were seen in the clinic as often as weekly for 6 to 18 months, typically after an acute exacerbation or hospitalization. Although specialist appointments and routine primary care visits were not halted during the study period, the NP-led care model was intended to be the central coordinator for care, aiming to achieve clinical stabilization and optimization before repatriation back

to routine primary care. In 2019, the smartphone-based TM platform *Medly* was integrated into the NP-led CCC model, enabling patients with multimorbidities including heart failure (HF), hypertension (HTN), and/or diabetes mellitus (DM) to record physiological metrics including blood pressure, weight, heart rate, blood sugar, and symptoms [42]. Although this list is not inclusive of all conditions associated with multimorbidity, they are common conditions that can be used as a foundation to realize a broader conceptualization of the tool in the future. On the basis of frequent readings at home, the algorithm generated self-care messages for patients and alerts for clinicians. Using a web-based dashboard containing a list of readings, alerts, and trend graphs, clinicians used their clinical judgment to conduct remote assessments, titrate medications, and determine further treatment actions. Critical alerts were sent by email to the NP and RN, although the RN conducted most monitoring duties during the study.

Ethics Approval

All research activities were conducted with ethics approval from the William Osler Office of Research Ethics (#18-0061), the University Health Network Research Ethics Board (#18-5667), and the University of Toronto Research Ethics Board (#37660).

Participants Sampling and Recruitment

There were 9 clinicians who were either frontline providers or administrators directly involved (ie, using the system in patient care or overseeing the TM in existing care workflows) in the implementation of the TM project and were invited via email to participate in the evaluation. Individuals were eligible to participate if they (1) were currently involved in the delivery

of TM in the integrated nurse-led care model and (2) could speak and read in English. To maintain anonymity, the participants were not specifically identified by role. However, the roles included NPs, an RN, a social worker, a dietician, a pharmacist, a kinesiologist, a clinical manager, and senior administrators. Written informed consent was obtained from all participants.

Data Collection and Analysis

Overview

A multimethod single-case study using an interpretivist paradigm was carried out to collect study data including in-depth interviews, supplemented with observations and questionnaires. All data were collected by the research coordinator (KG), an RN with frontline experience caring for patients with CCC and knowledge of diverse clinical operations using an interpretivist paradigm.

Key Informant Interviews

Qualitative in-depth interviews were conducted upon completion of the 6-month implementation. A semistructured interview guide was developed based on the 4 overarching constructs outlined in the NPT (Table 1) [38,40,43] and the study objectives. Interviews were conducted in person or over the phone based on the participant's schedule, lasting between 30 minutes and over an hour. The interviews were audiotaped and professionally transcribed verbatim. In all cases, the purpose of the interviews was stated elicit individuals' experiences and opinions about the implementation of TM in the nurse-led chronic care model and were aware that the interviewer was not involved in providing care services.

Table 1. NPT^a constructs and sample interview questions.

NPT construct	Construct definition	Interview questions
Coherence	Sense-making and understanding the purpose of the potential of the intervention	"Can you tell me about your role in the clinic? Can you tell me about your normal routine when you come into work? How do you compare TM ^b to the current practices delivering complex chronic care?"
Cognitive participation	Buy-in and decision to commit to the work of the intervention	"You have been part of the clinic, which is utilizing TM, what is your understanding of TM?"
Collective action	The work that team members do to engage with the intervention	"Tell me about your experience working with and using TM? Do you feel it offers my benefits that are valued by team members? Do providers agree on the intent and benefit of using TM? Can you describe if and how TM affected your interactions with the patients?"
Reflexive monitoring	Reflection and appraisal of the intervention	"In your opinion, has your delivery of the TM program changed over time? Do you feel TM has contributed to patient care and patient self-care in the CMC? ^c Are there factors that facilitate or inhibit TM in this care model? How could the TM system be changed or improved? How sustainable do you think the TM activities are in the long-term?"

^aNPT: Normalization Process Theory.

^bTM: telemonitoring.

^cCMC: Complex Medicine Clinic.

In Situ Observation

Participants were observed throughout the entire study period. The research coordinator was embedded within the team to collect data through observations and field notes, typically 2 out of 5 days a week during the 6-month study period.

Observations were made during patient visits, hallway conversations, team huddles, and group meetings to capture clinical discussions and workflows. Field notes were documented during the observations. The goal of this fieldwork was to generate comprehensive notes to better understand the

implementation of TM by the clinicians through observing workflows and operations.

Chart Review

A chart review was also performed to provide a clinical context for the complexity and acuity of the patient participants in this case. Clinical data included the number of diagnosed chronic conditions, number of medications per patient, and frequency of health encounters. Chart review metrics (ie, number of conditions, medications, and frequency of visits) were analyzed descriptively to understand the patient population and to inform observations, as well as interview questions.

Normalization Measure Development Questionnaire

The adapted Normalization Measure Development (NoMAD) questionnaire was administered to all participants upon study completion to supplement our understanding of the implementation processes in the nurse-led care model [44]. The 23-item NoMAD questionnaire represents a measure that was used to better understand participants' experiences with the implementation of TM in nurse-led care. Each question was adapted to the questionnaire to reflect the study's specific interventions. The word "telemonitoring" replaced the word "intervention" within the questionnaire. An email was sent as a reminder to complete the questionnaire during the last month of the study. Data within the NoMAD questionnaire were analyzed descriptively using absolute frequency and mean.

Analysis Approach

An interpretative description approach was used to guide the qualitative analysis [45,46]. Multiple coders worked together to review and code the transcripts inductively. A tabular matrix was created to define each construct and how it might relate to the project, which was then used to deductively analyze a detailed summary of the codes based on the 4 main constructs and subconstructs of NPT (Multimedia Appendix 1). For example, there was some discrepancy between several codes within the relational integration subconstruct and contextual integration subconstruct, which resulted in further refinement of the meaning in the NP-led chronic care context until consensus was reached. Following the analysis, key themes, emerging connections, and alternative explanations were discussed. Themes and subthemes were reviewed for feedback with 2 participants in person as a form of synthesized member checking [47]. As part of the iterative interpretative description

approach, other data sources from different clinical team members (ie, qualitative interview data, observation data, and the NoMAD questionnaire) were qualitatively analyzed for patterns and themes to make sense of the important ideas to be conveyed and access their meaning in a new context [47]. Furthermore, 2 researchers (KG and AS) independently read and reread the interview and observation memo transcripts and then met to discuss the findings until consensus was reached. Our intent was to compare codes with emerging themes and identify, if any, additional themes, data divergences, or other contextual factors related to the implementation. Convergence of the qualitative and quantitative data was examined by reviewing the results related to each NPT construct to further our understanding of the mechanisms that facilitate or inhibit TM of CCC in integrated nurse-led models of care.

Results

Overview

In total, 9 clinical team members agreed to participate in the implementation. However, 1 participant went on maternity leave shortly after the study started and therefore did not complete the questionnaire or participate in an interview. Another participant declined to participate in the postevaluations as they were not involved with the TM system in their role. Clinical team characteristics are listed in Table 2. In total, 86% (6/7) of the participants completed the questionnaires, and 100% (7/7) participants were interviewed about their experience. In addition, 2 (29%) participants were interviewed twice to clarify their statements and verify their intended meaning.

Table 2 presents the descriptive characteristics of the team. All the respondents were women. Overall, participants were highly experienced in their professional job category with the majority having >10 years of experience at the study institution and in their professional job category. Using the NoMAD general questions about the intervention, 67% (4/6) participants rated TM as familiar. In terms of coherence, most respondents agreed that TM was of value in their work (5/6, 83%), and all indicated that they would support TM in the future (cognitive participation). Interestingly, respondents had mixed opinions that TM could be easily integrated into the existing work (4/6, 67%). Regarding reflexive monitoring, most agreed that their feedback could be used to improve TM in the future (5/6, 83%).

Table 2. Clinical team characteristics.

Study ID	Age range (years)	Duration at study institution (years)	Duration in professional job category (years)	Current job category
CTM002	51-60	>15	>15	Frontline
CTM003	41-50	6-10	11-15	Frontline
CTM005	41-50	>15	11-15	Frontline
CTM006	31-40	<1	1-2	Frontline
CTM007	51-60	>15	3-5	Management
CTM008	61-70	>15	6-10	Management
CTM009	51-60	10-15	>15	Management

The following results present the perspectives of key team members involved in the implementation of TM within the integrated nurse-led model of care according to the NPT (Multimedia Appendix 2).

Coherence: Does TM Make Sense as Part of Nurse-Led Complex Chronic Care Delivery?

Introducing TM and How the Requirements to Implement TM Were Processed

The mechanism of coherence focused on introducing TM as an intervention to support complex care and understanding how TM workflows might affect patient care preferences, clinical workflows, and care delivery practices. Processing the steps involved in implementing TM as well as the potential benefits of addressing current care challenges within existing individual workflows in the nurse-led care model was the first step in *sense-making*. Participants described specific challenges in managing CCC before implementation, including relying on snapshot assessments during in-person visits, poor patient recall, and patient handwritten or device logs. Given their reliance on patient-reported histories, clinicians struggled to obtain consistent and often accurate health data between appointments:

[Patients] bring a log. We ask them to write it down and then they bring a lot to their appointments. Some patients are very good with that, some patients are not. It all varies from patient to patient. Some are very compliant, some are not. [CTM002]

Overall, participants found TM easy to understand and were familiar with its broad purpose. Several clinicians had previously used a TM system based on health coaching, allowing them to compare the new TM platform to their previous experience (ie, differentiation subconstruct) and envision the potential steps involved in this implementation. Some staff members felt that their complex patients may be apprehensive about TM technology. Clinicians wondered if their patients would use it and what kinds of benefits might be realized:

I think because we've had a long experience implementing Telehomecare...there's a lot of similarities, there are differences in the case of Medly. I think the basic monitoring of patients is the same, it's what you do with the information, who it's going to, and how you react to it. The kind of response it generates...I think this is interesting because we're looking at multiple conditions. [CTM008]

Envisioning the Workflow Changes Required for TM Varied by Role

Individual participants reported similar understanding in providing TM for CCC (ie, providing visibility to the ongoing health status of their complex patients at home regularly might improve care overall). This contributed to a communal sense-making of how TM would work in a unique clinical model:

The ability to access patients virtually without them having to come into the hospital setting to receive care from a healthcare provider. [CTM009]

Although all participants agreed on the purpose of TM, they had different views on the technology, the workload, and how each might affect their role (ie, the individual specification subconstruct). For the pharmacist, preexisting routines involved calling the patients weekly to obtain readings. The pharmacist thought that using TM would eliminate this process, creating more work time for other clinical responsibilities. By differentiating the workflow according to individual clinical responsibilities, the meaning of each clinician's role with regards to TM began to make sense:

I think because we've had a long experience implementing [TM systems]. While there's a lot of similarities, there are differences in the case of [this TM system]. I think the basic monitoring of patients is the same, it's what you do with the information, who it's going to watch it, and how you react to it. [CTM007]

Field observations further solidified strong support for TM in CCC from senior leadership and the NP in charge by discussing TM and evaluating TM workflows and individual workloads. One administrator was observed to describe their support for clinician engagement with TM and facilitation of the work of TM in nurse-led care. Clinicians seemed to internalize the collective effort based on how TM was perceived to address the current care gaps (ie, monitoring escalating acuity and providing consistent patient communication) faced in practice, thus making a collective decision to implement TM.

Cognitive Participation: Do Clinicians Engage With TM in Nurse-Led Chronic Care Delivery?

TM Training Varied by Clinical Responsibilities

Engagement with TM relied on clinicians to invest time in the go-live effort as well as throughout its implementation (ie, initiation subconstruct). During the implementation, the team engaged in multiple training sessions tailored to their roles. The process of learning to use TM centered around the individual's workflow that varied among clinicians. The NP spent time with the study coordinator learning to use the system, and the RN spent time shadowing at another site, observing not only their unique site-specific workflows but also the system in the context of different clinical responsibilities (ie, enrollment subconstruct). Having the bulk of TM responsibilities within the RN workflow was initially described as stressful because of perceived added workload:

The first month was stressful and then that, it eased out... [CTM002]

Other participants felt that the training was "straightforward" comparing similarities between the current care practices and TM tasks. This motivated clinicians to incorporate TM into daily work (ie, initiation subconstructs):

It was similar because we do ask them to check weight...blood pressure daily...and check their sugar, especially the patients who are on insulin. [CTM006]

Aligning Workflows Supported a Willingness to Engage With TM and Clinical Buy-in

Before implementation, an appointment would include an assessment of the patients' history, conditions, medications, and recent physiological trends. Clinicians would rely on patient-reported information, in-person physiological measurements, and devices to evaluate the patient status. Having remote readings readily accessible on a web-based dashboard in part legitimized the decision to invest time to align TM practices in their workflow and envision the future workflow benefits (ie, legitimation subconstruct). Aligning TM-embedded workflows with TM responsibilities facilitated clinician engagement in practice:

I have to look at the readings before we come up with a plan, whatever concerns there are, which part of the day their readings are up high and is it related to their meals? Are they carb loading, etc.? So that all depends on the readings. If I don't have that info, my assessment is incomplete and if my assessment is incomplete, I'm not able to make a complete, more comprehensive care plan for the patient and with the patient. [CTM005]

In determining the overall fit of TM within the current workflow practices on a day-to-day basis, participants felt that TM would be a good fit, particularly because of more frequent patient monitoring (ie, activation subconstruct) without creating additional appointments.

Collective Action: How Can Multicondition TM Be Successfully Embedded in Nurse-Led Chronic Care Delivery?

Alert Management Aligned Well With Several Clinical Roles

Team members described how physiological readings were monitored within the integrated nurse model (ie, interactional workability subconstruct). TM alerts aligned well with certain more traditional RN responsibilities, such as clinical triage. The RN was responsible for monitoring the dashboard (ie, skill set workability subconstruct) and triaged relevant readings to the NP or other clinicians as clinically necessary:

[Name] used to keep tab on all the patients, on the alerts also...if she thought a patient would benefit from my following up or my talking to the patient, she would let me know and I used to speak with the patient on the phone and not wait for them to come in the clinic. So that was really helpful process. We could immediately tackle if there was any issue and not wait for the patient to actually come in so find out something was going wrong. [CTM006]

Although the primary responsibility of monitoring was held by the RN, it was apparent that other clinicians were using TM routinely in practice (eg, the pharmacist and dietician). By sharing patients on TM, the team suggested that the workload could be more easily divided among other members of the team, given the similar clinical scope of others' responsibilities in this care model. Communication of alerts would occur through

normal triage methods, hallway check-ins, or daily clinical huddles. Given the similar skill sets and clinical responsibilities, the pharmacist noted that having alert emails would also improve their workflow:

I don't have the emails so I think that would be of benefit. But I think that was one of the things that I kind of said in terms of improving the workflow. Right now, that's not my responsibility to log onto see their alerts, so I think it would be nice to have more inclusivity of the entire team that is following some of these patients. [CTM003]

TM Facilitated Sharing of the Clinical Workload

Clinicians frequently reviewed the TM dashboard, discussing TM during in-person patient appointments and during clinical case-review sessions with the entire team. For example, the responsibilities associated with the RN's TM work were successfully transferred to the NP as part of a normal clinical handover (ie, skill set workability subconstruct) when the nurse went on a holiday. When probed, how this transition occurred, they described the monitoring responsibility as part of all other clinical responsibilities (ie, contextual integration subconstruct):

If [nurse name] is not here, then I just take over monitoring [TM name] when she is gone. [CTM006]

Participants felt that TM facilitated communication within the model and between individual clinicians as they could all review the clinical dashboard, discuss the acuity and severity of the alert, and discuss the most appropriate clinical response (ie, contextual integration subconstruct):

It was actually the nurse mostly, [Name]. She was keeping a check on all the patients regularly and if she noticed something to do with patient blood sugar or their weight, those things, she would let me know and then I would call the patient back and would be working on that. That's how we used to do it. [CTM005]

In the new care model, participants felt that patients were more clinically acute than originally anticipated in the care model, often requiring significant nursing interventions (ie, intravenous medications or urgent bloodwork) during office visits. The work associated with TM (follow-up, titrating medications, referrals, etc) in combination with often unexpected and acute clinical interventions, was such that on several occasions an additional RN was brought in to implement additional nursing interventions (intravenous medications, electrocardiogram, and hypoglycemia management).

Knowing the Patient, Their Conditions, and Clinical Context Facilitated Active TM

Knowledge of the individual patient, their clinical conditions, and their specific clinical context was considered essential for successfully embedding the intervention in the nurse-led team (ie, contextual integration subconstruct). In one case, a TM alert identified a previously stable patient who was quickly decompensating. On the basis of an alert, the patient was brought in for an assessment and subsequently underwent emergent stent insertion. In this case, the combination of fluctuating weight

and symptom reporting resulted in clinical action by the nurse-led team, which the care team deemed to have potentially saved the patient's life:

...I talked to [name] (the NP) and we brought him in today...We had to send him over...to the cath lab. I think he will be staying a couple days, so he won't be taking readings for the next few days. [CTM002-memo log]

In another case, a patient was alerting frequently. However, after reviewing the readings and current trends, the team was able to identify that the patient had not answered the symptom questions as intended:

In the beginning I was calling him every day but now I know...once he put them in, he continues to do that. So, I don't call him every day now even if I see that specific alert, unless like I see ok he's having chest pain. If there's no change in your condition, don't answer yes, but he still continues sometimes. So now I know (that with him). [CTM002]

Integrating TM in the social context of care involved patient caregivers as well. Clinical staff reported that caregivers would call the team about a TM reading or alert, indicating that they were also involved in TM, such as monitoring trends at home. This additional opportunity for communication, which otherwise would not likely have occurred (ie, without TM), facilitated providers' understanding of the clinical context and continued use of the TM system as a tool to conduct complex care.

Reflexive Monitoring: What Can Be Learned of Overall Implementation to Increase the Spread of TM-Enabled Nurse-Led Models of Integrated Care for Patients With CCC?

TM Enhanced Comprehensive Care of Patients With CCC

The ability to track and trend multiple readings over time, particularly those in the past, was reported as clinically informative (ie, systematization and communal appraisal subconstructs), changing the overall clinical workflow of care delivery in this model:

Even up until December, I was reviewing back, their blood pressure [from] back in August... [CTM006]

Although specific health outcomes were not evaluated, clinicians reflected on how patients seemed to improve over time, which indicated the feasibility of TM within a nurse-led model from the provider's perspective. All clinicians felt that the ability to monitor their acute patients more frequently was important; however, monitoring patients after intravenous interventions or other in-office procedures was thought to be particularly supportive in mitigating unanticipated changes in health status (ie, communal appraisal subconstruct):

It's definitely been positive, for sure reduced emergency visits, because the alerts have triggered that connection. It's also influenced – some of the ways that they're reacting to these very complex patients...They know now that they can probably avoid

an admission, they get an alert, a patient's put on some weight or starting to feel breathless... [CTM007]

Clinicians described faster response times to TM than originally intended, suggesting that TM for CCC was successfully embedded as part of their normal work. This frequency of increased clinical oversight using TM contributed to sustained patient-provider communications:

I think [we responded] immediately. The moment we used to see any alert which needed attention, we used to do immediately. We never waited. [CTM005]

At other times, alerts identified whether a patient had forgotten to take their readings or missed a medication, which otherwise may not have been noticed, indicating that TM enabled a higher level of care. In a few instances, participants found that patients depended heavily on the clinical team to reach out. For example, TM would prompt the patient to call the clinic if an alert was generated, but this did not happen routinely, in part because clinicians responded very quickly.

TM Provided a Reliable Routine Source of Health Data in Complex Chronic Care

TM provided reliable clinical data on patients, which were previously not available or consistent (ie, systematization subconstruct):

Some of our patients, they don't record their blood pressure or they don't bring their glucometers, it's not easily known, so [with TM name] all the practitioners were able to access it and they did it without hesitation...sometimes they would forget to bring their readings or they don't take their readings; now it's all there, so it's very convenient. [CTM005]

Clinicians reported that TM provided additional contextual information before a patient's appointment, which helped with the *prep* work of composing a clinical history and care plan. This enabled more clinically informed patients visits and made good use of the time allotted for structured appointments with each provider:

I think that allows me to do my prep work...I usually log on and get their trends, get all that information, so it's a little bit more accurate, and I have time to sort of process it a little better than if they were to bring it in writing. [CTM003]

Clinicians also described a better understanding of their patient's health status when using TM in practice, demonstrating the relation integration of TM:

We're able to follow them [the patients] more closely and if we get alerts that we would call them, it's another sort of like a layer of protection in terms of if they're running into trouble then we can follow or provide care. [CTM003]

In terms of the overall patient population characteristics, associated clinical workload, and evaluation of how reliant (ie, embedded) TM had become in the clinic after 6 months, researchers asked what percentage of the other patients in their care might routine TM also be feasible. The overall response

by clinicians was that they could envision most of their CCC patients benefiting from TM:

I think majority of our patients can be on [TM name]. It worked well for almost everyone we added. [CTM006]

Reconfigurations Suggested for TM Implementations in NP-Led Complex Care Models

In this implementation, the TM platform monitored 3 conditions (HF, HTN, and DM). However, clinicians identified several other conditions as highly prevalent within their complex patients (ie, reconfiguration) but also in the broader chronic care population. Opportunities to monitor mental health symptoms and/or conditions were similarly identified across participants:

We have a lot of people with anxiety and even depression, it's very prevalent in our patient population. You know we have the social worker for that very reason...Even if the Medly could have some questions about their mental well-being, I think that would help us. [CTM 006; CTM006-memo log]

The inability to monitor respiratory status in patients with chronic obstructive pulmonary disease (COPD) was identified as an area that would be clinically helpful in addition to the existing TM platform. Other routine metrics such as temperature have also been identified as important to monitor in future TM implementations:

For COPD, the temperature would be really helpful. Especially now, we are going into the winter season, it would be really helpful to have temperature for those patients [when they get flu-like symptoms] maybe even those with CHF as well... [CTM006]

Clinicians felt that visual differentiation of alerts by color (ie, critical vs noncritical) would be helpful in both the dashboard and email notifications, thereby designating a visual cue to quickly evaluate alert severity (ie, reconfiguration). The incorporation of TM into the routine care context in this model (ie, contextual integration) is such that a visual cue to identify critical needs could improve the efficiency of the monitoring process:

if we could get the system to identify the alert severity by color that would be very helpful...even if I only have just enough time to look at it quickly, I can see who is critical. [CTM002-memo log]

Discussion

Principal Findings

This study explored the perceptions and experiences of clinicians regarding the implementation of a TM platform for complex patients as part of a larger feasibility study in an integrated nurse-led model. Our findings suggest that TM made sense to the colocated nurse-led team by considering individually and collectively how this work might affect their current care preferences, workflows, and existing delivery practices. Team members were willing to engage with the intervention as it aligned with tasks the team had already asked patients to do,

such as monitoring blood pressure or weight at home regularly. A few clinicians had prior experience with the implementation of a TM system, which likely influenced their willingness to engage in and adopt the *Medly* system, which was evidenced by individuals comparing their experiences. Continuous patient engagement with the clinicians occurred frequently using TM and was considered fundamental in this case. Previous literature has indicated that regular interactions facilitated continued monitoring, further dialogue around disease management, documentation of new symptoms, and opportunities to identify health issues before they become critical [48,49].

TM aligned well with traditional RN responsibilities of assessment, communication, evaluation, triage, and delegation [50-52]. However, in this case, the RN had significant clinical responsibilities in addition to those of the TM, which may or may not be unique to other complex chronic disease management models. Previous research in TM of single conditions has suggested that nurses are well-positioned to manage TM requirements owing to the nature of the nurse-patient relationship [53], ability to analyze and apply TM data sources, multitasking, and providing a service that is fit for purpose [51,52,54]. However, other clinicians, particularly the pharmacist and dietician, routinely used TM data throughout the implementation in practice, suggesting that these roles might be better used in TM implementation in future. Previous literature has supported the greater involvement of pharmacists, given their growing scope of practice [55]. Although the scope of pharmacists varies widely across Canadian provinces, the support for an expanded scope in chronic disease populations has gained traction [56,57] given their in-depth knowledge of medication management, pharmacological interactions, as well as sign and symptom assessment and evaluation.

In terms of technology, several reconfigurations have been proposed to improve the existing platform. At the time of this study, a comprehensive mental health module was not available despite frequent links in the literature to conditions such as anxiety and depression in patients with CCC [50,58,59]. However, given our findings in support of this concept, we would strongly encourage a mental health component within the existing platform and other TM implementations targeting chronic care. Other conditions, such as COPD and chronic kidney disease, are important for monitoring in future TM implementations, as they are highly prevalent in the population.

During the study, the team continued to identify other patients who might have benefited from TM but were not eligible because of the preapproved participant numbers. This appears to suggest that TM was successfully embedded within routine practice in NP-led care, and that the full benefits of TM-enabled NP-led integrated care models have yet to be fully realized for patients, families, and health care systems. A multisite implementation with larger participant volumes is needed to evaluate the effectiveness of individual health outcomes and the organizational impact of this model of care delivery.

Implementation Learnings

Using NPT to evaluate the feasibility of implementation provided a foundation that can be used to enhance future research implementations as nurse-led care models expand and

virtual care solutions such as TM for patients with CCC become more prevalent. Our findings suggest that TM-enabled nurse-led care is feasible, as demonstrated by its successful implementation in an ambulatory chronic care model. We offer the following learnings for clinicians, administrators, researchers, and policy makers to consider in developing and spreading nurse-led models for patients with CCC.

1. TM of physiological metrics for HF, HTN, and DM could be used in clinical practice, as monitoring aligned well with existing complex care practices.
2. RNs may be able to manage TM, in addition to their clinical responsibilities, in a nurse-led complex care model with a colocated multidisciplinary team.
3. The role of pharmacists in monitoring patients through TM should be considered because their responsibilities align well with TM triage and assessment. They could delegate tasks to the more responsible provider, in this case the RN or the NP as required.
4. TM-enabled workflows in chronic care still require complex needs to be triaged and directed as clinically necessary to the most responsible care provider (ie, the NP), as this maintains the centrally coordinated approach inherent within nurse-led care models.
5. TM platforms for complex chronic patients could consider incorporating the following:
 - Methods of monitoring COPD and chronic kidney disease as these conditions are prevalent in the population of patients with CCC.
 - Monitoring mental health conditions, particularly for anxiety and depression, could support diverse complex care needs.
 - Easy to read, visual alert systems, including the use of color-coding systems to facilitate quick clinical evaluations of acuity and severity.

Strengths and Limitations

This study had several notable strengths. First, TM was embedded into an existing nurse-led care model and not into a pilot clinic, a purposed clinic model, or a clinical model, contributing to the feasibility of TM in a real clinical environment that is actionable and informative. Second, the use of NPT strengthened the research by characterizing the core process elements of embedding TM in the implementation process, enabling researchers to describe the *work* involved in implementing TM in the NP-led model and contributing to existing research in the chronic care space. Third, unlike other TM implementations, patients were onboarded during regular clinical hours, avoiding additional appointments for TM onboarding or more expensive at-home visits for equipment

setup and removal. Finally, patients within the complex care model were at times more medically acute, requiring a higher care level than envisioned initially in this outpatient model. Given the diversity and complexity inherent in multiple interacting diagnoses, the ability to manage this level of complexity using TM highlights the feasibility of TM for CCC in a nurse-led environment.

There were also several limitations to this study. First, interview data were collected upon study completion, and therefore, it was at times difficult to analyze clear differences in how the work was conducted (ie, mechanisms of collective action) and evaluation of the work processes (ie, reflexive monitoring) despite frequent clinical observations. Second, this study was conducted at a single site, but NP-led or nurse-led models of care could differ significantly in the scope of the care model, clinical roles, or target populations, thus hindering generalizability. Third, RN in this clinic had over 10 years of nursing experience, which may or may not be the case in future implementations. Finally, the NP-led care model was located within a large, multisite hospital system with access to existing clinical resources onsite, including a diagnostic imaging suite, laboratory, and urgent care center, and therefore, likely has access to clinical resources. This may have influenced the clinical workflow and normalization of TM in this case because access to these resources may not be generalizable to other sites. Other specialists were also available to support timely service delivery and provide additional clinical support to the clinic that likely shaped in part the overall clinician outlook of embedding TM in everyday routine practices.

Conclusions

A TM platform for complex chronic patients was successfully implemented within an NP-led integrated care model. From the perspective of clinicians and administrators, the process of normalization occurred because TM aligned well with existing complex care practices of frequent assessment and evaluation. Similar to other TM implementations, RN responsibilities within the TM system aligned well with the existing practices of clinical triage, assessment, and evaluation. However, our results demonstrate that the role of pharmacists and dietitians within the infrastructure of an ambulatory NP-led model may also align well with TM responsibilities. The feasibility of a new model of TM-enabled care for CCC was indicated in this study, which provides evidence that such models of care should be further investigated to determine their effectiveness in improving clinical management and better patient outcomes. Our research also provides theoretically informed lessons and recommendations that can be applied to future implementations and studies.

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Conflicts of Interest

ES is considered one of the inventors of the Medly system under the intellectual property policies of the University Health Network (UHN), and may benefit from future commercialization of the technology by the UHN.

Multimedia Appendix 1

Matrix of the operationalization of constructs and subconstructs of the Normalization Process Theory.

[[DOCX File, 15 KB - nursing_v5i1e36346_app1.docx](#)]

Multimedia Appendix 2

Themes from clinical team members.

[[DOCX File, 18 KB - nursing_v5i1e36346_app2.docx](#)]

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Abbreviations

CCC: complex chronic conditions
COPD: chronic obstructive pulmonary disease
DM: diabetes mellitus
HF: heart failure
HTN: hypertension
NoMAD: Normalization Measure Development
NP: nurse practitioner
NPT: Normalization Process Theory
RN: registered nurse
TM: telemonitoring

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Original Paper

Patients' Experiences of Care With or Without the Support of an Interactive App During Neoadjuvant Chemotherapy for Breast Cancer: Interview Study

Maria Fjell¹, RN, PhD; Ann Langius-Eklöf¹, RN, PhD; Marie Nilsson¹, MSW, PhD; Kay Sundberg¹, RN, PhD

Department of Neurobiology, Care Sciences and Society, Karolinska Institutet, Stockholm, Sweden

Corresponding Author:

Maria Fjell, RN, PhD

Department of Neurobiology, Care Sciences and Society

Karolinska Institutet

Alfred Nobels Allé 23

Stockholm, 14183

Sweden

Phone: 46 8 524 837 42

Email: maria.fjell@ki.se

Abstract

Background: Neoadjuvant chemotherapy (NACT) is often recommended for patients with breast cancer with more aggressive tumor characteristics. As with all chemotherapies, they can cause substantially disturbing symptoms. Most patients receive their treatment as outpatients, which means that they must take responsibility for self-care and management of symptoms at home for a long period. Patients with breast cancer undergoing chemotherapy may not receive sufficient support for management of treatment-related symptoms. For patients undergoing NACT, it has been concluded that information and supportive needs are not always met. In our previous study, the use of mobile health to support patients with breast cancer undergoing NACT reduced symptoms during treatment with the support of an interactive app. Therefore, it is important to investigate how patients experience their care and explore any specific contribution that the app may have brought in care.

Objective: This study aims to explore patients' experiences of care with or without the support of an interactive app during NACT for breast cancer.

Methods: This qualitative study was part of a larger randomized controlled trial and included 40 individual face-to-face interviews conducted with patients in both intervention and control groups after the end of NACT. The interviews were audio recorded, and the data were analyzed inductively using thematic analysis.

Results: No major differences in experience of care were observed between the groups. A total of 4 overarching themes emerged. In the first theme, *The health care context*, patients described care as assessable, although sometimes there was a lack of time and continuity with nurses. In the second theme, *Being a recipient of care*, it emerged that the patients experienced a warm and positive atmosphere at the clinics. In the third theme, *Taking an active role as a patient*, patients described being active in searching for information and various ways of participation in their own care. In the fourth theme, *The value of the app*, patients who had used the app experienced it as a complementary source of information, creating a sense of security. Using the app provided patients with the support of being contacted by a nurse if needed, enabled self-care, and facilitated the planning of daily activities.

Conclusions: Overall, patients' experiences of care were similar and mostly positive. However, for patients using the app, it provided additional support for information and self-care and enhanced participation in their own care. The easy access to a nurse gave patients a sense of security. The findings suggest integrating an interactive app as a complement to standard care to support patients with breast cancer during treatment.

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KEYWORDS

breast cancer; neoadjuvant chemotherapy; experiences of care; mobile health; mHealth; mobile app; patient participation; mobile phone

Introduction

Patients with breast cancer with more aggressive tumor characteristics are often treated using neoadjuvant chemotherapy (NACT), which is administered before surgery [1,2]. The main purpose of NACT is to reduce the tumor size, known as downstaging. This may allow less extensive surgery on the breast and axilla, thereby facilitating breast-conserving surgery instead of mastectomy, as well as improve cosmetic outcomes and reduce postoperative complications such as lymphedema [3,4]. NACT also allows early treatment of possible micrometastases and provides valuable prognostic information regarding the effectiveness of treatment [1,5]. The treatment is considered both safe and effective [1,6-8]. However, as with all chemotherapies, it can cause substantial physical and psychological symptoms [9,10].

In general, most patients with breast cancer receive treatment as outpatients, which means self-care and management of symptoms at home for a long period [11,12]. This means that patients are expected to participate in their own care, and this involves patient learning to obtain knowledge and skills to manage illness and symptoms in collaboration with the nurse [13]. It also includes a caring relationship between the nurse and patient built on reciprocity and trust [14]. However, it is evident that patients have different needs concerning participation [15]. There are patients who are satisfied with not being so active but also those who express that they want to participate in their own care, and for achieving that, there are both facilitators and barriers [16,17]. Participation should be considered on an individual basis, according to the patient's specific situation [18].

In contexts with short hospital stays and outpatient treatments, patients need to actively engage in self-care, but they need support in managing this condition [13,19]. Previous studies have shown that patients with breast cancer may not receive sufficient supportive care for treatment-related symptoms during chemotherapy [20,21]. Studies regarding patients' needs during NACT are few, and they report that information and supportive needs are not always met [22,23]. This may result in impaired well-being, reduced health-related quality of life, distressing visits to emergency departments, hospitalizations, and poor treatment outcomes [22,24]. Therefore, ensuring that the care needs are identified, assessed, and managed is imperative.

Technical advances in the field of mobile apps and web-based systems have led to an increased use of mobile health (mHealth) to improve the delivery of health care and to support patients with cancer [25,26]. Studies on the use of such technology have shown decreased symptom burden, improved health-related quality of life, and increased survival [26,27]. We developed an interactive app (Interaktor) for smartphones and tablets, with

the intention of supporting patients in real time during cancer treatment regarding symptom management [28]. The patients showed high adherence and engagement in using the app, which promoted continuous contact with the nurse [29] and led to less symptom burden during treatment of prostate and pancreatic cancer [30,31]. In a randomized controlled study using the Interaktor app during NACT, the results showed lower symptom prevalence and symptom distress and better emotional functioning than the control group 2 weeks after the end of treatment [32]. The next step in evaluating the use of the app was to explore whether the app contributed to standard care in any specific way. This study aimed to explore patients' experiences of care with or without the support of an interactive app during NACT for breast cancer.

Methods

Study Design

In this study, a qualitative design was applied to explore patients' experiences of care and the significance of using the app. This study is part of a larger randomized controlled trial (RCT; ClinicalTrials.gov NCT02479607) evaluating the Interaktor app in patients undergoing NACT for breast cancer [28].

Sample and Setting

In the larger RCT, 149 patients diagnosed with breast cancer and treated with NACT were included in an intervention group (n=74, 49.7%), using the app Interaktor in combination with standard care, or a control group (n=75, 50.3%), only receiving standard care [32]. Inclusion criteria were as follows: aged ≥ 18 years, diagnosed with nonmetastatic breast cancer planned for NACT, able to read and understand Swedish, and no medical condition of cognitive dysfunction. The trial was conducted at 2 university hospital oncology clinics in Stockholm, Sweden.

When agreeing to participate in the RCT, the patients were informed by the researcher that they could later be contacted and invited to participate in an interview study about their experiences of care during NACT and the significance of the app among patients who had used it during the study. Three months after the end of NACT, a consecutive sampling strategy for the interviews was adopted in the first 20 patients, with an equal number of patients from both the intervention and control groups at the 2 hospitals. Subsequently, a strategic sampling strategy was used to capture a range of patient characteristics based on group, age, marital status, educational level, occupation, and treatment duration in weeks. A final sample of 40 patients from the intervention (n=21, 53%) and control (n=19, 47%) groups was included in this study (Table 1). There were no statistically significant differences in the sociodemographic and clinical characteristics at baseline between the 2 groups.

Table 1. Sociodemographic and clinical characteristics at baseline (N=40).

Characteristic	Intervention group (n=21)	Control group (n=19)
Age (years) at inclusion, mean (SD; range)	51.7 (12.5; 30-73)	54.2 (13.5; 35-77)
Marital status, n (%)		
Married or cohabiting	17 (81)	14 (74)
Living alone	4 (19)	5 (26)
Education level, n (%)		
University	13 (62)	11 (58)
Secondary school	3 (14)	6 (32)
Primary school	5 (24)	2 (10)
Occupation, n (%)		
Working	16 (76)	13 (68)
On sick leave	2 (10)	1 (5)
Retired or unemployed	3 (14)	5 (26)
NACT ^a duration in weeks, mean (SD; range)	15.3 (1.9; 11-20)	15.6 (2.5; 11-23)

^aNACT: neoadjuvant chemotherapy.

Standard Care

Standard care consists of treatment and care according to national care guidelines, including visits to the physician at the oncology clinic before each chemotherapy treatment, approximately every second or third week, depending on the chemotherapy regimen. Moreover, the patient is assigned a contact nurse who has the overall responsibility for the patient throughout the care chain. The contact nurse provides the patient with information about the treatment and the planning of care during a scheduled visit before the start of treatment. During treatment, the contact nurse supports patients with information, establishes a care plan, assesses the patient's symptoms and needs, and takes actions based on these symptoms and needs. In case of questions or concerns related to treatment, the contact nurse is available during office hours. During other hours, patients are referred to the oncology emergency unit or inpatient or emergency department, depending on which hospital the patient is being treated at [33].

The Intervention With Interaktor for Patients With Breast Cancer During NACT

The content of Interaktor for NACT was developed through literature reviews, clinical guidelines, and discussions and consultations with health care professionals [32]. The app, running on a smartphone or tablet, has several features: self-reporting of 14 commonly prevalent symptoms during chemotherapy, the transfer of the reported symptoms to a secure server, a web interface where a nurse can monitor the patient's reports in real time, a risk assessment model for symptoms of

concern that sends alerts to a nurse at the clinic by an SMS text message, and continuous access to evidence-based self-care advice and relevant websites related to assessed symptoms and other areas of concern. Moreover, the patients could monitor their own reported symptom history over time in graphs. When alerted, the nurse calls the patient to discuss the symptoms and their management. If an alert is triggered, a notification suggests that the patient reads the related self-care advice [34]. During the RCT, the patients reported symptoms daily on weekdays (8 AM-4 PM), starting on their first day of NACT and continuing until 2 weeks after the end of NACT, approximately 18 weeks in total. More details and illustrations of the app have previously been presented [28].

Data Collection

Data collection for this study was conducted between January 2016 and August 2017. The interviews were conducted by the first and third authors (MF and MN) and an additional researcher. All interviews took place in a secluded room at the 2 oncology clinics 3 months after the end of NACT. A semistructured interview guide was used, covering different aspects of patient participation such as the relationship between patients and nurses, patients' information needs, self-care, and caretaking [18,35]. In addition, the patients from the intervention group were asked about the significance of using the app during treatment. The patients were asked to speak as freely as possible around each question, and depending on the extent of the answers, follow-up questions were used (Textbox 1). The interviews were audio recorded and lasted between 14 and 61 minutes, with a median duration of 27 minutes.

Textbox 1. Interview guide.**Question and follow-up questions:**

1. How did you experience the contact (care relationship) between you and the nurse during the treatment period?
 - How has it been? Give examples.
 - Has it come about naturally or have you and/or your relatives been forced to bear the weight of your care? Give examples.
 - Has the nurse considered your experiences/wishes about your care? Give examples.
 - Did you get help when you needed it? Give examples.
2. Do you feel that you have received enough information regarding your care and treatment? Give examples.
 - How has the information been provided (written, verbal, over the phone, or during visits)?
 - When was the information given?
 - Was the information provided in such a way that you understood and could absorb it? Give examples.
 - Did you lack any information? Give examples.
3. How did you experience your encounters with the nurse?
 - Were you given enough time with the nurse?
 - Did you feel you were taken seriously/respected? Give examples.
4. Have you been involved in your care?
 - Can you describe how you have been involved or not involved?
5. Was there a dialogue in your meetings with the nurse? Give examples.
 - In what way have you had the opportunity to express how you wanted your care/treatment to be?
 - Have you had the chance to ask questions or express concerns? Give examples.
 - Has the nurse considered any of your experiences/wishes in the planning of your care? Give examples.
6. Have you received advice and help on how to treat symptoms or other concerns? Give examples.
 - Did the nurse explain the cause of the symptoms? Give examples.
 - Did the nurse explain how the symptoms should be managed? Give examples.
 - How did you experience the information given by the nurse?
 - Did the advice help? Give examples.
 - Did you get help with other basic needs (eg, sick leave and counseling)? Give examples.
7. Is there anything you would like to change in health care? Give examples.
8. What significance did the app have for you during the treatment? (Note: this question concerns the intervention group.)
 - What significance did the app have for your involvement in care?
9. Is there something you would like to add before we finish the interview? Give examples.

Ethics Approval

This study was approved by the regional ethical review board of Stockholm, Sweden (registration numbers 2013/1652-31/2 and 201712519-32).

Data Analysis

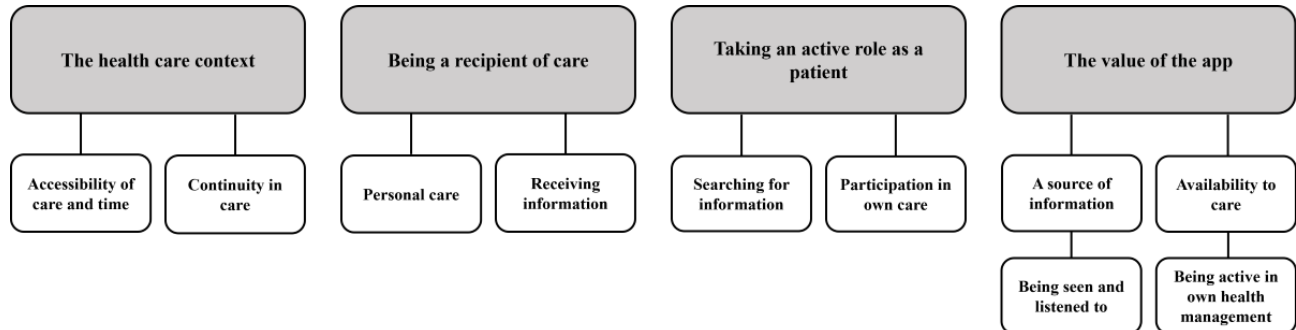
The interviews were analyzed with an inductive approach using thematic analysis described by Braun and Clarke [35,36]. The recorded interviews were transcribed verbatim, and the texts were read several times to become familiar with the data as a whole. Each group (intervention and control) was analyzed separately by the first and second authors (MF and ALE).

Statements from the patients in agreement with the study objective were systematically coded throughout the entire data set of each patient and transferred into a coding sheet. A code consisted of a few words or whole sentences. The codes from each group were then discussed by the 2 authors. As there were few differences in the codes concerning experiences of care between the 2 groups, the codes were merged into one coding sheet and tagged with an identification so that they could be distinguished. The analysis was continued by sorting the matching codes from both groups into areas. The areas were reviewed so that they covered all codes. Subsequently, the areas were analyzed into themes. The themes were then discussed, reviewed, and revised several times to ensure that they worked

well in relation to the areas with included codes. Finally, the themes were defined, named, and renamed, resulting in 4 overarching themes and 10 subthemes (Figure 1). Throughout the entire analytic process and during the writing of the

manuscript, all authors (MF, ALE, MN, and KS) continuously discussed the analysis to increase trustworthiness. To illustrate the findings, examples of individual quotes from patients are presented in the Results section.

Figure 1. Overarching themes (gray rectangles) and subthemes (white rectangles) identified through the thematic analysis of interviews with the patients (N=40).



Results

Overview

Regardless of whether the patients had used the app, few differences emerged in the patients' experiences of care within the themes, and both groups reported both positive and negative experiences. The descriptions of patients' experiences of care are presented in three overarching themes: *The health care context*, *Being a recipient of care* and *Taking an active role as a patient*. The significance of the app for patients is described in the overarching theme *The value of the app*.

The Health Care Context

Accessibility of Care and Time

Patients who had experienced accessibility to care knew who they should contact when needed, and they stated that it had been easy to get in touch with the nurse. A patient stated the following:

I had all the contact information I needed. If there was something acute or if I needed contact during the weekend, I had information on where to call and reached the right department instantly. So, it has really been a comfort. [Patient 53, Intervention group]

The patients said that they had received sufficient time from the nurse during visits or over the telephone. Patients who had experienced accessibility difficulties described that they had not received specific contact information, and it was difficult to get in touch with the nurse owing to staff shortages. Sometimes, their calls were returned several days later or not at all, leading to frustration. This was described as follows:

It was hard not being able to get in direct contact with the contact nurse...I was frustrated having to wait so long to be called. [Patient 5, Control group]

Occasionally, patients did not get enough time to consult with the nurse or the opportunity to ask questions during visits or over the phone.

Continuity in Care

Having a contact nurse was valuable for good continuity and was a great support during the treatment period, as exemplified by the following quote:

Having the same contact nurse was a comfort that meant a lot...everything became easier when I met familiar faces. [Patient 6, Control group]

Lack of continuity was described as having to meet too many different nurses and physicians or not knowing who their contact nurse was, which in turn led to confusion and feelings of insecurity regarding whether the nurse was in control or not. A patient described this as follows:

It was a bit confusing because I had a change of contact nurse four times and I have had four different physicians. There has been no continuity if you know what I mean. [Patient 58, Intervention group]

Being a Recipient of Care

Personal Care

The atmosphere at the oncology clinics was perceived as friendly, positive, confirming, and warm, which was not commonly experienced elsewhere. The patients could laugh and have fun with the nurse even though they were receiving treatment for cancer. A good dialogue with the nurse where both parties could ask and answer questions as well as having discussions even if they had different opinions were considered crucial. The patients described being listened to and treated with respect and empathy by the nurse, which led to trust, safety, and encouragement to keep up with treatments. The following quote describes how a patient experienced it:

They told me that we will make sure this becomes a parenthesis in your life. And exactly those words I took note of, which made it feel like there was a positive future in some way. [Patient 15, Intervention group]

Negative experiences such as a sense of coldness and not being taken seriously were also described:

I felt a sense of coldness in the beginning when I needed a hug instead. [Patient 44, Control group]

Experiencing a lack of dialogue about symptoms or concerns or having to remind the nurse repeatedly regarding, for example, booking appointments or referrals to counseling or prescriptions of medicines, gave feelings of being only one in the crowd.

Receiving Information

The patients were generally satisfied with the verbal and written information they had received as well as answers to questions about the treatment and related symptoms, self-care, and future planning. This created a notion of being prepared and knowing what to expect during treatment:

I never felt anxious or nervous because I knew what would happen and how I might feel. [Patient 3, Control group]

Sometimes, there was a lot of information, which was hard to take in and keep track of. In contrast, some considered the information to be insufficient in certain areas or felt that they had to nag for answers to their questions. On a few occasions, patients felt that information was withheld regarding why NACT was chosen for them specifically instead of surgery and how the treatment affected the whole body. As a patient stated the following:

I do not think the whole picture of my disease was explained to me. I had the feeling of being withheld information...I wanted to know everything, so I asked for my medical records to try to understand. [Patient 30, Intervention group]

Taking an Active Role as a Patient

Searching for Information

Some patients described that they actively searched for more information than what was provided by the nurse. Usually, the internet was used to search for information about the illness, treatment, and other patients' experiences of the treatment to reassure themselves as to whether symptoms and signs were normal or not:

I found out a lot of different things myself about what was going to happen, why I felt like I did and so on. I care about my own body. [Patient 1, Intervention group]

The pharmacy was also a source of more information regarding prescribed medications. Moreover, patient organizations focusing on patients with breast cancer were used, especially to get in contact with and receive information from persons who have had breast cancer and have undergone treatment.

Participation in Own Care

The patients described their participation in care in various ways. Not being an active participant was commonly mentioned, albeit positively; they had accepted the situation and had no need to influence, choose, or have specific requests about their care. The highest priority was to get well from a serious disease, and they had accepted the plan and trusted the nurse to recommend what was best for them:

I accepted and followed what they recommended for me and that worked. I had no need to influence my care and treatment. [Patient 23, Control group]

Sometimes, treatment decisions and future planning were presented as a package at an early stage, and patients felt that their participation was not requested. A patient stated the following:

You were told that you should participate in the care. I did not know what options I had, or I could say that no alternatives were presented for me. The treatment and the planning were already decided and presented for me, and I accepted it. [Patient 33, Intervention group]

There were patients who described participation as following advice from the nurse. Realizing that they could do something themselves helped them feel better and made the treatment more manageable. Furthermore, having a treatment plan facilitated their daily planning. Having the possibility of discussing different matters regarding their care was also important for their feelings of involvement.

The Value of the App

A Source of Information

The patients described using Interaktor as an easy and accessible source of information where symptoms caused by the treatment were explained. Patients could follow the related self-care advice instead of contacting the contact nurse for information about how to manage their symptoms. A patient said the following:

Using the app led me to get information, for example about the mouth, which I had huge problems with. I could read about common symptoms and then there were recommendations on what I could eat and do myself. I thought it also helped me to seek even more information. [Patient 15, Intervention group]

Thus, the information in the app was a good complement to the verbal and written information provided by the nurse during treatment and created a sense of security. The links to the websites in the app felt safe and useful for obtaining more in-depth information.

Availability of Care

Using Interaktor was experienced by the patients as an easy and straightforward way to reach the contact nurse, as they were contacted directly in the event of severe symptoms or concerns. This was described as safe because they knew that they would be contacted by the nurse when they felt ill and because they experienced that they were contacted quickly:

Well, the times when I needed help, I got it right away. Otherwise, without the app, I had to call, and they called me back. With the app, they basically called ten minutes later. [Patient 25, Intervention group]

Furthermore, being contacted in the event of an alert was much more convenient than having to look for the right telephone number for the contact nurse.

Being Seen and Listened To

Reporting symptoms in the app facilitated the patients to share information about their health condition with the nurse, who could then monitor the patients' reports. The patients also stated that in the event of severe symptoms that led to contact with the nurse, they had the opportunity to ask questions and discuss any problems. Thus, the patients felt that they were being monitored in a positive way and led to feelings of being seen and listened to and not being on their own:

For me, it contributed with feelings of not being cast aside or of being alone. There was someone who actually saw what I reported and provided feedback. For me, this gave me a sense security I would say, a stability. [Patient 6, Intervention group]

Being Active in Own Health Management

The patients described being active by reporting symptoms daily, as opposed to contacting the nurse themselves when they felt unwell. Furthermore, the app facilitated self-care actions when symptoms occurred, to increase well-being. Reporting and monitoring symptoms in the graphs provided patients with an opportunity to reflect on how they felt every day. Being more conscious and aware of their symptoms enabled them to see patterns and fluctuations in their symptoms. This also facilitated their planning of activities and created positive feelings and comfort when they discovered that many days were trouble free. Reporting and keeping track of symptoms in the app was described as a way of keeping a diary:

For me, it was good to be able to go back and check how many days I felt ill, and when I came back to the clinic, I could say that I had felt really ill two weeks after the treatment, and then it became a bit better. So, for me, given that my memory does not work, I think that was supportive. [Patient 30, Intervention group]

Discussion

Principal Findings

To the best of our knowledge, this is the first study to specifically explore experiences of care in patients with breast cancer during NACT and investigate the impact of an interactive app on standard care. Overall, patients from both groups expressed positive experiences with their care during NACT, although negative experiences were also mentioned. The patients in the intervention group experienced that using the app provided added value to standard care with regard to additional support for information, self-care, and enhanced participation in their own care. In Sweden, patients who receive NACT are treated according to national care guidelines, and the role of the contact nurse is to support patients throughout the chain of care [33]. However, results of this study are in congruence with those of other studies showing that patients request more support during their treatment in addition to what the health care offers [37]. Commonly, this support concerns information and how to manage symptoms caused by the illness and treatment [38]. Presently, the patients described the Interaktor app as providing extra support during the treatment period by having easy access

to self-care advice, information, and contact with the nurse if the symptoms were severe. The results are in line with those of the recent reviews where patients with cancer experienced apps as supportive tools that complemented or extended existing health care [39,40].

Although most of the patients felt well informed, a lot of information was given at the same time, which sometimes was hard to absorb. Studies have shown that patients undergoing treatment for cancer have a great need for relevant information to gain an understanding of the treatment [41-43]. Patients receiving chemotherapy often have trouble concentrating and difficulties remembering [44]. Supportive mHealth apps can thus be convenient for patients during treatment, as they can retrieve information to refresh their memory whenever needed.

We have previously reported increased symptom relief when using Interaktor [32], and the results of this study testify that the app was a facilitator for patients to participate in their own care. By reporting and monitoring their symptoms as well as using easily accessible self-care advice, they had been active in relieving their symptoms. Another benefit of using the app, mentioned by some, was the graphs showing the course of their symptoms, which was useful in planning everyday life. Furthermore, accessibility to nurses during treatment was essential for patients, especially in the case of severe symptoms. Accessibility to care characterizes how easily a patient can reach the health care provider. Availability refers to the extent to which the health care provider has the resources to be reached; for example, through personnel and technology [45]. Presently, Interaktor has served as a safe and convenient tool for achieving both.

Most patients described their dialogue with the nurse as respectful, encouraging, and personal. Using Interaktor reinforced patients' experiences of being seen, listened to, and feeling safe. Similarly, improved patient safety and increased communication between patients and health care providers were shown in a recent review of patients with cancer using mHealth [46]. Results from other studies on cancer care have shown that an established good relationship between the patient and nurse is vital for the patient to feel acknowledged, which also facilitates patient participation [18,44]. Interestingly, in this study, it was common for patients to be satisfied with their own care without the need to influence or have special requests for care. In contrast, some appreciated being active in searching for information and engaging in self-care. This indicates that patients may not be aware that there are many ways for them to participate in their own care. Studies have confirmed that the meaning of concept of participation is vague and needs to be clarified to be practically achieved in a clinical context [14,47].

Strengths and Limitations

The selected sample was considered to be ample in size and heterogeneity to provide richly textured information for trustworthiness of data. A thematic analysis method was chosen, providing a structured approach to handle the large data sets and to identify patterns across the data set [48,49]. In addition, by conducting most of the interviews and transcriptions, the first author, who also played a major part in the analysis, became acquainted with the material. The risk of the first author's

preunderstanding was considered by confirming the transparency of the analysis with the other authors. The fact that the interviews were conducted 3 months after the end of NACT could have caused recall bias; however, the richness of the data testifies against this bias.

Conclusions

In this study, it was evident that patients felt well taken care of and mostly had positive experiences of their care during their treatment for breast cancer. This was regardless of whether they had used the app. The results show that there is potential for improvements in how information, communication, and access

to a nurse are delivered in care. Patients using the interactive app experienced this as an added value during their treatment. The extra support for information and self-care enhanced participation in their own care, and easy access to nurses gave them a sense of security. These findings suggest that there are good reasons to integrate an interactive app as a complement to standard care to support patients treated for breast cancer. Further investigation should be conducted on nurses' experiences of the intervention with Interaktor and how it impacts their work. Moreover, an evaluation of the cost-effectiveness of the app is warranted.

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Authors' Contributions

ALE and KS contributed to the study design. Interviews and transcriptions were performed by MF and MN. All authors performed the analyses. The manuscript was prepared by MF and subsequently reviewed and revised by all the authors, who also approved the final manuscript.

Conflicts of Interest

None declared.

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Abbreviations

- mHealth:** mobile health
NACT: neoadjuvant chemotherapy
RCT: randomized controlled trial

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Original Paper

Uncovering Important Drivers of the Increase in the Use of Virtual Care Technologies in Nursing Care: Quantitative Analysis From the 2020 National Survey of Canadian Nurses

Waldo Beauséjour^{1*}, MA; Simon Hagens^{1*}, MBA

Canada Health Infoway, Toronto, ON, Canada

* all authors contributed equally

Corresponding Author:

Waldo Beauséjour, MA

Canada Health Infoway

150 King St W

Toronto, ON, M5H 1J9

Canada

Phone: 1 416 595 3449 ext 3421

Fax: 1 888 733 6462

Email: wbeausejour@infoway-inforoute.ca

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Abstract

Background: Canadian nurses are at the forefront of patient care delivery. Although the use of digital health technologies for care delivery is gaining momentum in Canada, nurses are encouraged to integrate virtual care into their practice. In early 2020, more Canadian nurses delivered care virtually compared with 3 years ago.

Objective: This study seeks to uncover the professional characteristics of Canadian nurses accessing virtual care in 2020, understand how these characteristics differ across types of technologies, investigate whether the nurses accessing virtual care possess the skills and knowledge needed to use these technologies, and determine the important drivers of the uptake of virtual care observed in 2020.

Methods: We used data from the 2017 and 2020 National Survey of Canadian Nurses. This survey collected data on the use of digital health technologies in nursing practice. It concerned regulated nursing professionals working in different health care settings and from different domains of nursing practice. We combined the chi-square independence test and logistic regression analysis to uncover the most relevant drivers of virtual care uptake by nurses in 2020.

Results: In early 2020, before the declaration of the COVID-19 pandemic, nurses who delivered care virtually were predominantly nurse practitioners (135/159, 84.9%) and more likely to work in a primary or community care setting (202/367, 55%) and in an urban setting (194/313, 61.9%). Factors such as nursing designation ($P<.001$), perceived quality of care at the health facility where the nurses practiced ($P<.001$), and the type of patient record-keeping system they had access to ($P=.04$) had a statistically significant effect on the probability of nurses to deliver care virtually in early 2020. Furthermore, nurses' perception of the quality of care they delivered through virtual technologies was statistically associated with their perception of the skills ($\chi^2_4=308.7$; $P<.001$) and knowledge ($\chi^2_4=283.4$; $P<.001$) to use these technologies.

Conclusions: This study emphasizes the critical importance of nursing designation, geographic location, and type of patient record-keeping system in predicting virtual care integration in nursing practice. The findings related to geographic location can be used by decision-makers for better allocation of digital health resources among care settings in rural and urban areas. Similarly, the disparities observed across nursing designations have some implications for the digital training of nurses at all levels of practice. Finally, the association between electronic medical record use and uptake of virtual care could accelerate the implementation of more modernized record-keeping systems in care settings. Hence, this could advance interoperability and improve health care delivery.

KEYWORDS

adoption of virtual care; secure messaging; nurses; nursing; telehealth; telehomecare; telemonitoring; remote patient monitoring; virtual videoconferencing; uptake of virtual care

Introduction

Background

Whether it is a hospital, nursing home, or community-based health facility, most Canadian health care settings have shifted to virtual care during the COVID-19 pandemic. However, before the pandemic, the adoption of this model of care delivery was already trending upward in Canada [1]. As nurses account for a large proportion of the workforce in these care settings and are at the forefront of patient care delivery, they are well positioned to benefit from the integration of virtual care technologies into clinical practice.

Virtual care refers to “any interaction between patients and members of their circle of care, occurring remotely, using any forms of communication or information technologies, with the aim of facilitating or maximizing the quality and effectiveness of patient care” [2]. It can be regarded as a multimodal technology that embodies telephone, videoconferencing, and messaging. In addition, virtual care can be viewed as a multipurpose technology for (1) remote patient monitoring (RPM), (2) telehealth, (3) patient education, (4) peer-to-peer education, and (5) health information exchange between patients and providers. Some authors have described virtual care as a mature version of telehealth [3,4]. As the Canadian health care system is increasingly embracing digital health solutions, more clinicians and patients are expected to use virtual care technologies. In Canada, the proportion of nurses virtually delivering care has increased substantially from 20% to 51% between 2017 and 2020 [5]. Although this growth was observed a few weeks before the pandemic, the progressive integration of virtual care technologies into nursing practice is very promising. These technologies can potentially augment nurses’ capability to deliver care in nontraditional ways and improve their scope of practice [6]. Nevertheless, to sustain this progress in a changing health care landscape, it is crucial to understand the promoters and inhibitors of the uptake of virtual care technologies by nurses.

Our review of the existing literature mainly focused on identifying potential enablers of and barriers to virtual care adoption in nursing practice. Our brief search demonstrated that three sets of enabling and inhibiting factors had been studied by previous researchers: (1) personal and professional characteristics of the nurses, (2) factors related to the care setting where the nurses practice, and (3) factors related to the patients they serve. For the first set of factors, numerous researchers have highlighted training in virtual care technologies as one of the key ingredients that can enhance the technological skills of nurses [7-10]. This professional enhancement can consequently create a sense of confidence, which in turn could lead to the adoption of digital technologies in nursing care [11]. Nonetheless, if the training was only technology focused and neglected clinical and practice aspects, it could impede adoption

by frontline staff [7]. In addition, enhancing nurses’ skills through training should be accompanied by ongoing technical support [12].

Nurses’ attitudes toward the adoption of virtual care were also one of the personal factors explored by previous studies. Nurses with positive previous experiences with other digital health technologies such as electronic medical records (EMRs) were more inclined to integrate virtual care in their practice [12,13]. Fronczek et al [14] believed that providing nurses with additional education and experience during their career would equip them with the skills required to practice in virtual care environments.

Regarding care setting–related factors, previous studies have mostly emphasized the following as the main enablers of and barriers to the uptake of virtual care by nurses: (1) policy [7,15], (2) good collaboration between services [7,12], (3) changing working environment [7], (4) lack of encouragement from managers [9], (5) lack of coordination of services [12], (6) ambiguity around the objective of integrating virtual care technologies into clinical practice [7], and (7) existence of written guidance on the use of these technologies [12]. Among these factors, policy seemed to be an important element. Garber and Chike-Harris [15] maintained that it is essential for nurse practitioners (NPs) to be knowledgeable about the policies affecting their practice when delivering care through telehealth.

Enablers and barriers pertaining to the technology per se involved five factors [9,12,16]: (1) ease of use, (2) flexibility, (3) contextual integration of the technology, (4) privacy, and (5) security. For privacy and security, both nurses and patients must be assured that they can use virtual care technologies safely [6]. However, Hardcastle and Ogbogu [17] clearly stated, “ensuring data security is arguably the most challenging aspect of virtual care.”

Most of the previous studies cited above [7-16] concentrated on identifying the factors driving the integration of virtual care into nursing practice. They also focused on finding out whether these factors affected nurses’ adoption positively or negatively. There is a paucity of research investigating the weight of each of these factors in predicting the adoption of virtual care technologies in nursing practice. Therefore, it is almost difficult to decide which factors to prioritize or which one would have the greatest impact on adoption from a policy standpoint. In addition, these previous studies [9,10,13,16] were mostly systematic reviews aiming to inventory the different enablers of and barriers to the adoption of virtual care technologies by nurses. They used qualitative research methods, including (1) focus group discussions, (2) in-depth or semistructured interviews, and (3) ethnographic methods. Hence, the small sizes along with the nonprobabilistic nature of the samples used in these studies restricted their ability to infer their results to a larger nursing workforce. In addition, some previous findings

concerned specific forms of virtual care technologies, notably videoconferencing and RPM, or focused on particular care settings. Building on these previous findings, our research contributes to filling the quantitative analysis gap in the literature on the drivers of virtual care adoption by nurses. In addition to quantifying the joint influence of the factors of adoption discussed above, our empirical research attempts to estimate the magnitude of the impact of each of these factors on the uptake of virtual care by nurses.

Objectives and Research Questions

The objective of this paper is twofold: (1) to examine the characteristics of Canadian nurses using virtual care technologies and (2) to investigate the drivers of the uptake of these technologies by nurses in direct patient care in 2020. Mapping the profile of nurses accessing virtual care technologies should help better address barriers to accessing these technologies. It should also help determine whether nurses have access to appropriate digital health solutions to enhance their scope of practice. More specifically, our study seeks to (1) uncover the professional characteristics of Canadian nurses accessing virtual care technologies in 2020; (2) understand how these characteristics differ across types of technologies, geographic location, and care settings; (3) investigate whether nurses accessing virtual care possess the skills and knowledge they need to use these technologies; and (4) determine the important drivers of the uptake of virtual care observed in 2020.

Methods

Data Source

The analysis used data generated from the 2020 National Survey of Canadian Nurses. This survey was designed to be representative of the entire Canadian nursing workforce, particularly nurses in direct patient care. The survey is conducted on a triennial basis. Two iterations of the survey were conducted in 2014 and 2017. The National Survey of Canadian Nurses mainly gathers data on the use of digital health technologies in nursing practice, more specifically, the use of EMR systems and virtual care technologies.

Study Population and Sample

The population of reference of the National Survey of Canadian Nurses comprised regulated nursing professionals working in different health care settings and from different domains of nursing practice, with a focus on nurses in direct patient care. These nursing professionals comprised (1) registered nurses (RNs), (2) NPs, (3) clinical nurse specialists (CNSs), (4) licensed practical nurses (LPNs), and (5) registered psychiatric nurses (RPNs). This categorization of regulated nursing professionals aligns with the definition adopted by the Canadian Institute for Health Information (CIHI) [18], except that the National Survey of Canadian Nurses also considered another group of regulated nursing professionals, called CNS. In 2019, the total number of regulated nurses in Canada was 439,975 [18].

During the design phase of the National Survey of Canadian Nurses, the survey confronted the lack of a pre-existing sampling frame that would have provided a complete list of all the regulated nursing professionals listed above. To construct an

alternative sampling frame, the survey conflated the membership lists provided by the Canadian Nurses Association (CNA) and Canadian Nursing Informatics Association (CNIA). We recognize that the use of this combined membership list as an alternative sampling frame may have coverage problems, meaning that all the participants from the population of interest may not be included in the survey frame. Nevertheless, both the CNA and CNIA have a large network of nurses, which accounts for a substantial proportion of the Canadian nursing workforce. Hence, their membership lists guaranteed an acceptable level of coverage for the 2020 National Survey of Canadian Nurses. In addition, to mitigate the lack of coverage and completeness of the sampling frame created from the combination of the CNA and CNIA membership lists, several strategies were implemented. They included (1) sending invitation emails to members of the l'Ordre des Infirmières et Infirmiers du Québec, (2) recruiting nurses from a web panel owned by the firm commissioned to field the survey, and (3) applying snowball methods by sending invitation emails to nurses referred by other nurses who had responded to the survey [5]. A total sample size of 1642 nurses was collected across Canada, 1132 (68.94%) of whom provided direct patient care. The National Survey of Canadian Nurses used a nonprobability sample; therefore, a margin of error cannot be associated with the sample.

Data Collection Instrument and Procedures

The 2020 National Survey of Canadian Nurses used a bilingual (English and French), user-friendly, and 30-minute-long web-based questionnaire. This questionnaire asked questions on EMR systems and virtual care technologies used by nurses providing direct patient care in their main care settings. In addition, several demographic data were collected during the survey: (1) primary domain of nursing practice, (2) nursing designation, (3) primary care setting, and (4) geographic location of the care setting where the nurse practiced. The survey link was distributed to all nurses from the CNA and CNIA membership lists through email invitations between January 20 and March 29, 2020. To boost the survey response rate, a multipronged modified Dillman [19] approach was implemented, including an incentive strategy. In addition, ethics approval was obtained before fielding the survey. The ethics approval was granted by an independent Canadian institutional review board in January 2020 (Advarra Inc; approval number: Pro00041060). It concerned the survey methodology or protocol, informed consent document, and data collection instrument. All the results expounded in this study were statistically weighted by the 2018 CIHI workforce data published in 2019 to ensure that they accurately represented the Canadian nursing workforce. A full description of the sample of Canadian nurses achieved in 2020 is provided in the survey report [5]. Similarly, a full version of the 2020 survey questionnaire along with the raw survey data can be accessed via the University of Victoria Dataverse portal [20].

Statistical Analysis

The data used in this paper concerned point-of-care nurses using virtual care technologies to deliver care in their main setting from the 2020 National Survey of Canadian Nurses. Data on 4

types of virtual care technologies were collected in 2020. The working definitions for these technologies are provided below (questions on access to virtual care technologies that were used in the National Survey of Canadian Nurses are provided in [Multimedia Appendix 1](#)):

1. Secure messaging or email refers to consultations via secure email or SMS text messages sent by patients to their health care provider (in this case, the nurses) about a specific health question or concern.
2. Videoconferencing refers to virtual visits conducted between patients while at home and their health care provider via face-to-face web-based virtual encounters. These virtual visits are more likely to be patient initiated.
3. Telehealth is a form of virtual care delivered through videoconferencing that is coordinated and facilitated by or between health facilities. It involves a remote clinician, who is the main provider, aided by another clinician based in the rural or remote region where the patient receiving the care resides. The patient can be either at home or at a health facility when receiving care [9].
4. RPM or telehome care occurs when a health provider (typically a nurse or paramedic) has electronic access to a patient's information for review, interpretation, and coaching opportunities to enhance the patient's self-management abilities.

Previous researchers [21-23] have favored the term information and communication technologies to refer to all digital technologies used to deliver care remotely. This delineation embodies a large palette of digital health technologies, including EMRs or electronic health record systems, which aim more at dealing with patients' health information or supporting clinical administrative activities [13]. This description seemed to be overly broad for the scope of our analysis as our definition of virtual care technology is not inclusive of EMRs and electronic health records. Instead, we limited our definition to the 4 aforementioned virtual care technologies collected from the 2020 National Survey of Canadian Nurses. In addition, our study used the terms virtual care use, uptake, and adoption interchangeably. Chen et al [24] relied on the number of times a telehealth technology was used to measure telehealth adoption. Their use index was quantitative in nature. Unlike these scholars, we defined binary use variables for the 4 virtual care technologies studied. For our study, *use* referred to the use of a virtual care technology by a nurse at least once, whereas a variable referred to a characteristic observed or collected for the nurses during the survey. Moreover, we used variable and factor interchangeably throughout the paper. We define our binary use variables as follows:



Here, the subscript i denotes the nurse, whereas j refers to the 4 virtual care technologies considered. The subscript j took the following values:



By conflating these 4 use factors, we created another binary use variable y_i . This combined variable refers to the use of at least

one of the 4 virtual care technologies; thus, it is the virtual care adoption variable. It constituted the main dependent variable of our analysis and was defined by the following equation:



The explanatory variables were derived from the body of literature on the adoption of virtual care by nurses, which has been expounded previously. These previous studies predominantly emphasized two groups of factors influencing the use of virtual care technologies in nursing care: nurses' skills and attitudes and factors pertaining to care settings where the nurses practice. On the basis of this, we retained the following independent variables: (1) nursing designation, (2) work experience (number of years working as a nurse), (3) skills and knowledge to use virtual care technologies, (4) perception of the quality of care delivered by the care setting where the nurse practices, (5) type of care setting, (6) geographic location of the setting, (7) patient record-keeping system used in the main care setting, and (8) policy about the use of virtual care technologies. These characteristics were analyzed using summary descriptive statistics and frequency tables. Moreover, the chi-square independence test along with association measures was used to test for the association between the use variables z_i^j and the independent factors retained. The joint effect of these predictors and their respective effects on virtual care adoption y_i were estimated through the specification of the following logistic regression model:



where X_i is a vector of observed explanatory variables representing the characteristics defined above for nurses, whereas β refers to a vector of regression coefficients, and π_i represents the probability that nurse i uses at least one virtual care technology. It is linked to the use variable y_i through the following equation:



Results

Current State of Virtual Care Use by Canadian Nurses

Table 1 shows the trends in the adoption of virtual care by Canadian nurses for each technology considered in the analysis between 2017 and 2020. This shows that the proportion of nurses virtually delivering care increased substantially between 2017 and 2020, with an overall average increase of 25 percentage points for the 4 technologies considered. The greatest rise was observed for secure email (+27 percentage points), whereas the smallest increase was noted for telehealth, indicating a more rapid uptake of the former and a slow adoption for the latter. Admittedly, some of these technologies require more infrastructure and technological resources than others do for their rollout in care settings. Data from the 2020 National Survey of Canadian Nurses were collected a few weeks before the World Health Organization declared COVID-19 a global pandemic; therefore, one may argue that the COVID-19

pandemic may not be the main driver of the surge in the use of virtual technologies by nurses observed in early 2020. Nevertheless, this progressive virtualization of nursing practice could help the Canadian health care system cope with the unprecedented increase in the demand for digital care by patients and streamline the deployment of nurses as they are at the

frontline of the response to the pandemic [25]. In addition, it is predicted that Canadian patients are likely to seek care through virtual modalities beyond the pandemic [26], thereby pushing nursing practice to adapt to these virtual care environments moving forward.

Table 1. Access to virtual care technologies by Canadian nurses in 2017 (N=1342) and 2020 (N=1047)^a.

Virtual care technologies	Value		
	2017, n (%)	2020, n (%)	Percentage point change ^b
Secure message	121 (9.02)	377 (36.01)	27
Videoconference	40 (2.98)	283 (27.03)	24
Telehealth	81 (6.04)	304 (29.04)	23
RPM ^c	107 (7.97)	356 (34)	26
At least 1 of the 4 technologies	268 (19.97)	534 (51)	31

^aSource: 2017 and 2020 National Survey of Canadian Nurses, Canada Health Infoway, Environics, and Léger [5,27].

^bPercentage point change refers to the difference between the percentage of nurses accessing virtual care technology in 2020 and the proportion accessing the same technology in 2017.

^cRPM: remote patient monitoring.

Main Characteristics of Nurses Who Used Virtual Care Technologies in 2020

Overview

Tables 2 and 3 show the number and proportion of nurses who delivered care virtually in 2020 according to the type of technology. The results in Table 2 are presented for the personal

and professional characteristics considered in the analysis, notably age, work experience, nursing designation, and skills and knowledge in delivering care through videoconferencing and telemonitoring. The results in Table 3 pertain to the characteristics of the main care settings where the nurses surveyed practiced, notably the geographic location of the care setting, the type of setting, and the patient record-keeping system used at the care setting.

Table 2. Personal and professional characteristics of Canadian nurses who used virtual care (VC) technologies in 2020 (N=1047)^a.

Factors or covariates	VC technologies					
	Secure email	Videoconferencing	Telehealth	RPM ^b	At least one VC technology	Did not use any VC technology
Age (years), mean (SD)	40.6 (11.7)	39.6 (11.2)	38.7 (10.4)	39.5 (11.0)	41.9 (12.3)	42.9 (11.9)
Work experience (years), mean (SD)	13.4 (11.1)	12.3 (10.8)	11.5 (10.3)	12.8 (11.7)	15.3 (12.3)	16.7 (11.8)
Nursing designation, n (%)						
RN ^c (n=683)	171 (25)	116 (17)	137 (20.1)	164 (24)	280 (41)	403 (59)
NP ^d (n=159)	122 (76.7)	114 (71.7)	114 (71.7)	119 (74.8)	135 (84.9)	24 (15.1)
LPN ^e , RPN ^f , and CNS ^g (n=143)	63 (44.1)	40 (28)	44 (30.8)	60 (42)	87 (60.8)	56 (39.2)
Other (n=61)	22 (36.1)	13 (21.3)	11 (18)	17 (27.9)	28 (45.9)	32 (52.5)
Have the skills to use videoconference or telemonitoring, n (%), n=407						
Strongly and moderately agree	N/A ^h	232 (57)	N/A	232 (57)	N/A	N/A
Have the knowledge to use videoconference or telemonitoring, n (%), n=407						
Strongly and moderately agree	N/A	243 (59.71)	N/A	243 (60)	N/A	N/A

^aSource: 2020 National Survey of Canadian Nurses, Canada Health Infoway, and Léger [5,27].

^bRPM: remote patient monitoring.

^cRN: registered nurse.

^dNP: nurse practitioner.

^eLPN: licensed practical nurse.

^fRPN: registered psychiatric nurse.

^gCNS: clinical nurse specialist.

^hN/A: not applicable.

Table 3. Characteristics of the main care settings where the Canadian nurses accessing virtual care (VC) technologies in 2020 practiced (n=1047)^a.

Factors	VC technologies, n (%)					
	Secure email	Videoconferencing	Telehealth	RPM ^b	At least one VC technology	Did not use any VC technology
Perception of overall quality of care at care setting						
Poor (n=97)	25 (26)	6 (6)	15 (15)	8 (8)	36 (37)	61 (63)
Fair (n=181)	45 (24.9)	18 (9.9)	25 (13.8)	25 (13.8)	60 (33.1)	121 (66.9)
Good (n=425)	183 (43.1)	145 (34.1)	149 (35.1)	187 (44)	242 (56.9)	183 (43.1)
Excellent (n=344)	124 (36)	110 (32)	114 (33.1)	138 (40.1)	193 (56.1)	151 (43.9)
I provide more efficient health care with virtual videoconferencing or telemonitoring (n=407)						
Strongly and moderately agree	N/A ^c	195 (47.91)	N/A	195 (47.91)	N/A	N/A
Geographic location						
Rural and indigenous communities (n=124)	33 (26.6)	21 (16.9)	37 (29.8)	48 (38.7)	64 (51.6)	60 (48.4)
Town or city (n=610)	195 (32)	128 (21)	134 (22)	159 (26.1)	275 (45.1)	336 (55.1)
Urban center (n=313)	153 (48.9)	131 (41.9)	135 (43.1)	153 (48.9)	194 (62)	119 (38)
Care setting						
Primary and community care (n=367)	165 (45)	128 (34.9)	136 (37.1)	139 (37.9)	202 (55)	165 (45)
Other hospitals (n=397)	107 (27)	75 (18.9)	83 (20.9)	119 (30)	179 (45.1)	218 (54.9)
Teaching hospital (n=176)	63 (35.8)	39 (22.1)	49 (27.8)	55 (31.3)	93 (52.8)	83 (47.2)
Other nonhospital (government and others; n=107)	44 (41.1)	37 (34.6)	37 (34.6)	47 (43.9)	57 (53.3)	50 (46.7)
Patient record-keeping system						
Paper only (n=149)	39 (26.2)	34 (22.8)	33 (22.1)	31 (20.8)	54 (36.2)	95 (63.8)
Fully electronic (n=280)	101 (36.1)	70 (25)	81 (28.9)	101 (36.1)	146 (52.1)	134 (47.9)
Hybrid (n=618)	260 (42.1)	210 (34)	198 (32)	235 (38)	346 (56)	272 (44)
Main care setting has a policy about the use of email to communicate with patient						
Yes	427 (40.8)	N/A	N/A	N/A	N/A	N/A

^aSource: 2020 National Survey of Canadian Nurses, Canada Health Infoway, and Léger [5,27].

^bRPM: remote patient monitoring.

^cN/A: not applicable.

Age and Work Experience

Nurses virtually delivering care were aged, on average, 42 (SD 12.3) years, slightly half a year younger than the overall sample collected in 2020 (mean 42.5, SD 12.1 years). The aging of the nursing workforce is an important issue as it may lead to a nursing shortage [25], which would be detrimental for the Canadian health care system as it strives to respond to the growing demand for long-term care stemming from an aging population [18]. On average, nurses who had used telehealth tended to be younger (mean 38.7, SD 10.4 years) than their peers using the other virtual care modalities (mean 39.5, SD 11.0; 39.6, SD 11.2; and 40.58, SD 11.7 years for telemonitoring, videoconferencing, and secure email, respectively). Similarly, these nurses providing care through telehealth had, on average, fewer years of practice (mean 11.5, SD 10.3 years) than others using the other virtual care modalities (mean 12.3, SD 10.8; 12.8, SD 11.7; and 13.4, SD 11.1) years

for videoconferencing, telemonitoring, and secure email, respectively). Nurses who lacked access to virtual care technologies, on average, were older (42.9, SD 11.9 years) and had more years of service (16.7, SD 11.8 years) than their counterparts accessing virtual care technologies.

Nursing Designation

As shown in Table 2, NPs constituted the nursing professionals who were the most likely to deliver care virtually in 2020 (135/159, 84.9%) regardless of the type of virtual care technology considered. Although RNs made up 68.34% (300,669/439,975) of the total supply of Canadian-regulated nurses and 69.08% (273,617/396,085) of the nurses employed in nursing-specific jobs in 2019 [18], they were more likely to report a lack of access to virtual care technologies (403/683, 59%) than other nursing designations. Given their role in the delivery of care across the care continuum, from primary care to end of life, RNs are well-positioned to bring about health

transformations that benefit the Canadian health care system [28]. Therefore, having greater access to virtual care technologies can potentially optimize their scope of practice.

Skills and Knowledge to Use Virtual Care Technologies

Several studies have argued that nurses' skills and knowledge are among the factors that facilitate the integration of virtual care into nursing practice [7-10,12]. The results in Table 3 show that more than half of the nurses who had used videoconferencing or telemonitoring in the past (232/407, 57% and 243/407, 59.7%, respectively) reported that they had the skills and knowledge to deliver care through videoconferencing and telemonitoring.

Main Care Settings of Nurses Using Virtual Care Technologies

Overview

Table 3 shows some variations in the use of virtual care technologies by nurses across care settings. Primary and community care settings include nursing homes, long-term care facilities, and homecare, whereas other hospital settings embody community hospitals and continuing care or rehabilitation hospitals. Overall, nurses working in primary and community care settings were more likely to use virtual health services (202/367, 55%) than nurses working in other settings. In addition, the use of secure messaging (165/367, 44.9%) and telehealth (136/367, 37.1%) was more prevalent among primary and community care nurses. These results align with those of Taylor et al [7], who found disparities in frontline staff acceptance of telehealth within and across service settings.

Geographic Location of Main Care Setting

At their inception, virtual care models were intended to deliver care to rural communities with limited access to traditional health care facilities [29]. In early 2020, a few weeks before the pandemic, more nurses working in rural and remote communities were delivering care virtually to their patients than 3 years ago. Approximately 51.6% (64/124) of nurses serving rural and indigenous communities reported that they had used at least one of the virtual care technologies considered in the analysis, an increase from 30% in 2017 [5]. However, Table 3 shows that rural nurses were less likely to use secure messaging (33/124, 26.6%) and videoconferencing (21/124, 16.9%) relative to their town and urban peers. In addition, the growth in the proportion of nurses using virtual health has been more substantial for nurses in cities and urban centers than for nurses serving rural and indigenous communities [5]. Results of the 2020 National Survey of Canadian Nurses also suggested that nurses serving rural and indigenous communities were more likely to report a lack of skills (16/48, 33.3%) in using virtual care technologies relative to their peers serving in towns or cities (52/191, 27.2%) and urban centers (35/166, 21.1%). Similarly, lack of knowledge to interact with virtual care tools was more prevalent among rural nurses (15/49, 30.6%) than among nurses practicing in

towns or cities (47/191, 24.6%) and urban centers (32/166, 19.3%). These disparities in competencies required to use virtual care could be one of the drivers of the discrepancies observed in the use of virtual care technologies between rural and urban nurses.

Drivers of the Uptake of Virtual Care Technologies by Nurses

Overall Factors

Table 4 reports the results of the regression model specified earlier in equation 4. Overall, the model is statistically significant ($\chi^2_{14}=160.7$; $P<.001$). Hence, the professional characteristics of the nurses, their perception, and the characteristics of the care setting where they practice have a joint effect on the probability that these nurses deliver care virtually. In terms of goodness of fit, the estimated model has allowed to correctly predict >60% (count $R^2=0.6693$) of the probabilities for nurses to use virtual care or not.

Regarding the individual effect of each factor entering the model, of all the care setting-level factors considered, only 1 was found to have a significant effect on the probability for nurses to deliver care virtually. Nursing designation ($P<.001$), perceived quality of care delivered by the care setting ($P<.001$), and type of patient record-keeping system ($P=.04$) all had a statistically significant effect on the probability of nurses using virtual care when their categories entering the model were taken together. In contrast, the model failed to provide statistical evidence for the effect of work experience, type of care setting, and geographic location of the care setting on predicting whether a nurse used virtually health. Therefore, knowing where a nurse worked, either their health care setting or the location, may not contribute to predicting whether they delivered care virtually or not.

For nursing designation, some differences across the considered designations are worth noting. NPs and the combined group of LPNs, RPNs, and CNSs were respectively 7 times (odds ratio 7.04) and more than twice (odds ratio 2.24) as likely to use virtual care technologies than RNs. These results confirm the disparities found earlier in the use of virtual care by nurses across designations. The data showed that the proportions of NPs and the combined group of LPNs, RPNs, and CNSs delivering care virtually in 2020 outnumbered the proportions of RNs. Similarly, there were some discrepancies in the probability of using virtual care across the perception of overall quality of care in the care setting. Indeed, nurses who perceived the overall quality of care in their care setting as excellent or good were more than twice (odds ratios 2.14 and 2.04, respectively) as likely to use virtual care relative to those who perceived the quality as poor. Nurses who felt that the overall quality of care in their care setting was poor did not significantly differ from those who rated the quality as fair in terms of their probability of using virtual health.

Table 4. Results of the estimation of model defined in equation 4^a.

Predictors	Log-odds coefficient	SE	Odds ratio (95% CI)	Average marginal effect	<i>P</i> value > z
Nursing designation	N/A ^b	N/A	N/A	N/A	<.001 ^c
RN ^{d,e}	N/A	N/A	N/A	N/A	N/A
NP ^f	1.951 ^g	0.248	7.04 (4.33-11.43)	0.417	<.001
LPN ^h , RPN ⁱ , and CNS ^{j,k}	0.805 ^g	0.196	2.24 (1.52-3.28)	0.187	<.001
Other	0.218	0.285	1.24 (0.71-2.18)	0.049	.45
Work experience	-0.001	0.006	1.00 (0.98-1.01)	-0.0001	.93
Perceived quality of care delivered by setting	N/A	N/A	N/A	N/A	<.001 ^c
Poor ^e	N/A	N/A	N/A	N/A	N/A
Fair	0.021	0.281	1.02 (0.59-1.77)	0.004	.94
Good	0.711 ^g	0.251	2.04 (1.24-3.33)	0.153	.005
Excellent	0.763 ^g	0.256	2.14 (1.29-3.55)	0.165	.003
Care setting					.34 ^c
Primary and community care ^e	N/A	N/A	N/A	N/A	N/A
Other hospitals	-0.248	0.161	0.78 (0.57-1.07)	-0.052	.12
Teaching hospital	-0.006	0.205	0.99 (0.67-1.49)	-0.001	.98
Other nonhospital	0.052	0.241	1.05 (0.66-1.69)	0.011	.83
Patient record-keeping system	N/A	N/A	N/A	N/A	.04 ^c
Paper ^e	N/A	N/A	N/A	N/A	N/A
Fully electronic	0.507 ^l	0.232	1.66 (1.11-2.49)	0.105	.03
Hybrid	0.511 ^l	0.206	1.67 (1.05-2.62)	0.106	.01
Geographic location of care setting	N/A	N/A	N/A	N/A	.13 ^c
Rural and indigenous communities ^e	N/A	N/A	N/A	N/A	N/A
Town or city	-0.267	0.213	0.77 (0.51-1.16)	-0.057	.21
Urban center	0.027	0.238	1.03 (0.64-1.64)	0.006	.91
Constant	-1.078 ^g	0.350	N/A	N/A	.002

^aNumber of observations=1131; log likelihood -480.386; Akaike Information Criteria 990.772; number of iterations=4; likelihood ratio $\chi^2_{14}=160.2$; probability $>\chi^2=0.0$; pseudo R^2 (McFadden)=0.3722; count $R^2=0.6693$.

^bN/A: not applicable.

^cTo test for the overall effect of each categorical variable on the dependent variable (probability to use virtual care), we used a Wald test. These values correspond to the *P* value associated with the chi-square statistic calculated for the Wald test for each categorical variable.

^dRN: registered nurse.

^eOmitted category of the categorical variable entering the model to avoid the problem of multicollinearity.

^fNP: nurse practitioner.

^g $P<.01$.

^hLPN: licensed practical nurse.

ⁱRPN: registered psychiatric nurse.

^jCNS: clinical nurse specialist.

^kTo deal with the low sample sizes for LPNs, RPNs, and CNSs, we grouped them in a single category. We recognize that these 3 nursing professionals differ significantly in terms of their education, duties, and work settings.

^l $P<.05$.

The patient record-keeping system that nurses had access to was found to have a statistically significant global effect on the probability of using virtual care. However, nurses with access to fully electronic and hybrid record-keeping systems were

approximately twice as likely to deliver care virtually (odds ratios 1.66 and 1.67, respectively) than their peers using paper charts.

Although it was found to have no statistically significant effect on the probability of using virtual care, work experience had a negative effect on the outcome variable of the model. This indicates that nurses with more years of nursing practice would be less likely to adopt virtual technologies in clinical care. However, the marginal effect of work experience on the probability of using virtual care was found to be minimal.

Drivers Related to Virtual Care Through Secure Email and Videoconference

A policy-related variable was collected for nurses who delivered care through secure email, whereas skills and knowledge data were gathered for those delivering care through videoconferencing technology. A chi-square test of independence was conducted to investigate whether these factors were associated with the use of virtual care for these 2

technologies. The results of the test are provided in Table 5 and concern the subsample of nurses delivering care through secure email and videoconferencing. Table 5 shows that the existence of a policy on the use of email to securely communicate with patients in the care setting was statistically weakly associated with the use of email by nurses to consult with their patients ($\chi^2_2=61.4$; $P<.001$; Cramer V=0.24). For nurses who had consulted directly with a patient via videoconference, their perception of the quality of care delivered through these virtual technologies was statistically driven by their skills and knowledge ($\chi^2_4=308.7$, $P<.001$; and $\chi^2_4=283.4$, $P<.001$, respectively). Furthermore, these self-assessment factors were strongly associated with perceived quality of care (Cramer V=0.62 and Cramer V=0.59, respectively). Therefore, taking into consideration how nurses feel about their skills and knowledge to use videoconference can help predict their perception of the quality of care delivered through these digital means. Consequently, this will improve their adoption of these virtual technologies.

Table 5. Independence test and association measures.

Characteristics and independent variables	Dependent variables	Chi-square (df)	P value (2-sided)	Level of association ^a
Policy				
Policy about the use of email to communicate with the patient	Had used secure email to deliver care	61.4 (2)	<.001	0.24
Perception				
Skills to use virtual care	Perception of quality of care delivered through videoconference or telemonitoring	308.7 (4)	<.001	0.62
Knowledge to use virtual care	Perception of quality of care delivered through videoconference or telemonitoring	283.4 (4)	<.001	0.59

^aCramer V was calculated for the level of association.

Discussion

Principal Findings

Our study endeavored to quantify the effect of some of the drivers that were found to affect the adoption of virtual care in nursing practice by a spate of previous researchers who relied on qualitative methods. We were able to quantify the distribution of the uptake of virtual care across nursing designation, care setting, and geographic region. For instance, the results suggested that RNs and rural nurses reported the lowest adoption rate for the use of virtual care. For nursing designations, we found statistical evidence for disparities in the use of virtual care across designations. This could be linked to the differences in the scope of practice, roles, and competencies across all levels of nursing practice. For geographic location, Chen et al [24] found significant disparities in the adoption of telehealth between rural and urban hospitals. In addition to allowing them to reach out to patients in remote sites, virtual care is regarded by rural nurses as a mechanism that offers them the possibility to enhance and maintain skills and professional knowledge [9,30]. Moreover, some scholars have argued that telehealth could positively affect rural clinicians' occupational well-being, leading to greater retention and recruitment rates in remote care settings [31]. In addition, the results expounded in this paper

shed light on the modalities of virtual care technologies that are being used across care settings and geographic locations. This will enable decision-makers to pinpoint the gaps in terms of the use of virtual health technologies. Thus, the allocation of digital health technology resources in rural and urban settings could improve.

The results of our regression model provided statistical evidence for the collective effect of nurses' professional characteristics, their perceptions, and the characteristics of the care settings where they practice their use of virtual care technologies. All these factors entering our regression model had already been identified in the literature. However, previous studies have looked into them separately but not as a whole. Furthermore, these studies failed to report on the magnitude of the effect of these factors on the use of virtual care in nursing care. Our results suggest that the effect of work experience on the use of virtual care was very marginal, signaling that this factor would not be a relevant predictor of the adoption of virtual care in nursing practice. Similarly, the existence of a policy on the use of email to communicate with patients in the care setting was found to be weakly associated with the use of email. Nurses have an instrumental role to play in supporting the design of policies and regulations aimed at supporting virtual care [32].

The significant association between the patient record-keeping system and the use of virtual care technologies is a promising finding that will help to better inform initiatives aimed at achieving interoperability. Our results suggest that nurses who access electronic EMRs have a higher likelihood of delivering care virtually. Earlier studies found that a lack of interoperability could fragilize the uptake of virtual care technologies by frontline workers [7].

Previous studies were limited to identifying enablers and inhibitors; however, they provided us with the main elements for our investigation. Therefore, by filling the gaps in terms of quantitative analysis of the drivers of virtual care adoption by nurses, our study complements these previous studies. However, similar to the study by Mair et al [13], we still believe that the integration of virtual care technologies into nursing practice can be convoluted and multifaceted. Concurrently, virtual care integration will substantially benefit nurses as the scope of their practice will be more developed, and nursing care delivery will become more flexible [6].

Limitations

Our study used data generated from the 2020 National Survey of Canadian Nurses. This survey combined the CNA and CNIA membership lists to establish the survey sample. In addition, other strategies were implemented to mitigate the lack of coverage and completeness resulting from the conflation of CNA and CNIA membership lists. Despite these strategies, nonmembers and underrepresented groups of nurses might have been left out from our analysis. Future studies could endeavor to obtain a more complete list of the Canadian-regulated nursing workforce from the CIHI. Moreover, limited professional characteristics and care setting-level factors were collected through the survey. In addition, factors related to the types of

patients served by nurses were omitted from our analysis, although they were highlighted as relevant drivers of adoption in the literature. Consequently, several pertinent explanatory variables might have been omitted from the regression model. This omission of relevant predictors could generate some specification errors, although the predictive power of the model was satisfactory, and its overall significance passed the statistical hypothesis test. Nevertheless, our study laid the foundation for future research aiming to undertake a quantitative analysis of the drivers of virtual care adoption in nursing practice. From a resource allocation standpoint, future research could investigate the factors that drive the number of visits delivered by nurses through virtual care means and how these factors vary across virtual care technologies.

Conclusions

Our investigations suggest that the use of virtual care in nursing practice is mostly driven by three factors: (1) nursing designation, (2) the geographic location where a nurse practices, and (3) the type of patient record-keeping system accessed in the care setting. The disparities observed in the use of virtual care across nursing designations should draw the attention of both nursing leaders in care settings and nursing educators. These leaders need to ensure that virtual care technologies are accessible to nurses at all levels of practice and digital training is well embedded into nursing education programs. On the geographic location front, the disparities observed could be alleviated through the balanced and effective allocation of digital health resources between urban and rural regions. Finally, the association between access to EMRs and the use of virtual care by nurses should foster the adoption of more modernized patient record-keeping systems. This will have some positive implications for interoperability and health care delivery.

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Authors' Contributions

WB contributed to the conception and design of the study; literature review; data analysis and interpretation; and preparation, review, and editing of the manuscript. SH contributed to the conception and design of the study and reviewed the manuscript.

Conflicts of Interest

WB and SH are employees of Canada Health Infoway Inc.

Multimedia Appendix 1

Increase in the use of virtual care in nursing care (December 2021).

[DOCX File, 20 KB - [nursing_v5i1e33586_app1.docx](#)]

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Abbreviations

- CIHI:** Canadian Institute for Health Information
- CNA:** Canadian Nurses Association
- CNIA:** Canadian Nursing Informatics Association
- CNS:** clinical nurse specialist
- EMR:** electronic medical record
- LPN:** licensed practical nurse
- NP:** nurse practitioner
- RN:** registered nurse
- RPM:** remote patient monitoring
- RPN:** registered psychiatric nurse

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Original Paper

Nurses' Perspectives on an Electronic Medication Administration Record in Home Health Care: Qualitative Interview Study

Sara Karnehed¹, MSc; Lena-Karin Erlandsson¹, PhD; Margaretha Norell Pejner¹, PhD

School of Health and Welfare, Halmstad University, Halmstad, Sweden

Corresponding Author:

Sara Karnehed, MSc
School of Health and Welfare
Halmstad University
Kristian IV:s väg 3
Halmstad, 30118
Sweden
Phone: 46 733224077
Email: sara.karnehed@hh.se

Abstract

Background: eHealth is considered by policy makers as a prerequisite for meeting the demands of health care from the growing proportion of older people worldwide. The expectation about what the efficiency of eHealth can bring is particularly high in the municipal home health care sector, which is facing pressure regarding resources because of, for example, earlier discharges from hospitals and a growing number of patients receiving medications and treatments at home. Common eHealth services in home health care are electronic medication administration records (eMARs) that aim to communicate delegated tasks between professionals. However, there is an extensive gap in the research on how technology affects and is experienced by home health care professionals.

Objective: The objective of this paper is to shed light on how home care nurses experience eMARs in a Swedish municipality.

Methods: This qualitative interview study was conducted among home health care nurses using eMARs to facilitate communication and signing of delegated nursing tasks. The analysis of the interviews was performed using constructivist grounded theory, according to Charmaz.

Results: Of the 19 day-employed nurses in the municipality where an eMAR was used, 16 (84%) nurses participated in the study. The following two categories were identified from the focus group interviews: nurses become monitors and slip away from the point of care. The nurses experienced that they became monitors of health care through the increased transparency provided by the eMAR and the measurands they also applied, focusing on the quantitative aspects of the delegated nursing tasks rather than the qualitative aspects. The nurses experienced that their monitoring changed the power relations between the professions, reinforcing the nurses' superior position. The experience of the eMAR was regarded as transitioning the nurses' professional role—away from the point of care and toward more administration—and further strengthened the way of managing work through delegation to health care assistants.

Conclusions: Previous analyses of eHealth services in health care showed that implementation is a complex process that changes health care organizations and the work of health care professionals in both intended and unintended ways. This study adds to the literature by examining how users of a specific eHealth service experience its impacts on their daily work. The results indicate that the inscribed functions in an eHealth service may affect the values and priorities where the service is in use. This presents an opportunity for future research and for health care organizations to assess the impacts of specific eHealth services on health care professionals' work and to further examine the effects of inscribed functions in relation to how they may affect actions and priorities at individual and organizational levels.

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KEYWORDS

e-health; eHealth; eMAR; electronic medication administration record; homecare nurses; home health care; nursing profession; delegation; task-shifting; medication administration

Introduction

Background

The extensive use of eHealth has brought many new services to health care organizations, such as electronic health records (EHRs), mobile health apps, and electronic medical records. As defined by Eysenbach [1], eHealth refers to the use of internet technologies to organize and deliver health care, aiming to improve health care by using information and communication technology. Owing to their many affordances, caregivers introduce eHealth services with the expectation of increasing patient safety, making care more effective, reducing costs, and providing better conditions for people to receive medical care at home [2-4]. Policy makers consider eHealth as a prerequisite for meeting the demands of health care from the growing proportion of older people worldwide [5], and national policies aimed at facilitating the progress of eHealth infrastructures have been adopted in many countries. In Sweden, the government has undertaken a political vision for the country to become a world leader in using the opportunities offered by eHealth; therefore, an agency has been established to support this process [6]. The expectations of what eHealth can bring are particularly high in the municipal home health care sector, which is facing pressure concerning resources because of earlier discharge from hospitals and a growing number of patients receiving medications and treatments at home [7]. Prior studies indicate positive attitudes among decision-makers about eHealth services in municipal home health care, regarding it as an enabler and simplifier [8], which is in line with the political agenda. However, despite its many affordances, many implementations of eHealth services fail [9-11]. This might be because of resistance among health care workers [12], who correlate eHealth with threats to essential care values, fear of lost power, and professional integrity [13]. In a similar manner, eHealth can be experienced by health care professionals as taking focus from patient-centered meetings [14-16] and contributing to an increased amount of documentation and standardization of tasks, with lower staff influence as a result [17]. Thus, attitudes about eHealth seem to differ between policy makers on the one hand and health care professionals on the other hand. Prior studies have shown that the implementation of eHealth services is a complex process that changes health care organizations and the work of health care professionals in both intended and unintended ways [18,19]. To further understand the impact of eHealth and how it influences health care and health care work, extended knowledge about how health care workers experience different health services in different contexts is needed. Most studies regarding eHealth are researched in hospital care, whereas there is an extensive gap in research regarding eHealth services in professional home health care settings, especially services that aim to facilitate and make communication between professionals more effective [20,21]. To gain more knowledge in this field, where the use of eHealth is particularly expanding, this study focused on nurses' experience of an electronic medication administration record (eMAR) used to communicate and sign delegated nursing tasks in a home health care setting.

Setting and Technology

In Sweden, a person in need of care at home can apply for assistance. In cases of demand for care such as personal hygiene, food delivery, or purchasing, this is provided by a health care assistant (HCA). On the other hand, medical care is provided by a registered nurse. A customary solution in home health care is for HCAs and nurses to work in different organizations within the municipality. In cases of support for medical care, it is common for nurses to transfer tasks to HCAs through delegation. Delegation is regulated by the National Board of Health and Welfare's National Guidelines [22]. A frequent intervention in home health care is support regarding drug administration [23], which is also the most delegated task from nurses to HCAs in home health care [24,25]. It has been shown that common deviations regarding drug administration are failure to sign the list after administration, which has traditionally been made manually on paper; incorrect doses; and omission of doses, which can harm patient health [24,26,27]. Studies have shown that the use of an eMAR may increase patient safety and reduce common mistakes [28,29]. Therefore, more than half of the 290 municipalities in Sweden have recently implemented eMARs to improve efficiency and increase patient safety [30]. The eMAR in this study was implemented through the initiative of the local municipal board as part of a municipality-wide eHealth strategy, which is in line with the National Digitalization Strategy in Sweden [31].

The eMAR is used for the documentation of medication administration and other delegated tasks. It contains a worklist generated by the nurse to support HCAs, informing the tasks to be performed for each patient—for example, administer drugs to patient X at 8 PM—and the HCA logs the administration of medication manually. The eMAR does not interoperate with the EHR but is a separate system. More particularly, it comprises a web-based administration tool on a computer and a mobile app of the eMAR. Access to the eMAR in the computer is limited to system administrators and authorized personnel (nurses and managers). Through computers, nurses create worklists and handle delegations. The eMAR also provides information and statistics on signed and unperformed interventions at the individual and group levels, information on medication availability in patients' homes, and information on delegations. When a nurse registers a task via the computer, it is displayed directly in the mobile eMAR app and is visible to the HCA. The eMAR app can be used when nurses perform health- and medical care-related tasks; however, it is mostly used by HCAs when performing delegated tasks, such as drug administration to patients. The HCA creates a signature in the wearable eMAR in connection with the delegated task being performed.

In summary, there is political intention in Sweden and other countries to use and introduce eHealth, and most municipalities are active in this regard. Common eHealth services are eMARs that aim to communicate delegated tasks among professionals. However, more knowledge is needed regarding how the use of eMAR systems is experienced by municipality home health care nurses in their daily work. With nurses being one of the critical users of eMARs, their experiences provide a beneficial

understanding of the challenges and profits related to the use of similar eHealth services.

The aim of the article is to shed light on how home care nurses experience eMARs in a Swedish municipality.

Methods

Study Design

This paper describes home care nurses' experiences with an eMAR used in a Swedish home health care setting. A qualitative inductive approach was applied using focus group interviews as the data collection method. The analysis of the interviews was conducted using constructivist grounded theory (GT), according to Charmaz [32,33].

Setting and Participants

Nurses employed in a municipality in southwest Sweden, where an eMAR has been used since May 2019, were asked to participate in the study. Nurses were responsible for patients in municipal home health care. They were first informed orally about the meaning of the study by their managers and received oral and written information from the study's authors. Of the 19 day-employed nurses in the municipality, 16 (84%) nurses participated in the study. The authors were informed that the 16% (3/19) of nurses who did not participate in the study were not working when the interviews took place. There was no prior relationship between the participating nurses and the researchers conducting the focus groups.

Data Collection

Data collection took place from November 2019 to January 2020, using focus group interviews conducted by the first and last author (SK and MNP), 6 and 8 months after the implementation of the digital application. The interviews were accomplished in 4 focus groups, with 5 to 7 nurses in each group, and took place at the participants' workplace. Approximately 63% (10/16) of the nurses participated in the focus group interviews both 6 and 8 months after the implementation. Furthermore, 13% (2/16) of nurses only participated in the focus groups conducted 6 months after the implementation. In contrast, 25% (4/16) of the participating nurses only participated in the focus group conducted 8 months after the implementation. This arrangement was because of practical reasons, as not all nurses in the municipality were working at the same time. The participants' average work experience as a nurse in the municipality where the study took place was 11 years, ranging from <1 year to 30 years of employment. Each focus group interview lasted for 60 to 70 minutes and was recorded using a mobile microphone. The discussions in all focus groups began with an initial open interview question. No other interview guides were used. The initial question concerned the participants' experiences of using the eMAR: *what is your experience working with the digital application?* During the interviews, participants were encouraged to focus on the general topic announced by the initial question. The interviewer asked follow-up questions such as *can you explain* and *in what way* to obtain detailed answers.

Analysis

Interviews were transcribed and analyzed following constructivist GT, according to Charmaz [32,33]. Charmaz [32] applied a social constructivist approach to GT, which considers reality as diverse and relates to the interviewees' statements and the researcher's interpretation of these as one of the many descriptions of reality. Furthermore, a social constructivist approach acknowledges that eHealth services are products made by humans within particular social and historical contexts who bring their understanding and assumptions into practice and, thus, represent and promote social institutions and hierarchies [34-40]. After the first interview, the data were transcribed and read several times by the first and last authors (SK and MNP). Initially, the data were coded line by line, in so-called initial coding, which implies naming each line of written data with a label that categorizes, summarizes, and accounts for each piece of data, emphasizing the actions and processes. The next step in the coding process involved focus coding, which compared the different initial codes, asking which theoretical categories these statements may indicate. Furthermore, the initial codes were assessed using data, and codes with greater analytic power were distinguished into focus codes. This coding process continued during data collection in the following 3 focus group interviews. When all data were collected, focus codes were compared and merged into further abstraction in so-called conceptual categories, covering the core meanings of nurses' experiences. During the analytical process of the research, analytical ideas that occurred were written in memos, which were informal notes written individually by the researchers. Bearing thoughts in the memos were further developed in the conceptual categories. The coverage of the codes and categories in the data was checked during the analysis, which was then discussed by the authors and experienced GT researchers.

Ethics

The study was reviewed and approved by the Swedish Ethics Review Authority (Drn 2019-03263). Participants were informed of the voluntary nature of participation and the right to withdraw at any time. The use of the mobile recordings was explained before each interview. Data were handled confidentially.

Results

Overview

Nurses' experiences of eMAR were described in the following two categories: *nurses become monitors* and *slip away from the point of care* with their respective codes. *Monitoring through transparency*, *monitoring shift focus*, and *monitoring changes power relations* were recurring factors in the data related to the first category. Monitoring was possible through the increased transparency provided by the eMAR and the measurands that the nurses also applied, focusing on the quantitative aspects of the delegated nursing tasks rather than the qualitative aspects of the tasks. Furthermore, nurses' monitoring of the HCA's work performances through the eMAR affected the power relations between the professions. The second category included the codes *eMAR creates new working tasks* and *eMAR enforces delegation as routine*, as the eMAR entailed an increased amount of administrative work away from the point of care and

further strengthened the way of managing work through delegation to HCAs.

Nurses Become Monitors

Overview

The nurses delegated most of the drug administration to HCAs. However, because of legislation, nurses were still responsible for the task being performed correctly. The eMAR allowed nurses to monitor HCAs regarding their performance of the task continuously and was considered by the nurses as giving them insight into the HCAs' work. Monitoring was enabled through the enhanced transparency afforded by the eMAR service. However, it also appeared that the monitoring prompted nurses to focus on the quantifiable parts of the working tasks as they applied the eMAR's specific focus on time, the performer, and its measurable variables about the delivered care. In this way, the nurses experienced monitoring as causing a shift in focus from other aspects of the task. In addition, the monitoring affected the relationships with HCA, where the nurses' superior position was considered to be strengthened because of the monitoring possibilities.

Monitoring Through Transparency

The eMAR provided transparency for nurses through real-time information about the HCA's performance regarding delegated tasks. In this way, nurses were able to control and keep HCAs under surveillance. When the eMAR was introduced, nurses realized that delegated tasks were not always performed correctly. The nurses estimated that the number of missed tasks was much greater than before digitalization, as they had rarely noticed omissions before. Transparency meant that the nurses could act on the information given by the eMAR immediately, something they regarded as positive, as they felt responsible for the delegated tasks being performed correctly. The increased information provided by the eMAR was considered positive in terms of patient safety and quality of care, as the nurses now had the possibility to acknowledge mistakes and work on improvements:

We see everything that happens. Now we notice how much is not going right, we did not do that before.

Before eMARs, signing lists were usually collected for inspection by the nurse every 1 or 2 months. With eMAR, nurses experienced reduced paper administration as they did not need to check and change documentation at the patients' homes. This work could now be conducted from the office. The ability to discover deviations and update information at a distance from the office was regarded as positive.

Monitoring Shifts Focus

The scope of the use of the eMAR varied among nurses. It replaced the paper-signing lists; thus, all nurses were obliged to use eMAR to document and control the delegated tasks. However, some inscribed functions (built in by designers) were only used by a small number of nurses; for example, the ability to compare the number of alarms within and among groups of HCAs. Furthermore, nurses assessed information in diverse ways. Some estimated the documented information in eMAR as neutral facts, whereas others perceived it as containing a

correct but reduced part of reality, which had to be complemented with other sources of information. Sometimes, the HCA performed the medication administration correctly but failed to document it properly.

The eMAR provided information about the time at which the drug administration had been performed and by whom. However, qualitative aspects of the performance, such as whether the patient was given the correct information, critical estimation about the plausibility of the prescription, patient involvement, the quality of the performance, or other aspects of nursing work, were not included in the information provided. However, most nurses used this reduced quantified information as a basis for assessing how well the HCAs performed their work. This resulted in quantification of HCAs' work performances, as the nurses applied the apps' specific focus on time and documentation:

And you can get a report for each specific HCA as well as what percentage they are on, so you can see if it is one that has hundred percent or if someone has only signed 80 percent in time, then maybe you should have a conversation with that person.

The inscribed functions and design of the eMAR also influenced the focus of the users. Nurses experienced that HCAs used the information in the eMAR to a greater extent than the information that was still provided on paper. For example, when administering drugs, one must check the medication, identity of the patient, written medication list, and information in the eMAR. However, the nurses experienced that HCAs did not always check the medication list on paper and relied only on the information in the eMAR. The nurses thought that this was because the information was stored in separate places, and the technology was accessible and more attractive than paper to use. According to the nurses, HCAs' prioritization of performing the tasks included in the eMAR sometimes led to a decreased focus on other important areas of their work, which were not included in the eMAR. As the following quote illustrates, the focus shifted from the patients to the eMAR and documentation itself:

When I worked one weekend, I remember it very clearly, they were so stressed. There was a member of staff there and she was sweating, she just focused on the app "There mustn't be any delays, mustn't be any delays." And I was just: "But you will not be hanged because you have given a drug five minutes late to a patient." But she was really worried about that she would get rid of her delegation to give drugs. It was the only thing she focused on, to give drugs within the time-frame in the application, and the risk is that she missed something else, like how the patient in front of her was doing.

Correct documentation could also give nurses a false picture of everything working well in care situations. Only when measurable tasks within the eMAR were omitted were the nurses informed. In the case of other misconducts, eMAR did not provide any information.

Monitoring Changes Power Relations

The eMAR offered an opportunity for nurses to control the HCAs' work performances. Monitoring affected their relationship with HCAs, changing the power relations between the professions. HCAs could not know when or if they were being checked. Nurses felt that the monitoring possibilities sometimes created stress, fear, and frustration among HCAs, and they described increased power in relation to HCAs. The eMAR alerted the nurse with visual alarms when a task was not performed correctly, which led to a focus on negative feedback from the HCAs. Monitoring was perceived as a new and complex situation for nurses:

It is a shift of power in that we can get such control over what they do. And they know about it. In that way, it is a power factor. That's exactly what it is, you go in and say "Now I have seen this mistake, so now we withdraw your delegation...so they are a bit stressed sometimes."

Although the eMAR was implemented as an initiative from the local municipal board, the nurses felt that they were held accountable for the implementation by the HCAs, who were frustrated with the nurses' monitoring and focus on documentation:

It is negative stress. Sometimes it feels like they think we have invented this. "How silly, we do the best we can, and we don't have time and we are so stressed," and so on. Then we have to promote this eMAR and explain that it is a quality system that we use according to our guidelines. Sometimes I feel that we have to take the shit for this in some way.

Slip Away From the Point of Care

Overview

In addition to the monitoring illustrated in the category above, the nurses also experienced that their professional role was transitioned, as the eMAR imposed them to perform new administrative working tasks and was used and designed to facilitate delegation as a modus operandi in the home health care organization. This further positioned nurses to administer and control nursing tasks rather than perform the tasks themselves.

eMAR Creates New Working Tasks

The implementation of the eMAR brought new assignments and areas of responsibility for the nurses, such as investigating deviations to a much larger extent than before, having personal follow-up meetings with HCAs, and providing technical support to colleagues. Although they were grateful for the reduced paper administration because of digitalization, they also experienced an increased amount of these other administrative tasks, which they regarded as time consuming and not a part of what they considered their actual responsibilities as nurses. For example, the eMAR often alerted when a task had not been signed at all, and to investigate such a situation, the nurse had to find out who was responsible for performing the task among the HCAs. They needed to ask the HCA unit manager for information regarding work schedules, which often required emailing and calling to

get hold of information. Notifications from the eMAR demanded immediate action from the nurses not only as they were responsible for the delegated tasks but also to keep the mobile screen for HCAs clean; otherwise, it would have been impossible for them to see other relevant information behind the notifications. The need for prompt action on eMAR alarms resulted in workflow disruptions for nurses. They felt that they were spending considerable time in investigations and personal follow-up conversations with HCAs and assessed this type of work as being outside their nursing profession and actual responsibilities:

And at the same time, you have all your own work that you have to keep up with and you sit there in conversations with managers and healthcare assistants, yes, it is not entirely simple. It can be quite frustrating when you have the whole diary full, and you have three booked meetings where you must discuss this and try to be flexible and still clear about the rules.

The nurses were not involved in decisions regarding the implementation of the eMAR and had no established formal ways of providing feedback to the eMAR developers. Smaller updates and new functions came without prior notice, and as the delegated tasks were considered to be the nurse's area of responsibility within the organization, HCAs turned to them with questions about technology and its use:

They come and ask me "How do I do this in the application, how does the application work?"...Yes, you feel that you are not only a nurse but also have become some kind of technical support or something. For my part, it's all right, but it's not really part of my job as a nurse (laughs).

Nurses expressed that they had the skills and abilities necessary to use digital health technology and services. They had experience working with eHealth services as EHRs, digital booking systems for medical products, mobile telephones, and email services were already a part of their daily work. The fact that not all systems were integrated was something they perceived as time consuming because of different log-ins and the occasional need for double documentation. The nurses expressed ambivalence about the functions of the various systems but accepted the organization's existing digital systems, although they did not always facilitate their work:

You just have to teach yourself and become friends with the systems...I don't know, it is difficult to dislike something that we must use. You just have to learn.

eMAR Enforces Delegation as Routine

The nurses' experiences indicated that the delegation of drug administration was routine within the organization. There were not enough nurses employed to administer drugs to the patients themselves without delegating the task to HCAs. Nurses said that this situation also existed before implementation. However, eMAR was designed in accordance with this organization of work and, in this way, strengthened delegation as a way of working. The nurses felt a certain pressure to delegate the administration of drugs to HCAs:

Quite simply, we have to deliver a delegation to someone we have barely seen or know who they are or what they are capable of.

The nurses had formal responsibility for medical tasks even if they were delegated, and they tried to find ways of influencing the HCAs' ability to fulfill these tasks correctly. This was realized by providing suggestions about the changed working routines in the organization. However, the nurses experienced a lack of mandate to influence organizational issues, and their attempts to organize the HCAs' work were not encouraged within the organization:

It's not so simple. If I say: "The two who have the phones with the application must be responsible for the drug administration," then I am perceived as controlling how they should do their work, and then it does not fall on fertile ground, and I get back from the management "That it is not my job to tell how they should do it." But the reason I do it is that no one else does it either. I have a responsibility to ensure that the drugs are given when they are supposed to be given, and if no one else takes responsibility for personnel management, you must go in and give a suggestion.

Owing to a perceived lack of mandate to influence identified structural causes of deviations regarding the delegated tasks, such as understaffing, lack of medication competence among HCAs, lack of internet connection at some places in the municipality, provision of portable devices that enable mobile connection for the eMAR, or issues regarding work organization, the nurses focused on individual causes of deviation, which was supported by the organization's guidelines. The individual focus on personal follow-ups with HCAs was experienced as frustrating as nurses sometimes felt that the discussions made no difference.

Discussion

The eMAR Has Transformative Effects

eHealth has many affordances, and it is important to acknowledge its many possibilities. The expectations for what eHealth can offer are often high, which is indicated in the very adoption of the concept, as defined and extensively cited by Eysenbach [1] as follows: not just a technical development but also an attitude that the use improves health care locally and worldwide. This enthusiastic state of mind is also visible in the Swedish Governmental Vision of eHealth 2025 [31], which aims for the country to be the best worldwide in using the opportunities offered by digitalization. However, it is not surprising that digitalization in health care is proceeding at a rapid pace. However, this study shows that the use of the eMAR was experienced as transforming some aspects of the nurse's profession toward a function of more control through monitoring and administration. This was not a pronounced goal for the use of eMAR but instead, an unintended consequence that might add to the understanding of the different views of eHealth between policy makers and health care professionals that now exist. The findings in this study are in line with results from previous research, stating that nurses considered documentation

and navigation in the eMAR system as time consuming and took time away from their patient near work [16]. However, previous research has also stated that using an eMAR does not result in less direct patient care [41]. Consequently, this study shows that a broad perspective should be considered in eHealth interventions, embracing both the intended and unintended aspects of their meaning and impact on social relations, professionals, and organizations. Therefore, these impacts should be taken into consideration when planning for and using this type of eHealth service.

As we have shown, the eMAR enabled nurses to monitor HCAs in real time regarding delegated tasks. The monitoring resulted in increased insight and clarity for the nurses, which was considered positive concerning patient safety, as they experienced more control over their area of responsibility. However, the information provided by the eMAR was mediated through its measurands, which focused on time and the performer, only making specific parts of reality visible. In this way, the use of the eMAR prompted nurses to assess tasks through numbers and measure the HCA's work performance in percentages, which they regarded as a focus shift from more qualitative aspects of nursing. This process can be understood using literature on transparency related to visualizing technologies. Flyverbom [42] uses the term *prism* as a metaphor for transparency to illustrate how visualizing technologies provide a mediated representation of reality. In this way, transparency not only makes certain things visible but also produces differences [37]. Orlikowski and Scott [43] made a similar reasoning, stating that materializations of discourse have performative consequences that affect practice. In our case, before the use of the eMAR, signing lists for documentation of medication administration were materialized in paper sheets in the patient's home. In contrast, the eMAR provided nurses with information about the person who performed the delegated task and the time when it was performed. Using the Orlikowski and Scott [43] perspective, this is most likely a material-discursive shift from retrospective transparency to real-time transparency, which resulted in work disruption and new working tasks for the nurses who had to act on the information by investigating deviations and holding follow-up meetings with HCAs. Real-time monitoring also affected the power relations between the 2 professions, strengthening the HCAs' subordinate positions.

Furthermore, the transition of the nursing profession toward a function of controller, as well as an increased focus on administration and measurands, is in line with the New Public Management model, introduced in the Swedish health care sector in the 1980s [44], where the pursuit of control, efficiency, productivity, and transparency is fundamental. The eMAR might further strengthen this development. However, depending on its design, an eHealth service may rely on, develop competence and judgment, or foster quality improvement through control, review, and governance. It is not implausible to consider that using an eMAR, where the measurable is prioritized, may lead to a focus on measurable parts of health care tasks, in favor of more immeasurable tasks, for example, to stop talking to patients while a task is performed and relieve anxiety by listening or the use of personal judgment.

eMAR Enforces Delegation as Routine

Our findings demonstrate that nurses experienced delegation as praxis within the organization and that the eMAR supported this way of working. The nurses felt that they were expected to delegate tasks such as drug administration to HCAs. The Swedish National Board of Health and Welfare's regulations and general advice on the delegation of tasks in health care [22] describe that delegation can be used in exceptional cases and must not be applied to solve staff shortages or for economic reasons. Nevertheless, former studies have shown that HCAs perform most tasks requiring nurses, and instead of being a complementary solution, where medical tasks such as drug administration are undertaken by nurses, delegation has become routine in Swedish home health care settings [24,45]. This was confirmed by this study's results.

The study findings revealed that the eMAR alerted nurses that existing structures regarding delegation within the organization did not always function properly. Nurses experienced an increased omission of doses and late administration of drugs after the implementation of the eMAR. Medication administration is a complex task requiring counting, mixing, calculating, and controlling that the administration be performed at the right time for the right person in a correct dose and for accurate purposes [46]. The eMAR only provided information on parts of the task, leaving out other aspects of the administration. Even if the nurses experienced that their increased control of medical administration through the eMAR had positive effects on patient safety, they also acknowledged that other aspects that were not visualized in the eMAR had lower quality. The nurses' experiences of omissions regarding drug administration and other commonly delegated tasks should be further investigated to gain more knowledge about how this form of extensive delegation of medical tasks to HCAs affects patient security and quality of care.

To improve the situation regarding omissions, the nurses proposed structural changes in how HCAs worked. However, as they felt a lack of mandate to influence organizational issues, they focused on having follow-up conversations with individual HCAs. This was regarded as a time consuming and complex task to accomplish, partly because of the negative character of their feedback to the HCAs. This complexity regarding reporting and communicating adverse events in home health care has been highlighted in a prior study demonstrating that reporting of adverse events that involve colleagues is considered distressing by nurses [47]. The eMAR used in this study allowed nurses to observe inaccuracies in delegated tasks. To use this information constructively so that future mistakes can be prevented and a culture of safety may be fostered in the health care organization, structures for processing this increased amount of data are needed. Focusing on individual feedback rather than structural ones might hinder organizational changes that can contribute to delegated tasks being performed correctly. Therefore, we suggest that the information regarding mistakes and deviations displayed in the eMAR should be analyzed and managed with a broader focus than on individuals and at a higher level within the organization so that preventive work and a structural take on deviations can be conducted.

eHealth services were not new to the participants in this study. Several eHealth systems were already in use when the eMAR was implemented. Experiences from prior eHealth services, as well as eHealth services in use, might have influenced the nurses' experience of the eMAR. For example, previous research highlights the connection between the general use of digital technologies in daily life and the perception of digital technologies at work, stating that people who appreciate the advantages offered in a digitized society also recognize and expect profits provided by digital technologies at their job [48]. However, these aspects were not investigated further in this study.

Co-design as a Possibility

The findings in this study also indicate that the eMAR was implemented from the top of the organization and that the principles of co-design were not applied. Nurses had many ideas about the desirable features and design of the eMAR but lacked formalized paths to communicate with eMAR developers. The sender was regarded as unclear, and smaller updates were unannounced for reasons that the nurses were not informed of. The impression that decisions about eHealth services are made by unidentified persons at a higher level in the organizational hierarchy indicates a lack of employee involvement and has been previously acknowledged in research concerning eHealth in health care organizations [49]. As the eMAR was dependent on internet access and did not work in all geographical locations in the municipality, security was not perceived by the nurses to meet the safety requirements of health care. Therefore, analog paper copies and backup plans were always available. This suggests that the eMAR was not fully adapted to a specific context. Acknowledged factors for successful implementation of eHealth services are user involvement before implementation, sufficient time for users to learn the system, formalized feedback sessions where users can discuss experiences and specific issues, and available support from super users of the implemented system within the workplace [8,50]. Furthermore, the interaction between users and developers should continue, as problems and challenges in the system are addressed once the eHealth service is in use [36,51]. Therefore, we suggest that future implementations and uses of eHealth services involve end users to ensure alignment with the ongoing processes in the health care organization, as well as to incorporate professional values and understandings. Through collaboration, nurses and other health care professionals might have a greater influence on which areas of their work can benefit from eHealth and in what direction their professions will develop.

Methodological Discussion

Using GT analysis, according to Charmaz [32,33], proved to be useful in exploring how home care nurses in a Swedish municipality experienced eMARs. This method was considered helpful in achieving the objectives of the study. Furthermore, using interviews for data collection made it possible to see diversity in reality; however, there were some aspects that must be emphasized. First, the number of participants in the focus groups is recommended to be small [52], which was the case in this study, so that all the participants are able to speak. The composition of the group, in accordance with Krueger and Casey

[52], was homogeneous, as all participants were nurses working in the same organization. Familiarity with technology is related to improved acceptance, and some challenges might only be visible during the first months immediately following implementation [53]. The dates of the focus groups were set so that participants would have some experience with the eMAR and, at times, intended to make participation possible for most of the nurses employed in the municipality. For practical reasons, some nurses participating for the second time, 8 months after the implementation, were placed in the same group as nurses who participated for the first time. Whether the composition of the focus group interviews influenced the discussions at the time of the interview and, thus, the results is difficult to say. On the other hand, the number of nurses in the municipality where the study was conducted was small, and almost everyone (16/19, 84% nurses) participated. Therefore, there is reason to believe that nurses discussed the issue on occasions other than during the interviews. From this point of view, the result is not believed to have been affected by the fact that some nurses participated for the second time, together with those who were interviewed for the first time. Second, to achieve credibility [54], the analysis was conducted jointly by the first and last authors (SK and MNP). The findings have also been discussed in 2 different seminars with other researchers affiliated with nursing and sociology. Finally, the process in this study is described in such a way that it can be followed and repeated by others. However, the findings in future studies may differ as the use and development of technology is rapidly advancing, and the user adapts to prevailing conditions. The nurses participating in the study were offered to take part in the interview transcripts but did not ask for it.

The social constructivist perspective applied in the study distinguishes itself from the assumption about objective reality and, instead, adopts the assumption that reality is multiple, processual, and constructed [32,33]. In this manner, the study did not aim to evaluate the efficacy of the eMAR; rather, the experiences of its users and the human and technology

interactions were explored. When adopting a social constructivist perspective that recognizes eHealth services as social artifacts, it is possible to highlight the intended and unintended consequences and implications on existing hierarchies and social life. The constructivist approach has been useful in acknowledging this broader experience of eHealth services and recognizing larger structures embedded in participants' experiences.

Future studies should focus on the attitudes and experiences of end users of eHealth services, as well as developing theories and methods for investigating the effects and processes when technological and human agency come together in health care.

Conclusions

Previous analyses of eHealth services in health care have shown that implementation is a complex process that changes health care organizations and the work of health care professionals in both intended and unintended ways. This study adds to the literature by examining how users of a specific eHealth service—an eMAR used to manage the delegation of medical administration—experienced impacts on their daily work. The results showed that the nurses experienced that eMAR gave them more control and knowledge about how delegated tasks were performed. However, the eMAR also brought more complex and unexpected changes to their work situation, such as more administration, a focus shift toward quantifiable aspects of work, and changed power relations between the professions. As the nurses applied the eMARs' specific focus on time and documentation and its broader focus on delegation as a way of working, the results also indicate that inscribed functions in an eHealth service may affect values and priorities where the service is in use. This presents an opportunity for future research to assess the impact of specific eHealth services on health care professionals' work and further examine the effects of inscribed functions in relation to how they may affect actions and priorities at the individual and organizational levels.

Conflicts of Interest

None declared.

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Abbreviations

- EHR:** electronic health record
eMAR: electronic medication administration record
GT: grounded theory

HCA: health care assistant

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Original Paper

Investigating #covidnurse Messages on TikTok: Descriptive Study

Bhavya Yalamanchili¹; Lorie Donelle², PhD, FCAN, RN; Leo-Felix Jurado¹, PhD, RN, APN, NE-BC, CNE, FAAN; Joseph Fera³, PhD; Corey H Basch¹, MPH, EdD

¹William Paterson University, Wayne, NJ, United States

²Western University, London, ON, Canada

³Lehman College, Bronx, NY, United States

Corresponding Author:

Corey H Basch, MPH, EdD

William Paterson University

300 Pompton Rd

Wayne, NJ, 07470

United States

Phone: 1 9737202603

Email: baschc@wpunj.edu

Abstract

Background: During a time of high stress and decreased social interaction, nurses have turned to social media platforms like TikTok as an outlet for expression, entertainment, and communication.

Objective: The purpose of this cross-sectional content analysis study is to describe the content of videos with the hashtag #covidnurse on TikTok, which included 100 videos in the English language.

Methods: At the time of the study, this hashtag had 116.9 million views. Each video was coded for content-related to what nurses encountered and were feeling during the COVID-19 pandemic.

Results: Combined, the 100 videos sampled received 47,056,700 views; 76,856 comments; and 5,996,676 likes. There were 4 content categories that appeared in a majority (>50) of the videos: 83 showed the individual as a nurse, 72 showed the individual in professional attire, 58 mentioned/suggested stress, 55 used music, and 53 mentioned/suggested frustration. Those that mentioned stress and those that mentioned frustration received less than 50% of the total views (n=21,726,800, 46.17% and n=16,326,300, 34.69%, respectively). Although not a majority, 49 of the 100 videos mentioned the importance of nursing. These videos garnered 37.41% (n=17,606,000) of the total views, 34.82% (n=26,759) of the total comments, and 23.85% (n=1,430,213) of the total likes. So, despite nearly half of the total videos mentioning how important nurses are, these videos received less than half of the total views, comments, and likes.

Conclusions: Social media and increasingly video-related online messaging such as TikTok are important platforms for social networking, social support, entertainment, and education on diverse topics, including health in general and COVID-19 specifically. This presents an opportunity for future research to assess the utility of the TikTok platform for meaningful engagement and health communication on important public health issues.

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KEYWORDS

COVID-19 pandemic; nurse; burnout; social media; stress; TikTok; nursing; COVID-19; pandemic; social support; digital peer support; health communication; peer support

Introduction

Nurses play an integral role in health care, with around 28 million nurses worldwide. The nursing profession dominates the variety of occupations in the health care industry, with about 59% of professionals. Despite nurses accounting for the majority of health care professionals, there is still a need for 5.9 million nurses globally [1].

Due to the COVID-19 pandemic, there has been an overwhelming number of deaths including many health care workers. The International Council of Nurses (2020) confirms 1500 nurses perished from COVID-19 in 44 countries [2]. The nature of the nursing role creates situations where most nurses are at high risk of being overworked, experiencing burnout, and exposed to potentially psychologically traumatizing events [3]. This has only been exacerbated by the onset of the COVID-19

pandemic. Previous research conducted during similar outbreaks (H1N1, severe acute respiratory syndrome) showed that nurses experienced the highest levels of work-related stress, and subsequent distress, compared to other groups of health care providers [4].

The pandemic heightened and brought to public attention many health care-related disparities. Nurses encountered many new and difficult challenges resulting from stress. The rates of severe stress among nurses have been reported as high as 56.4% [5]. The proportion of mental health issues among nurses during the pandemic are markedly higher than the general population prevalence of anxiety and depression estimated at 11.2% and 4.7%, respectively [6].

One of the most prominent causes of stress among nurses during the COVID-19 pandemic is the persistent fear of infection due to their proximity to those already ill. Contracting the infection as well as the possibility of spreading it to loved ones is reported as a major fear of nurses, thereby increasing stress levels both on the job and at home [7]. Many nurses were unable to stay with their loved ones during the beginning of the pandemic, elevating the potential for chronic stress, grief, and anxiety [8]. One study that looked specifically at nurses living in isolation to protect their relatives found high rates of stress in 39.1% of the participants [9].

Working long hours at the frontlines of the COVID-19 pandemic, nurses were substantially impacted by the lack of resources, increased physical and emotional stress, and increased risk of harm [10]. The lack of resources proved to be a substantial stressor for nurses, especially during the initial months of the pandemic when adequate personal protective equipment (PPE) was unavailable. Anecdotal accounts from the beginning of the pandemic consistently showed that concerns regarding inadequate PPE increased symptoms of anxiety, stress, and fear among nurses and other health care workers [3,11]. Shahrour and Dardas [7] found that the lack of PPE was associated with higher stress and worse mental health outcomes. Moreover, hospitals were inundated with COVID-19 admissions, as a result, nurses were given little reprieve from the high workload and the uncertainty of when the pandemic will end [8]. Global mental health experts note that COVID-19-related challenges increased the risk of moral harm and emotional stress [12]. Nurses providing patient care during unprecedented times and complex decision-making, and repeatedly seeing traumatic events resulted in anxiety, depression, exhaustion, and burnout [12,13].

Over the past 15 years, social media use has increased substantially, with around 72% of the American public using some type of social media platform [14]. These platforms are available for individuals of all genders and backgrounds; user demographics of these platforms vary as they garner different audiences. Research indicates that 78% of US adult women use at least one type of social media platform like TikTok or YouTube, compared to 66% of US adult males [14].

TikTok essentially functions as a repository of short-form mobile videos [15]. The social media app is marketed as a platform to develop creativity and content development skills, an edutainment portal, and a vehicle for commercial advertising

[16]. TikTok, a user-friendly platform originally designed to engage young audiences, enables users to develop, create, and share content and campaigns to a large and diverse audience. An influencer is an emerging role on social media defined as “everyday, ordinary Internet users who accumulate a relatively large following on blogs and social media through the textual and visual narration of their personal lives and lifestyles, engage with their following in digital and physical spaces, and monetize their following by integrating ‘advertorials’ into their blog or social media posts” [17]. Although nurses do not engage in commercial marketing, health communication can also be viewed under the umbrella of social marketing [18]. Nurses require knowledge and communication skills to reach the growing number of individuals and families who access health and health-related information through online and social media channels. However, the use of social media by health care professionals is a contentious issue; the presence of online misinformation challenges the integrity of online health information, and although many providers are embracing social media use, others perceive its use as unprofessional [19].

Social media in the nursing workplace can be beneficial if it is used appropriately. Social media has shown to enhance professional networking and provide an outlet to share feelings and seek support from other nurses and health care professionals. It also serves as a way to inform and educate consumers and colleagues, and can even enhance timely communication with patients and members of the health care team [20]. During a time of high stress and decreased social interaction, nurses have turned to social media platforms like TikTok as an outlet for expression, entertainment, and communication. Anecdotally, nurses have used #TiredHealthcareWorker on TikTok to document and expose untenable COVID-19-related working conditions, the unrelenting stress, and the impact on their mental health [21]. There is a clear lack of research published in this area. In response to this gap in the research literature, the purpose of this cross-sectional study was to describe the content of videos on the hashtag #covidnurse on TikTok.

Methods

This cross-sectional content analysis study included 100 videos in the English language from the hashtag #covidnurse on TikTok. At the time of the study, the hashtag had 116.9 million views. The videos were excluded if they were not in the English language and were not relevant to the subject being explored, nursing and COVID-19. The coding categories were finalized on July 19, 2021, whereas the coding was completed on August 14, 2021. The videos were included if they were in the English language and were relevant to the subject being explored, both nursing and COVID-19. The first 100 videos using the search term #covidnurse to have these criteria were included. For each video, the date of posting, number of views, comments, and likes were indicated. All videos were also analyzed for mention or suggestion of the content categories, which were created inductively and collaboratively. Data was collected by observing TikTok videos for mention or suggestion of various predetermined categories. Additionally, information about the creators was noted based on the video, bio, or caption. All the data from the video were collected, categorized, and organized

using Excel (Microsoft Corporation). A single reviewer (BY) watched all 100 videos and indicated whether or not the content categories were present in each video. A second reviewer (CHB) watched 10 (10% of the sample) randomly selected videos for the same content to determine interrater reliability. Of the 220 data points, the two reviewers only differed on 3 points, resulting in a score of $k=0.97$.

Organization, data entry, and analysis were all completed in Excel. Descriptive statistics and independent 1-tailed t tests ($\alpha=.05$) were completed to determine if the predetermined content characteristics had an impact on video interaction based on views (number of times the video was watched), likes (number of times the like button was hit indicating a level of approval), or comments (number of individual remarks) a video garnered. This study was exempt from review, as the William

Paterson University Institutional Review Board does not review methods that do not involve human participants.

Results

Combined, the 100 videos sampled received 47,056,700 views; 76,856 comments; and 5,996,676 likes. The respective averages were as follows: 470,567 (SD 1,232,554.2); 769 (SD 1626.44); and 59,967 (SD 231,319.51). Of the 100 videos, 39 mentioned safety, 54 did not mention safety, and 7 mentioned nurse-to-patient ratios. Table 1 shows different content characteristics and indicates how many of the videos reviewed included this content. The number of views, comments, and likes for videos with this content is also given in the table. Note that two content categories were eliminated from the table since they were not observed in any of the videos sampled. They were “mentions suicide” and “has misinformation.”

Table 1. Observed content, views, comments, and likes of 100 TikTok videos on nursing.

	Videos (n=100), n	Views (n=47,056,700), n (%)	Comments (n=76,856), n (%)	Likes (n=5,996,676), n (%)
Individual is a nurse	83	43,894,700 (93.28)	69,398 (90.30)	5,662,290 (94.42)
Individual in professional attire	72	41,016,100 (87.16)	50,933 (66.27)	5,316,127 (88.65)
Mentions/suggests stress	58	21,726,800 (46.17)	45,405 (59.08)	2,562,825 (42.74)
Uses music	55	27,115,100 (57.62)	43,429 (56.51)	2,938,897 (49.01)
Mentions/suggests frustration	53	16,326,300 (34.69)	44,630 (58.07)	2,288,307 (38.16)
Mentions/suggests importance of nursing	49	17,606,000 (37.41)	26,759 (34.82)	1,430,213 (23.85)
Mentions/suggests social support	44	11,830,701 (25.14)	31,251 (40.66)	1,598,048 (26.65)
Uses humor	40	25,442,101 (54.07)	23,770 (30.93)	3,829,229 (63.86)
Mentions/suggests exhaustion	40	14,486,500 (30.79)	34,305 (44.64)	1,481,081 (24.70)
Mentions/suggests mental health	34	7,785,400 (16.54)	27,474 (35.75)	1,066,005 (17.78)
Using post as encouragement	32	10,716,500 (22.77)	15,457 (20.11)	963,531 (16.07)
Mentions/suggests being strong (mentally, physically, or emotionally)	26	11,613,400 (24.68)	24,872 (32.36)	1,449,092 (24.16)
Mentions/suggests being scared	25	7,507,000 (15.95)	26,791 (34.86)	1,164,559 (19.42)
Mentions/suggests hours worked	19	4,687,400 (9.96)	9590 (12.48)	408,386 (6.81)
Mentions/suggests burnout	19	1,089,400 (2.32)	6653 (8.66)	90,661 (1.51)
Mentions/suggests death (in relation to professional role regarding patient death or within the context of COVID-19-related deaths)	17	7,899,200 (16.79)	24,574 (31.97)	1,564,957 (26.10)
Uses dance	15	5,138,900 (10.92)	4685 (6.10)	361,124 (6.02)
Mentions/suggests COVID-19 vaccine	3	857,600 (1.82)	4082 (5.31)	81,800 (1.36)

There were 4 content categories that appeared in a majority (>50) of the videos: 83 showed the individual as a nurse, 72 showed the individual in professional attire, 58 mentioned/suggested stress, 55 used music, and 53 mentioned/suggested frustration. Despite the fact that videos with these content characteristics made up the majority, some did not garner a majority of the roughly 47 million total views. Those that mentioned stress and those that mentioned frustration received less than 50% of the total views ($n=21,726,800$, 46.17% and $n=16,326,300$, 34.69%, respectively). These observations,

though, were not statistically significant. Independent 1-tailed t tests ($\alpha=.05$) were run to see if videos with this content garnered significantly more views, comments, and likes than videos without this content. All tests resulted in P values larger than .05. Hence, it does not appear that mentioning stress or mentioning frustration resulted in significantly more views, comments, or likes. Although not a majority, 49 of the 100 videos mentioned the importance of nursing. These videos garnered 37.41% ($n=17,606,000$) of the total views, 34.82% ($n=26,759$) of the total comments, and 23.85% ($n=1,430,213$)

of the total likes. So, despite nearly half of the total videos mentioning how important nurses are, these videos received less than half of the total views, comments, and likes. These observations, however, were also not statistically significant as determined by independent 1-tailed *t* tests ($\alpha=.05$). The respective *P* values were .19, .18, and .095.

Discussion

Although the year 2020 will be best remembered for the COVID-19 pandemic, 2020 was also distinguished globally as the year of the nurse and midwife. Over the course of the pandemic, the tireless work of nurses has been highly regarded in the mass media and through public displays of appreciation worldwide. Nurses have been indispensable to mitigating and containing the spread of COVID-19. However, their strong sense of duty to patients, their families, and their nursing colleagues was not without personal consequences to their physical and emotional well-being [10,22]. This research assessed the TikTok video messages conveyed within the hashtag #covidnurse.

TikTok videos in this study focused primarily on nurses' health and well-being, acknowledging the challenges faced by nurses, and provided a number of supportive and encouraging messages. Interestingly, messages related to COVID-19 and related to health promotion actions were only briefly mentioned. This finding seems inconsistent with others who have reported the importance of websites and social media as a health information resource during the pandemic [23]. Even more compelling is the notion that visual or illustrated health messages posted on platforms such as TikTok can reach and impact audiences with diverse health and digital health literacy skills; visual messaging can help to engage *hard to reach* people, contributing to information equity [24]. In our study, there were limited mentions of COVID-19 vaccines and no mention of misinformation. Yet, the World Health Organization has positioned misinformation (particularly online information) as a parallel pandemic and a substantial barrier to an efficient resolution to the COVID-19 outbreak. It may be the #covidnurse term emphasized nurses' experiences in providing direct care to patients with COVID-19 in acute care settings rather than nurses' role as health educator and communicator.

This study is limited by the inclusion of only one hashtag, studying content in English only, and the cross-sectional approach in which data was collected. Collecting data from videos only in English is limiting because neither the COVID-19 pandemic nor nursing care are geographically limited. Another limitation of the study is the fact that the data represents a snapshot in time and the results cannot be generalized. As the pandemic and social media evolve, the content from this hashtag also has the potential to change. However, this is the best possible assessment of the content studied as of the study closing date. Further, the presence of bots on this study sample, although highly unexpected, could not be verified. Despite these limitations, this study serves as an example of the type of content in this understudied area of research.

Social media and increasingly video-related online messaging such as TikTok are important platforms for social networking,

social support, entertainment, and education on diverse health and related topics including COVID-19 [25-27]. In a study assessing nursing students' COVID-19-related tweets, researchers reported that tweets "...praised the hard work of the medical staff, and urged the public to take responsible actions [compliance with public health recommendations]" [28]. In their systematic review of acute care nurses' pandemic work experiences, researchers found a high level of collegial support among nurses during the pandemic and expressed concern among practicing nursing about caring for and about the health and well-being of their coworkers [22]. This is consistent with the findings from this study where we report a high proportion of videos that highlight stress, frustration, exhaustion, and mental health issues relevant to nursing within the context of COVID-19. The TikTok hashtag #covidnurse may serve as a platform for nurses and others to process their experiences, give and receive empathy, and lighten their emotional load through sharing with others, bearing witness in the virtual sense [29].

In addition, several messages contained within #covidnurse also reflect compassionate messages of humor, peer support, and remaining strong [22]. Godfrey and Scott [30] found that nurses engaged in a peer support program during the COVID-19 pandemic benefitted from reduced stress, increased resilience, and a sense of community. The TikTok #covidnurse online site may provide nurses an *always available* informal peer support environment where viewers will see they are not alone, are appreciated for their work, experience empathy, and have their thoughts and feelings validated by their peers [30].

Despite the supportive video messages reported within this study, there is a growing concern regarding malicious and hurtful feedback from TikTok viewers. These vitriol responses are a growing concern across online social media platforms [31]. Comments in this study were not analyzed according to the civility of the comments; however, nursing students' tweets about the COVID-19 pandemic "used inappropriate language such as profanity and name-calling on this public platform." Similar findings were noted in a 2019 study of uncivil tweets among nursing students and nurses [28]. This presents an opportunity for future research: to assess the civility of TikTok commentary and therefore the utility of the TikTok platform for meaningful engagement and health communication on important public health issues. TikTok and other social media platforms are increasingly important health promotion and health communication venues with considerable audience impact. TikTok is an especially relevant platform for health promotion and health education targeted to children and young adults, presenting health information in a way that is engaging and relevant to a substantial online audience. The peer-to-peer nature of TikTok also serves as an accessible source of health information, social support, and health promotion coaching among the users [32]. Nurses, perceived as trusted health care providers, may find TikTok to be an especially important vehicle for health promotion activities for children and young adults. Further this research indicates the ability of TikTok to serve as a catalyst for social support. In conclusion, this research has important implications for nursing practice and the use of ethical and effective social media platforms for health promotion.

Conflicts of Interest

None declared.

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Abbreviations

PPE: personal protective equipment

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Original Paper

Developing and Testing a Protocol for Managing Cardiopulmonary Resuscitation of Patients with Suspected or Confirmed COVID-19: In Situ Simulation Study

Azizeh Sowan¹, RN, MSN, MBA, MSDA, PhD; Jenny Heins², RN, MSN, CMSRN, CHSE; Christopher Dayton³, MD, MPH; Elizabeth Scherer⁴, MD, MPH; Wing Sun Tam⁵, MBChB, MPH; Haritha Saikumar⁶, MD

¹School of Nursing, The University of Texas Health at San Antonio, San Antonio, TX, United States

²Center for Clinical Excellence, University Health, San Antonio, TX, United States

³Division of Pulmonary and Critical Care Medicine, Department of Emergency Medicine, The University of Texas Health at San Antonio, San Antonio, TX, United States

⁴Division of Trauma and Emergency Surgery, Department of Surgery, The University of Texas Health at San Antonio, San Antonio, TX, United States

⁵Emergency Department, Audie L Murphy Veterans Affairs Medical Center, South Texas Veterans Health Care System, San Antonio, TX, United States

⁶Pulmonary and Critical Care, The University of Texas at Austin Dell Medical School, Austin, TX, United States

Corresponding Author:

Azizeh Sowan, RN, MSN, MBA, MSDA, PhD

School of Nursing

The University of Texas Health at San Antonio

7703 Floyd Curl Dr

MC 7975

San Antonio, TX, 78229-3900

United States

Phone: 1 210 567 5799

Fax: 1 210 567 1719

Email: sowan@uthscsa.edu

Abstract

Background: Resuscitating patients with suspected or confirmed COVID-19 imposes unique challenges to organizations and code blue teams. Studies that applied the American Heart Association (AHA) COVID-19–related Interim Resuscitation Guideline and similar European guidelines are scarce.

Objective: This study aimed to develop and test a cardiopulmonary resuscitation protocol based on the AHA COVID-19–related Interim Resuscitation Guideline.

Methods: The study was conducted as an in situ simulation in a medical intensive care unit. The COVID-19 cardiopulmonary resuscitation protocol was created and validated by 11 health care team members and tested using 4 simulation sessions where 46 code blue team members participated. During the simulation, we observed role clarity, the effectiveness of communication, team dynamics, infection control measures, and the availability of essential supplies and equipment.

Results: The main issues identified in each simulation session were debriefed to the code blue teams and used to further revise the protocol. These include the assignment of tasks, availability of equipment and supplies, and failure of communication between the in-room and out-of-room teams. Solutions included changes in the placement of team members and roles and responsibilities; the creation of an isolation code medication package, a respiratory therapy kit, and an isolation code blue bag; and the use of two-way radios and N-95 masks with eye goggles to enhance communication between the teams.

Conclusions: This study shed light on the challenges to implement the AHA COVID-19–related Interim Resuscitation Guideline. The in situ simulation was an effective approach for rapid training, identifying unreliable equipment and ineffective and inefficient workflow, and managing the complexity of the physical environment.

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KEYWORDS

in situ simulation; critical care; COVID; cardiopulmonary; resuscitation; COVID-19; treatment; health care; nursing; health care equipment; health care resources; health care training; health care staff

Introduction

The provision of cardiopulmonary resuscitation (CPR) to patients with suspected or confirmed COVID-19 presents infection control challenges inherent to the urgency of the procedure, interventions that cause aerosolization, and the need for multiple health care team members in close proximity. The additional complexity and resource management that accompany enhanced-isolation CPR (EI-CPR) also presents challenges related to communication barriers and the need to limit personnel and equipment exposure integral to safety-focused strict isolation protocols. To provide effective and safe EI-CPR, it is crucial that the risk of COVID-19 transmission to the health care team and patients be minimized and that communication, workflow, and resources be effectively managed.

In light of these challenges, the American Heart Association (AHA), in collaboration with other professional societies, has recommended modifications to the standard CPR algorithms [1] and issued a COVID-19–related Interim Resuscitation Guideline (thereafter referred to as the AHA COVID-19 Resuscitation Guideline) [2]. Studies that applied the AHA COVID-19 Resuscitation Guideline and similar European guidelines are scarce [3-7]. In response to these gaps, our simulation-based study aimed to develop and test a protocol based on the AHA COVID-19 Resuscitation Guideline for adult patients in hospital settings.

Careful integration of the AHA COVID-19 Resuscitation Guideline into the code blue workflow and testing different case scenarios based on institutional policies and available resources are crucial to the efficacy, efficiency, and safety of CPR. For example, Foong et al [5], Cheruku et al [6], and Sliver et al [7] proposed 3 different workflow models depicting the placement of code blue teams and equipment and used different communication tools between the in-room (inside the patient room) and out-of-room teams to maximize infection control measures. According to Foong et al [5], some of the unanticipated problems experienced in the new workflow were related to infection control, the conduct of resuscitation, resources, and poor communication between the teams. Continuous practice modifications and performance debriefing were necessary to optimize workflow, increase team competence, and improve the effectiveness of CPR [5].

Recent studies supported the effect of “in situ” simulation as a new simulation modality, in comparison to “off-site” simulation, on increasing confidence, competence, and teamwork and identifying system-based challenges to CPR [8,9]. Unlike off-site simulation that occurs in controlled lab environments, in situ simulation is encountered in a real-life setting where the clinical procedure occurs. The use of iterative in situ simulation to test protocols and train the multidisciplinary team members in preparation for EI-CPR for patients with suspected or confirmed COVID-19 has not been well-reported in the literature. In this in situ simulation–based study, we integrated

the new AHA COVID-19 Resuscitation Guideline in our EI-CPR procedure by developing a protocol disseminated via a pocket card for the code blue team to manage the steps, roles, communication methods, and process of resuscitation.

Methods

Design, Setting, and Sample

This prospective observational study was conducted as an in situ simulation in a medical intensive care unit (ICU) in a 670-bed, Level I trauma magnet facility located in Southwestern United States after Institutional Review Board approval. The COVID-19 CPR protocol was created and validated by 11 health care team members. The protocol was then revised and tested using 4 simulation sessions as described below. A total of 46 health care team members participated in the 4 simulation sessions. Each mock code included 11 to 12 participants. The main eligibility criterion to participate in the in situ simulation sessions was being a member of the code blue team. Membership in code blue teams and the roles and responsibilities of the health care team members were assigned by the Directors and Patient Care Coordinators of all units in the hospital at the beginning of each shift. Non–code blue team members were not eligible to participate in the study.

Using a convenience sampling approach, our plan was to have as many code blue teams as required to streamline and refine the resuscitation process based on the new protocol (ie, until no major issues in communication, team dynamics, or equipment were found). Streamlining the process required 4 code blue teams as described below.

Creating and Testing the New Protocol

The code blue procedure for patients with suspected or confirmed COVID-19 was discussed in the Hospital Resuscitation Services Committee meeting where the AHA COVID-19 Resuscitation Guideline was reviewed. A protocol for COVID-19 CPR was created based on the new AHA guideline by WST and HS, 2 physicians and authors of this manuscript. Key information in the protocol was also made available in a double-sided pocket card. A meeting was conducted with a convenient sample of 6 nurses, 3 physicians, 1 respiratory therapist (RT), and 1 pharmacist (N=11) from the 30-bed, COVID-19–designated medical ICU who volunteered to provide feedback on the new protocol. The feedback targeted the clarity and validity of the information on the protocol and pocket card, ease of use based on the card and font sizes, and delineation of roles inside and outside of the room.

The feedback from the multidisciplinary team was incorporated, and the guideline and pocket card were revised. [Multimedia Appendix 1](#) highlights the changes incorporated into our COVID-19 CPR process based on the AHA COVID-19 Resuscitation Guideline in comparison to our standard CPR algorithm prior to COVID-19 [1]. The new protocol focused on team organization as in-room and out-of-room teams, roles

and responsibilities, equipment placement, communication and coordination, the process of conducting CPR, and emphasized personal protective equipment (PPE) donning. It is worth noting that the AHA COVID-19 Resuscitation Guideline “recommended” the use of mechanical chest compression. Although these devices are used now in ICUs, their use was limited to the emergency department at the time of the study and due to a lack of resources.

The new COVID-19 CPR protocol was disseminated to all units in the hospital in the form of a pocket card by the nurse educators of the units and published in the COVID-19 resources file on the intranet. The chairman of the Resuscitation Services Committee also shared it electronically with hospital physicians.

In Situ Simulation

We conducted 4 in situ simulation sessions to train 4 code blue teams on our COVID-19 CPR protocol and test and streamline the process outlined in the protocol. The 4 in situ simulation sessions were conducted in the medical ICU using a high-fidelity mannequin simulator (Laerdal Medical). The standard code blue scenario used for this purpose was as follows: “Patient was admitted with COVID-19. Upon entering the patient’s room, the nurse finds the patient unresponsive to verbal cues. Patient state 1: ventricular fibrillation. Patient state 2: asystole. Patient state 3: post intubation and return of spontaneous circulation.” A total of 46 health care team members—20 nurses, 15 physicians, 5 RTs, 2 anesthesiologists, 1 technician, and 3 pharmacists—participated in the 4 mock codes.

The code blue teams were aware of the study but unaware of the timing of the mock code until they heard the overhead announcement to elicit a real-life response. The Directors and Patient Care Coordinators of all units in the hospital assigned roles and responsibilities to code blue teams at the beginning of each shift and provided nurses with a copy of the guide and pocket card in advance of the simulations. Code blue procedures were announced per the current protocol (ie, no designation for a positive or suspected COVID-19 patient was provided). Upon arrival, participants were prebriefed on (1) the COVID-19 CPR protocol using the pocket card, (2) the use of a high-fidelity mannequin simulator, and (3) the focus of the simulation. Participants were encouraged to ask questions. The nurse educator (JH) and 2 intensivists (CD and ES) served as content experts for all simulation sessions. Debriefing was conducted after each session by the nurse educator who facilitated the simulation. The debriefing also solicited the participants’ feedback about the new protocol and the value of the pocket card on streamlining the resuscitation process.

Our focus during the simulation was on the changes incorporated into the resuscitation process. We observed role clarity; the effectiveness of communication between the in-room and out-of-room teams; team dynamics; appropriate PPE donning and doffing; and the availability of essential medications, supplies, and equipment to ensure that high-quality CPR was provided. We additionally observed each member’s competence in completing their designated tasks.

Ethical Considerations

The study was approved by the Institutional Review Board of University of Texas Health (HSC20200657N).

Results

The main issues identified in each simulation session ([Multimedia Appendix 2](#)) were debriefed to the code blue teams and used to further revise the protocol and streamline the workflow.

First Simulation

Limiting the number of team members inside the room was one of the changes to the workflow after COVID-19 ([Multimedia Appendix 1](#)). A major issue faced in the first simulation session was the experience of fatigue by the technician from the continuous compressions. To solve this problem in subsequent simulations, we decided to place the technician with the out-of-room team, assign the compression task to the first response nurse, and add a third nurse to the in-room team to provide high-quality compressions. This change would result in 3 nurses inside the room and 2 technicians outside the room. All 3 nurses in the room could administer medications and rotate providing high-quality compressions. The technicians would serve as runners and gatekeepers to obtain equipment and ensure the proper doffing of PPE and cleaning of equipment.

Another change we implemented to the workflow was placing all first-line code medications in the Pyxis crash cart. Bringing medications from the Pyxis crash cart into the isolation room caused major workflow disruption and delayed medication administration ([Multimedia Appendix 2](#)). A viable solution was the creation of an isolation code medication package by the pharmacy. In the debriefing and subsequent mock codes, the teams were instructed to take the isolation code medication package found in a tray in the code cart into the isolation room upon initial entry, as opposed to the full tray of code medications from the crash cart or the code cart itself.

Second Simulation

The addition of a third nurse to the in-room team allowed for high-quality compressions to be maintained and additional tasks such as medication administration and rhythm analysis to be completed by all members of the in-room team. Failure of communication between the in-room and out-of-room teams was the main issue faced in the second simulation. After COVID-19, we decided to use Cisco phones (Cisco 8821) as a communication tool between the in-room and out-of-room teams. Cisco phones are used by nurses in our hospital for daily communication with the multidisciplinary team and family members and to answer the call light. As described in [Multimedia Appendix 2](#), Cisco phones were not the best method of communication during the mock code.

During the same day and using the same code blue team members, we decided to repeat the second simulation ([Multimedia Appendix 2](#), Simulation 2 Part B) using the call light system (Rauland Responder 5), which also revealed communication issues ([Multimedia Appendix 2](#)). As a solution,

the code blue team suggested the use of two-way radios, which were tested in the third simulation.

Third Simulation

The two-way radios (Motorola VL50) were a better method of communication than Cisco phones and the call light system. One of the radios was assigned to one of the in-room nurses. However, due to the multiple responsibilities of the nurses on the team, the radio was sometimes left unattended. As a result, we decided to assign the main communication role in subsequent simulations to the physician team leader to narrate the code events to the recorder who was a member of the out-of-room team.

Another issue revealed in this session was a communication barrier related to wearing a respirator mask by the physician

leader, which made it difficult to hear team members in close proximity and hampered communication via the two-way radios with the recorder from outside the room. The use of N-95 masks with eye goggles, as opposed to respirator masks, was suggested to enhance communication between the physician team leader and the out-of-room team in subsequent simulation sessions.

The third problem faced in this simulation was related to the commonly used supplies not being readily available in the room since the crash cart was no longer used inside the room. A respiratory therapy kit was developed and placed on each crash cart for the first responder to bring into the room along with the isolation code medication package as a solution to the problem (Multimedia Appendix 2). The list of supplies is available in Figure 1 (Multimedia Appendix 3).

Figure 1. Final Pocket Card. ETT: endotracheal tube; CPR: cardiopulmonary resuscitation; ICU: intensive care unit; LMA: laryngeal mask airway; RT: respiratory therapy.

Front page

ENHANCED ISOLATION Adult CODE BLUE
Updated on 5/14/20

ENHANCED ISOLATION Adult CODE BLUE
Code Blue called overhead

TEAM	Role	Responsibilities
INSIDE	Physician 1	- Code leader, Communicates/Narrates with Nurse 5 via two-way Radio
	Physician 2 - Anesthesia	- Airway management
	Respiratory Therapist	- Place O2 source and towel/mask, bring Ambubag/Filter - Bring in RT Kit - Compression if no airway available - Assist with Airway - Avoid unnecessary disconnections of airway circuit - Alert set up (RT Supervisor brings vent to room)
	Nurse 1 - (Patient's primary nurse)	- Start compressions - IV access, draw labs, administer meds
	Nurse 2 - (BRT Nurse if available)	- Bring Code Blue Bags (behind) to room entrance - Manage defibrillator, apply pads to patient - IV access, draw labs, administer meds, manage defibrillator, assist with compressions
OUTSIDE	Nurse 3	- Brings crash cart outside room. Ensures items in room - defibrillator, defib pads, backboard, meds, two-way radios - Receive supplies from outside room - IV access, draw labs, administer meds, manage defibrillator, assist with compressions
	Nurse 4	- Manage cart (in PPE)
	Nurse 5	- Hands equipment and crash cart contents to Nurse 3 - Recorder
	Nurse 6 (Charge Nurse)	- Crowd control until house supervisor arrives - Nurse leader - Distributes PPE & designates roles upon entering room - Designates staff to bring unit, Glidescope and ultrasound - Prepares Glidescope trolley and COVID ultrasound - On standby pending need for additional hands or equipment anticipated - Provide medications
	Physician 3 when available - (COVID ICU APP)	- Recorder
	Pharmacist	- Recorder
	Tech 1& 2	- Recorder
House supervisor	- Recorder	

ISOLATION CODE BLUE BAG

- 10 face shields
- 10 N95 masks (7 regular & 3 small)
- 10 surgical masks
- 10 gloves
- 10 regular gloves in each size
- 10 pairs of size 7.5 surgical gloves
- Two-way radios (4)

ISOLATION CODE MED PACK (in Crash Cart Med Tray)

- Epinephrine 1 mg Inj X 3
- Sodium bicarbonate 50 mEq Inj X 2
- Atropine 1 mg Inj X 1
- Dextrose 50% 50 mL Inj X 1
- Calcium chloride 1 g Inj X 1
- Lidocaine 100 mg Inj X 1
- Flushes

RT KIT (on Crash Cart)

- Ambubag (with tubing)
- HEPA filter
- PEEP valve
- Kelly clamp & Tape for ETT
- EtCO2 filter line set
- End Tidal CO2 colorimeter
- 10cc syringe
- Yankauer and Tubing
- 15L Oxy mask and Towel

Unit Specific Glidescope trolley

- Covered in large plastic
- Available Glidescope Blades (MAC 3 & 4, LoPro 3 & 4)

Back page

When the Code Team Arrives and During the Code

- All members must wear appropriate PPE, supplies available in the ISOLATION CODE BLUE BAG.
- Start compressions, if needed.
- Apply oxygen source and then cover the patient's face with a mask or towel to minimize droplets aerosolization or secretions contamination while performing CPR
- Code cart remains outside the room with pre-made meds
- Bring defibrillator into the room
- If not intubated place on nasal cannula and 15L oxy mask as an alternative to bag-mask device for a short duration.
- If intubated, CAN DISCONNECT from ventilator in a case-by-case scenario. Appropriate precautions should be taken and Kelly clamps should be used. Examples below:
 - Airway obstruction
 - Changing HEPA filter
- Anesthesia will be the designated team to intubate to maximize first-pass success. Please refer to COVID-19 Adult Respiratory Support Recommendations.
- CPR may be paused while intubating or while suctioning to allow for increased first-pass success and preventing further aerosolization.
- Preferred method: RSI with videolaryngoscope.
- If intubation unsuccessful, convert to LMA early. If ventilated with LMA or bag-mask device ensure tight seal and use of inline HEPA filter.

After the Code

- Any staff member who is unwell, has had equipment failure, or likely self-contaminated should be first to doff and exit the patient room.
- Doff PPE ONE TEAM MEMBER AT A TIME.
- Doff PPE slowly and carefully according to pre-existing protocol.
- All devices and medication exiting the room need to be cleaned per protocol.
- If the isolation code med pack enters the isolation room and is NOT opened:
 - The isolation code med pack is thoroughly wiped down with Cavi Wipes once out of isolation room.
 - Then, the isolation code med pack is returned to the crash cart medication tray.
- If the isolation code med pack enters the isolation room and is OPENED:
 - Medications NOT used in intact packaging are sealed in NEW bag provided in the crash cart.
 - A designated nurse disinfects the new sealed bag with germicidal disposable wipes once out of isolation room.
 - The sealed, disinfected bag is placed back in the crash cart medication tray.

UHS guidelines references in this document can be found at <https://www.universityhealthsystem.com/coronavirus-covid19/healthcare-protocols-and-guidelines?web=1>

Fourth Simulation

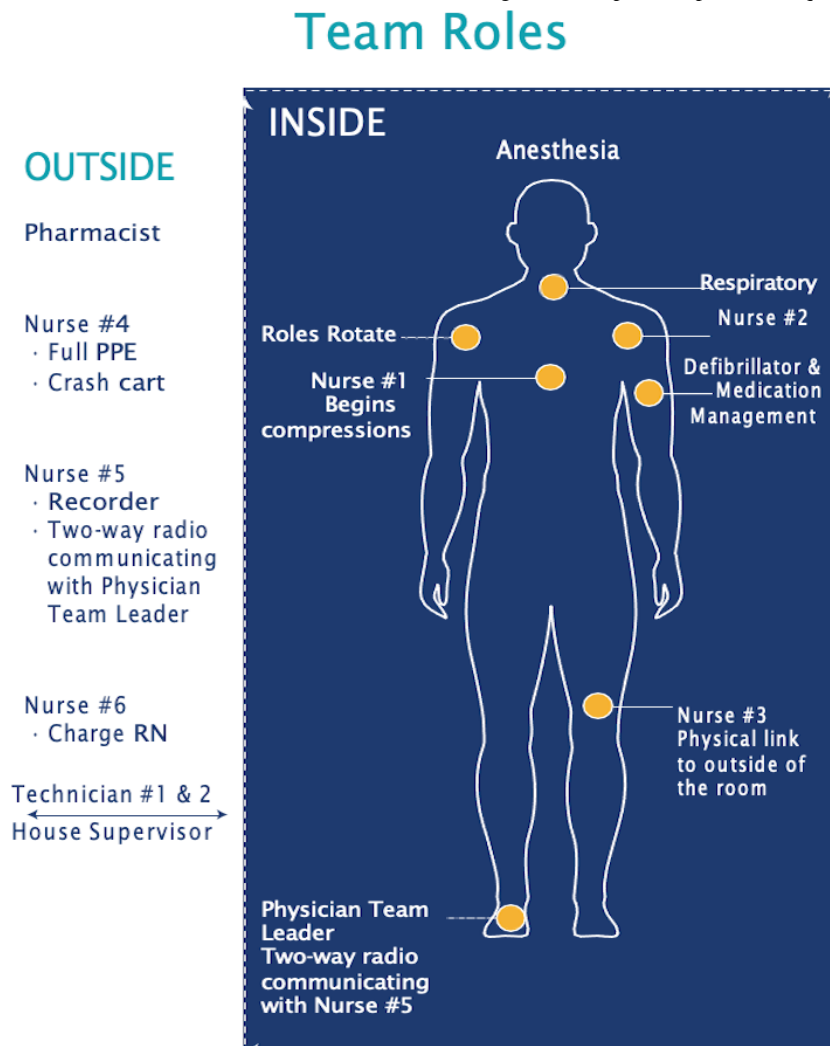
Assigning the main communication role to the physician team leader provided effective communication between the in-room and out-of-room teams. The recorder nurse from the out-of-room team served as the communicator of the needs for the in-room team, recorded events, and directed information from outside the room (eg, "Anesthesia is here"). As a result, two-way radios were issued to each unit and placed on each crash cart in the hospital. The use of N-95 masks with eye goggles, as opposed to respirator mask, by the physician team leader allowed clear communication between the in-room and out-of-room teams.

No further major issues with equipment, supplies, communication, or workflow were faced in the fourth simulation session.

Final Protocol After Simulation

The issues faced in the 4 in situ simulation sessions helped us further revise our COVID-19 CPR protocol. The changes described in Multimedia Appendix 2 (last row) were incorporated into the protocol and pocket card in its final format (Figure 1, Multimedia Appendix 3). The final placement of team members as in-room and out-of-room teams is presented in Figure 2.

Figure 2. Placement of code blue team members based on the new resuscitation guide. PPE: personal protective equipment; RN: registered nurse.



Main Debriefing Points and Lessons Learned

The debriefing sessions focused on the difference between COVID-19 code blue response (ie, infection control, role clarity, team organization, communication, and equipment) in comparison to the traditional response. Our debriefing also included a skill-related discussion when we observed a need for improvement. The main debriefing points communicated to the team and lessons learned are presented in [Multimedia Appendix 4](#). Staff perception about the new pocket cards and protocol was also solicited during the debriefing. Staff believed that the pocket card was an easy-to-use tool to remind members of their roles and placement, the necessary equipment, and the conduct of CPR.

Discussion

Principal Findings

COVID-19 created an urgent need for new resuscitation policies to manage the risk of disease transmission and optimize timely intervention for the patient. The pandemic has also increased awareness of the potential for future contagion that may require modification of resuscitation policies based on the associated risks of the particular pathogen. Our in situ simulation revealed

challenges unique to COVID-19 while implementing the AHA COVID-19 Resuscitation Guideline. The main challenges were related to communication, roles and responsibilities, and skills.

COVID-19 introduced unique barriers to communication during EI-CPR—related to code blue team separation into in-room and out-of-room teams; the need to maintain a closed door between the teams to contain aerosol-generating procedures that hindered the visibility of the procedure and communication clues; and the need for donning PPE and protective measures. Two-way radios were an effective communication tool between the in-room and out-of-room teams. However, communication via two-way radios is not as intuitive as face-to-face communication. Although easy to use, two-way radios allow half-duplex communication where only one person can talk at a time and hinder the natural flow of communication. Additionally, the radios are handheld and require a push on the talk button for use, which limits the clinicians' physical movement in emergency procedures such as CPR. Furthermore, the radios need a closed loop of communication (such as "roger that"). Practicing communication using the radios and ensuring appropriate functioning and charge of the devices are important to minimize communication problems.

The few available studies on COVID-19–related CPR guidelines used other communication methods between the in-room and out-of-room teams. For example, Foong et al [5] used a whiteboard. Although cost-effective, a whiteboard is limited to visual communication and requires team members to keep looking at the board to read the written messages while performing time-sensitive procedures. Cheruku et al [6] used hospital-based mobile phones and networked videoconferencing, whereas Silver et al [7] used baby monitors. The 3 studies indicated the success of these communication strategies. Baby monitors are a cost-effective solution and have been used in Canadian hospitals to facilitate communication during CPR [10].

The negative effects of N-95 masks and face shields on speech perception among health care workers in the COVID-19 pandemic were recently examined by Bandaru et al [11]. The authors found a significant increase in speech reception threshold and a significant decrease in speech discrimination scores, suggesting the use of alternate methods of communication. Despite the challenges faced by health care practices worldwide, COVID-19 may open opportunities for communication companies to develop intuitive, hand-free, full-duplex communication systems.

The organization of team members into in-room and out-of-room teams depends on the number of team members, available resources, and system policies. In our setting, it was ideal to have 2 physicians, 3 nurses, and an RT in the room. Our out-of-room team consisted of 2 nurses, 2 technicians, a pharmacist, a gatekeeper, and another physician if needed. Our teams' organization differed slightly from Cheruku et al [6], who included only 1 in-room physician and based their practice on remote medication delivery and adjustment of the ventilator and equipment [6]. Similar to our practice, 2 physicians in the room were used by Foong et al [5]. However, airway management was a responsibility of one of the physicians and an RT was not part of the resuscitation team in that study [5]. Despite the slight differences among studies in team organization, preassignment of roles to team members was emphasized to decrease role confusion and facilitate an effective response to a COVID-19 code blue emergency.

Similar to Cheruku et al [6], the lack of infection control was not an issue revealed in our study due to the fact that our staff was extensively trained on PPE donning and doffing. On the other hand, Foong et al [5] reported violations in infection control measures related to PPE donning and doffing, cross

contamination between the in-room and out-of-room teams, and failure to comply with hand hygiene standards.

Limitations

Our study shed light on the challenges to implement the AHA COVID-19 Resuscitation Guideline. Our results are likely generalizable to other situations in which enhanced precautions are necessary. The 4 in situ simulation sessions identified and tested solutions to these challenges. Hospital systems need to implement new CPR algorithms to minimize the spread of COVID-19 [2]. The findings of this study should be interpreted in light of the following limitations. First, the study was conducted in a high-tech, Level I trauma magnet facility and well-equipped ICUs with sufficient resources. Additionally, our system provides robust PPE donning and doffing training programs. Therefore, the process of CPR and distribution and responsibilities of the in-room and out-of-room teams may not be generalizable to settings with limited resources. Second, the main focus of this study was identifying challenges and testing solutions to the new COVID-19 CPR protocol disseminated via a pocket card that includes team response to COVID-19–related EI-CPR. Our study did not focus on team competence on CPR, resuscitation metrics (eg, time to successful intubation and the quality of compression), effective handoff from the first responder nurse to the code blue team, or time taken for code blue. The study also did not use tools such as Simulation Team Assessment, and the results were solely based on observation and the debriefing process. Expanding this study in the future to include these outcome measures and tools is warranted. Third, team response during simulation may not reflect the actual performance in real cardiac arrest situations. Team members may lack the motivation to perform well during simulations or may overperform due to the Hawthorne effect. This suggests the need to observe performance during actual cardiac arrest situations.

Conclusions

COVID-19 introduced unique challenges to implementing the AHA COVID-19 Resuscitation Guideline. The main challenges were related to communication, roles and responsibilities, and equipment placement. The new COVID-19 CPR protocol disseminated via a pocket card provided an easy-to-use tool for code blue teams to remember their placement, carry out their roles and responsibilities, interact effectively, and place equipment properly. Preassignment of roles to team members is crucial to decrease role confusion and facilitate effective response. The two-way radios were effective to facilitate communication during code blue events.

Acknowledgments

The authors would like to acknowledge the contributions of the code blue team members from all participating units.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Difference in code blue process between the standard cardiopulmonary resuscitation (CPR) algorithm and the AHA (American Heart Association) COVID-19–related Interim Resuscitation Guideline.

[[DOCX File , 17 KB - nursing_v5i1e38044_app1.docx](#)]

Multimedia Appendix 2

Process of revising COVID-19 cardiopulmonary resuscitation (CPR) protocol.

[[DOCX File , 17 KB - nursing_v5i1e38044_app2.docx](#)]

Multimedia Appendix 3

Main debriefing points communicated to the team and lessons learned.

[[DOCX File , 61 KB - nursing_v5i1e38044_app3.docx](#)]

Multimedia Appendix 4

Final pocket card.

[[DOCX File , 17 KB - nursing_v5i1e38044_app4.docx](#)]

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Abbreviations

AHA: American Heart Association

CPR: cardiopulmonary resuscitation

EI-CPR: enhanced-isolation cardiopulmonary resuscitation

ICU: intensive care unit

PPE: personal protective equipment

RT: respiratory therapist

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Original Paper

Nurses' Experiences After Implementation of an Organization-Wide Electronic Medical Record: Qualitative Descriptive Study

Rebecca M Jedwab^{1,2}, CCRN, BSc, MNP, MNursPrac; Elizabeth Manias³, RN, BPharm, MPharm, MNStud, PhD; Alison M Hutchinson^{1,4}, RN, BAppSc (AdvNurs), MBioeth, PhD; Naomi Dobroff^{2,5}, RN, BHSci (Nursing), MPH; Bernice Redley^{1,4}, RN, BN (Hons), CritCareCert, PhD

¹Centre for Quality and Patient Safety Research-Monash Health Partnership, Institute for Health Transformation, School of Nursing and Midwifery, Deakin University, Melbourne, Australia

²Nursing and Midwifery Informatics, Monash Health, Melbourne, Australia

³Institute for Health Transformation, School of Nursing and Midwifery, Deakin University, Melbourne, Australia

⁴Nursing and Midwifery, Monash Health, Melbourne, Australia

⁵School of Nursing and Midwifery, Deakin University, Melbourne, Australia

Corresponding Author:

Rebecca M Jedwab, CCRN, BSc, MNP, MNursPrac
Centre for Quality and Patient Safety Research-Monash Health Partnership
Institute for Health Transformation
School of Nursing and Midwifery, Deakin University
221 Burwood Highway, Burwood
Melbourne, 3125
Australia
Phone: 61 3 92517777
Email: jedwabr@deakin.edu.au

Abstract

Background: Reports on the impact of electronic medical record (EMR) systems on clinicians are mixed. Currently, nurses' experiences of adopting a large-scale, multisite EMR system have not been investigated. Nurses are the largest health care workforce; therefore, the impact of EMR implementation must be investigated and understood to ensure that patient care quality, changes to nurses' work, and nurses themselves are not negatively impacted.

Objective: This study aims to explore Australian nurses' postimplementation experiences of an organization-wide EMR system.

Methods: This qualitative descriptive study used focus group and individual interviews and an open-ended survey question to collect data between 12 and 18 months after the implementation of an EMR across 6 hospital sites of a large health care organization in Victoria, Australia. Data were collected between November 2020 and June 2021, coinciding with the COVID-19 pandemic. Analysis comprised complementary inductive and deductive approaches. Specifically, reflexive thematic analysis was followed by framework analysis by the coding of data as barriers or facilitators to nurses' use of the EMR using the Theoretical Domains Framework.

Results: A total of 158 nurses participated in this study. The EMR implementation dramatically changed nurses' work and how they viewed their profession, and nurses were still adapting to the EMR implementation 18 months after implementation. Reflexive thematic analysis led to the development of 2 themes: *An unintentional divide* captured nurses' feelings of division related to how using the EMR affected nurses, patient care, and the broader nursing profession. *This time, it's personal* detailed nurses' beliefs about the EMR implementation leading to bigger changes to nurses as individuals and nursing as a profession than other changes that nurses have experienced within the health care organization. The most frequent barriers to EMR use by nurses were related to the Theoretical Domains Framework domain of environmental context and resources. Facilitators of EMR use were most often related to memory, attention, and decision processes. Most barriers and facilitators were related to motivation.

Conclusions: Nurses perceived EMR implementation to have a mixed impact on the provision of quality patient care and on their colleagues. Implementing technology in a health care setting was perceived as a complex endeavor that impacted nurses' perceptions of their autonomy, ways of working, and professional roles. Potential negative consequences were related to nursing workforce retention and patient care delivery. Motivation was the main behavioral driver for nurses' adoption of EMR systems and hence a key consideration for implementing interventions or organizational changes directed at nurses.

KEYWORDS

computerized medical records systems; COVID-19; implementation science; motivation; nurses; qualitative research

Introduction

Background

The implementation of health care technology systems such as electronic medical record (EMR) systems causes major changes in nurses' workplaces, work, and workflows [1]. Understanding EMR-related impact on nurses is needed to support their work in providing round-the-clock, direct patient care [2]. The implementation of new health care technologies has been shown to increase nurses' stress [3-5]; hence, such implementation may exacerbate existing problems of nurse shortages and high workloads. There is an urgent need to understand ways to support nurse retention and productivity in rapidly changing workplaces [6]. In contrast to international settings, the implementation of EMR systems throughout Australian hospitals has been relatively recent and has been promoted as enabling safe patient care [7] rather than financial incentivization. Examination of the impact of EMR implementation on nurses is limited and has largely focused on aspects of EMR implementation such as integrating EMR knowledge and exposure into university nursing education [8] or EMR usability [9]. Although EMR usability is often an enabler of EMR use and uptake, the study by Lloyd et al [9] focused on the comparison between nurses and medical colleagues and differences between clinical settings, rather than nurses' experiences. Nurses' attitudes toward health care technology were the focus of an integrative review of Australian literature; however, the scope of the review by Mills et al [10] was broader than EMR systems and identified mixed outcomes related to nurses' attitudes toward health care technologies (both positive and negative perceptions of usefulness and impact on patient care) [10]. Although 1 observational time and motion study examined an Australian health care organization's large-scale EMR implementation, the focus was on time spent on nursing activities and time spent with patients and not on the nurses' experiences of using the system [11]. Another Australian qualitative study explored nurses' early experiences after EMR implementation [12]; however, the EMR was a hybrid system (mix of paper and electronic documentation) and therefore a gap remains in understanding nurses' experiences of a large-scale full EMR implementation in their workplace [13]. There is a need to investigate nurses' experiences of an EMR implementation to ensure any changes to nurses' work do not impact the delivery of safe, high-quality patient care. In the qualitative study underpinning this paper, Australian nurses' postimplementation experiences of an organization-wide complete EMR system were examined inductively and deductively, using a theoretical framework to support the understanding and contextualization of its influences on nurses' behaviors.

Purpose

As EMRs become commonplace throughout Australian health care organizations and demands on nurses increase, it is vital

to explore nurses' experiences and monitor and mitigate negative impacts on nurses' work and workflows and the nurses themselves. This study aimed to explore Australian nurses' EMR experiences after implementation of an organization-wide EMR system to inform future technology implementation strategies that enhance nurses' work, workflows, and well-being.

Methods

Overview

This qualitative descriptive study used data collected from focus group and individual interviews and free-text responses to an open-ended question at the end of a survey: "Please use the box below for any additional comments on your experiences of EMR." Qualitative data were collected in the context of a large mixed methods pre- and postimplementation study. Preimplementation qualitative data and pre-post survey findings have been reported elsewhere [14-16].

Inclusion and Exclusion Criteria

All nurses working in inpatient areas throughout 6 hospital sites of a single health care organization where the EMR was implemented in 2019 were eligible for inclusion. Nurses working casually (ie, not in a permanent position) as part of the EMR implementation team or working in areas where the EMR system was not fully implemented (ie, using a combination of paper and electronic documentation) were excluded.

Setting, Recruitment, and Data Collection

A large multisite public health care organization located in Victoria, Australia, was the setting for this study. The health care organization provides public health care services to persons of all ages in inpatient and outpatient settings, employs over 8500 nurses and midwives, and has approximately 3300 beds across major hospital sites and multiple community locations. The service caters to a multicultural, linguistically and sociodemographically diverse community. The Australian health care system provides public health insurance coverage for all, with the option for individuals to purchase private health insurance if desired [17]. The health care organization implemented the EMR system in 3 stages during 2019: one site went live in August 2019, two sites in October 2019, and three sites in November 2019.

Recruitment for participation in the post-EMR implementation phase included several strategies: nurses provided their email address at the end of a survey indicating their consent to be contacted to participate in qualitative data collection; nurses were invited to provide free-text comments at the end of the survey; and real-time in-person convenience sampling recruitment was undertaken in clinical settings. Using these multiple recruitment strategies helped to minimize the intrinsic limitations of convenience sampling, limited response bias, and supported broad participation in data collection. All nurses who

met the eligibility criteria and indicated interest, verbally or in writing, were given an opportunity to participate.

Data collection occurred between November 2020 and June 2021. Throughout this period, access to the hospital sites varied owing to restrictions associated with the COVID-19 pandemic. Web-based platforms were used when in-person access was restricted. In-person data collection complied with COVID-19 pandemic-related health care and social distancing restrictions. All focus group and individual interviews were conducted by the first author (RMJ; female PhD student employed at the health care organization) at mutually agreeable times that included after hours and weekends. To acknowledge their time for participation, a drink voucher was offered to nurses at the completion of the focus group or individual interviews (approved by ethics committees). None of the nurses withdrew consent or participated more than once.

The semistructured interview guide was based on the “4I” model for appreciative inquiry [18] and included open-ended questions such as “How are you feeling about the EMR?” and “What works well?” The same interview guide was used for all focus group and individual interviews (Multimedia Appendix 1). Nurses had the option of providing demographic information, including their age, gender, nurse classification, years of work experience, highest education level, hours worked per fortnight, clinical work area, and the specific site of the health care organization. In addition, the free-text survey comments provided in response to the statement “Please use the box below for any additional comments on your experiences of EMR” were included in the analysis. The researcher (RMJ) collected field notes and reflective notes to ensure reflexivity. All interviews were recorded and transcribed verbatim for analysis. Nurse participants were not invited to review transcripts or results owing to logistic issues of repeated contact and privacy concerns and to minimize any burden.

Study Rigor

Study trustworthiness incorporated consideration of study credibility, dependability, transferability, and reflexivity [19]. Credibility was upheld by including multiple research team members in data analysis. The use of illustrative quotes, research team involvement in discussions of data interpretation and analysis, and keeping detailed field notes supported study and data dependability. Transferability was supported by broad inclusion criteria and recruitment of diverse nurse participants across multiple hospital sites. Research team reflexivity was discussed and managed through reflection on roles, biases, and perceptions in relation to data interpretation and analysis [20].

Theoretical Framework

Justification for using the Theoretical Domains Framework (TDF) [21] and Capability, Opportunity, Motivation-Behavior (COM-B) model [22] as an analytical framework and model for deductive analysis in this study is 4-fold: First, there is a lack of theory-informed investigations examining Australian nurses' experiences of EMR adoption in their workplace. Second, the use of this theoretical framework and model to examine barriers to and facilitators of nurses' EMR use supports the identification of targeted theory-informed behavior change

interventions that address specific barriers and promote desired behaviors [23]. Third, the analytical framework and model have been widely and successfully used to evaluate and design interventions related to health care settings and digital health [24,25]. Finally, the TDF considers a wide range of individual, organizational, and contextual factors that affect behavior; hence, it assists in exploring and understanding behavioral influences on nurses' postimplementation EMR experiences.

Data Analysis

Overview

Complementary inductive and deductive data analysis methods over 2 stages were used to create meaning from the data and elicit a deep understanding of nurses' perspectives and experiences post-EMR implementation. All qualitative data were included in both stages of inductive and deductive data analysis. Inductive data analysis using reflective thematic analysis [20] was completed first to minimize the risk of fitting data to a predetermined idea or model [26] and to explore and capture meaning across the data set [27]. In the second analytical stage, the TDF was used as a deductive theoretical coding framework to support the understanding of factors that affected nurses' behaviors in the post-EMR implementation phase [21].

Inductive Data Analysis

The following six steps of reflective thematic analysis by Braun and Clarke [20] were used to guide the inductive data analysis:

1. Familiarization: data familiarization included listening to the audio recordings multiple times and multiple readings of the interview transcripts and qualitative comments. Field comments and reflexive notes were also reviewed.
2. Coding: data were transferred into Microsoft Excel (version 2019), and each quote was defined as up to 3 sentences long. Coding was undertaken inductively by the first author in 2 rounds and then grouped into subthemes and themes.
3. Generating initial themes.
4. Developing and reviewing themes.
5. Refining, defining, and naming themes: regular discussions with the research team throughout data collection and data analysis were used to support coding, subtheme and theme development, refinement and naming, and discussion of data saturation. The lack of new information was reached by the end of the 19th interview; however, data collection continued to ensure that opportunities were given for all nurses interested in participating.
6. Writing-up: the findings of thematic analysis are included in their entirety in this paper.

Deductive Data Analysis

After the completion of inductive data analysis, deductive data analysis commenced with the coding of each quote to one of the 14 domains of the TDF [21]. Context was used to identify each code as either a barrier to or facilitator to nurses' use of the EMR. The TDF data were subsequently mapped to the corresponding COM-B components [22].

Ethics Approval and Data Reporting

Approval (low-risk) was obtained from both Monash Health and Deakin University Human Research Ethics Committees

(references HREC/46439/MonH-2018-154603(v3) and 2019-003). The Consolidated Criteria for Reporting Qualitative Studies guidelines were used to guide data reporting [28].

Results

Overview

A total of 158 nurses participated in this study: 35 (22%) nurses participated through focus group interviews (6/22, 27%) or individual interviews (16/22, 73%). The survey, sent to 4159 nurses, had a response rate of 9.5%. A total of 31.4% (123/392) of survey respondents provided free-text responses to an open-ended question that were analyzed in conjunction with focus group and individual interview data. In total, 20% (78/392) of survey respondents provided their email addresses, but despite initial contact and 2 reminder emails, only 22% (17/78) of these nurses participated in a focus group or individual interview. A total of 36% (8/22) of interviews were conducted on-site at the health care organization and the remainder were web-based (14/22, 64%). The focus group or individual interviews lasted between 12 and 70 (median 32) minutes, with up to 9 nurses per focus group. Nurses who did not wish to provide their demographic information or refused audio recording but wished to participate through the collection of field notes were permitted to do so.

Participant Demographics

Participant demographics information was available for 146 nurses. Most were registered nurses (45/146, 30.8%), aged between 50 and 59 years (40/146, 27.4%), female (132/146, 90.4%), had worked between 4.5 and 9 years (24/146, 16.4%), had a postgraduate qualification (55/146, 37.7%), and worked part-time (60/146, 41.1%) in critical care areas (74/146, 50.7%) of the health care organization (Multimedia Appendix 2).

Nurses Adopting and Adapting to the EMR

The first stage of data analysis involved inductive data analysis using reflexive thematic analysis and led to the development of two overarching themes: (1) *An unintentional divide*; and (2) *This time, it's personal*. Exemplar quotes for each theme and subtheme are presented in Multimedia Appendix 3.

Theme 1: An Unintentional Divide

The implementation of the EMR system caused feelings of division among nursing staff related to the implementation and adoption of EMR; ongoing support; perceptions of EMR and how it affected their work; and how EMR impacted the nurse as an individual and their profession. *An unintentional divide* includes three subthemes: (1) Then and now, (2) Clicking or caring, and (3) Consequences and assumptions.

Subtheme 1: Then and Now

Subtheme 1: Then and Now contrasts nurses' reflections on their initial reactions to EMR implementation processes and adapting to the new system. Nurses reflected on missed opportunities to improve clinical practice with EMR compared with paper-based systems and discussed different social influences that impacted their experience of adapting to a new way of working. Nurses also discussed the differences in how they thought the EMR was implemented, that is, whether they thought it was beneficial

to change all clinical documentation over to a computer system at once, and factors that influenced their experiences and helped them to adapt over time, such as culture, training, and support (offered both during implementation and on an ongoing basis).

Nurses referred to differences between their initial reactions to the implementation process and support provided at the time of implementation "then" and "now" when data collection occurred (between 12 and 18 months after implementation). Nurses felt that their initial reactions (shock, disappointment, and stress) had developed over time into some level of acceptance (learning about different aspects of EMR and getting used to working with computers).

Nurses discussed their unmet expectations related to specific aspects of the EMR implementation, such as eliminating documentation duplication and expanding nurses' scope of practice. Some nurses felt their expectations were not met with the EMR and found the implementation period stressful; hence, it took them time to adjust (Multimedia Appendix 3, quotes 1-4). The timing of the EMR implementation, and if all clinical documentation were transitioned to the EMR at once, it affected whether some nurses deemed it as a positive or negative experience (Multimedia Appendix 3, quote 5).

Nurses also discussed the factors that influenced their experiences and adaptation to the new system, such as attitudes and culture, support, training, and education. Nurses felt that the implementation was both positively and negatively affected by the attitudes of their colleagues and the ward culture, as well as whether nurses were confident in using technology (Multimedia Appendix 3, quotes 6-8). Some nurses admitted that getting used to the system was difficult and took some time; however, as time went on, they adapted and learned. Nurses acknowledged that EMR adoption was more difficult for colleagues who worked part-time and therefore lacked EMR experience or exposure (Multimedia Appendix 3, quotes 9-11, 17, and 18).

The EMR implementation was described as successful by nurses when they felt that they had learned the system and adapted their ways of working and workflows. Many nurses attributed this success to the ongoing support provided by the organization throughout the EMR implementation and were grateful. Nurses also identified super users (nurses who had undergone increased EMR training and education and provided collegial support specific to EMR implementation) and their training as valuable and supportive (Multimedia Appendix 3, quotes 14 and 15). However, it should be noted that some super users acknowledged that they experienced difficulty and stress, which they attributed to pressure to support their peers with the EMR while also caring for their own patients (Multimedia Appendix 3, quote 16). At the time of data collection, some nurses thought that the EMR could be better used to its full capacity, citing knowledge gaps from inadequate training and ongoing education, and poor understanding of new EMR workflows impacted its use (Multimedia Appendix 3, quote 12). Nurses provided suggestions for how the health care organization could better support their workforce during an EMR implementation, as well as suggestions to improve EMR acceptance that often

referred to individualization of the screen or alerts ([Multimedia Appendix 3](#), quote 19).

Subtheme 2: Clicking or Caring

This subtheme reflected nurses' different feelings about what they should spend their time on the EMR or their patients. With limited time, some nurses felt they faced a choice between having "to click" (ie, use the EMR) versus "care" (ie, spending time on patient care). Some nurses felt that their duty toward the EMR took them away from direct patient care and interpersonal interactions ([Multimedia Appendix 3](#), quotes 20 and 21). Others expressed concerns that colleagues were completing EMR documentation that did not match their clinical actions because they were worried about the potential for negative responses from management ([Multimedia Appendix 3](#), quotes 22 and 23).

Nurses often expressed both positive and negative views about EMR workflows and their impact on nurses (eg, device integration not being available for all clinical areas, communication changes, and medication safety concerns related to visibility and clarity of orders on EMR; [Multimedia Appendix 3](#), quotes 24-30). Nurses reported negative feelings related to poor experiences with the privacy of patient information with the EMR (ie, anyone being able to read the computer screen), not finding the EMR easy to use, the layout of the EMR, and vast amounts of information ([Multimedia Appendix 3](#), quotes 34-36). Negative experiences of using the EMR caused nurses to develop workarounds to circumnavigate EMR aspects they were unhappy with or that did not fit their desired way of working ([Multimedia Appendix 3](#), quotes 37 and 38). This negativity was often voiced in the context of the time taken to perform nursing tasks or documentation, time spent finding out where to document on the EMR, or correcting documentation from other colleagues ([Multimedia Appendix 3](#), quotes 39-42). In contrast, nurses' positive EMR experiences related to patient care delivery included the ability to view all clinical information in one location, improved legibility owing to eliminating handwriting, and less duplication of documentation ([Multimedia Appendix 3](#), quotes 32 and 33).

Nurses felt that their autonomy had been negatively impacted by EMR and that their clinical documentation on the EMR was of lower quality than when it was on paper ([Multimedia Appendix 3](#), quotes 43 and 44). The EMR was perceived as both a physical and psychological barrier to providing patient care, and the EMR hardware and software disrupted nursing care ([Multimedia Appendix 3](#), quotes 41, 42, and 45-48). When asked what matters most, nurses most often responded that nursing documentation quality and meaningfulness in the context of providing quality and safe patient care ([Multimedia Appendix 3](#), quotes 49 and 50).

Subtheme 3: Consequences and Assumptions

Consequences and assumptions captured the impact of the EMR implementation on nurses' work satisfaction and well-being, and how this affected different groups of nurses. Many nurses reported how they were impacted by the EMR implementation. Some attributed their decrease in work satisfaction since EMR implementation to having less time with patients and

experiencing changes to their work and interpersonal relationships.

Negative changes in nurses' work satisfaction and personal well-being also had negative impacts on their intention to remain in the workforce ([Multimedia Appendix 3](#), quotes 51-53). Some nurses' comments indicated that they were questioning whether they remained in their roles, whereas others stated that they knew of nurses who had resigned from the organization owing to the pressure associated with EMR implementation. There were nurses who acknowledged that there were other work stressors, not just EMR, contributing to nurses' decreased well-being and work satisfaction, including the COVID-19 pandemic. The pandemic was often referred to as an additional burden on nurses and appeared to exacerbate the stress of EMR owing to requiring personal protective equipment to work in isolation rooms while using the EMR ([Multimedia Appendix 3](#), quotes 54 and 55). Conversely, other nurses acknowledged that having the EMR was useful during the SARS-CoV-2 pandemic, providing up-to-date clinical information accessible to the entire health care team ([Multimedia Appendix 3](#), quote 56).

Differences in nurses' assumed or actual EMR knowledge created unrest among groups of nurses, including older and younger nurses, and those who were more knowledgeable or proficient with the EMR and those who were not. Nurses felt that some colleagues who were not competent or confident in using the EMR negatively impacted them because of subsequent challenges with documentation, where missing information from previous shifts made it difficult for nurses to complete their work. Some nurses reported that they felt divided from their colleagues, and they were being judged on their EMR ability, not their clinical knowledge or nursing experience ([Multimedia Appendix 3](#), quotes 57-59). Judgment related to EMR knowledge and capability extended to assumptions about groups of nurses, specifically related to age. When referring to younger nurses, it was assumed they were more computer-literate and therefore would be more competent with EMR. Older nurses were acknowledged as valuable peers who were not as competent with technology as their younger colleagues and felt the largest negative impact of the EMR implementation ([Multimedia Appendix 3](#), quotes 60-62). However, some nurses expressed surprise that there were older nurses coping with the EMR implementation ([Multimedia Appendix 3](#), quote 63).

Theme 2: This Time, It's Personal

Nurses reported that the EMR implementation was a bigger change and had had more personal consequences for both the nurse individually and nursing as a profession than other workplace changes they had experienced. *This time, it's personal* includes two subthemes: (1) A constantly changing profession and (2) What will nursing become?

Subtheme 1: A Constantly Changing Profession

Subtheme 1: A constantly changing profession reflects nurses' experiences of the change of an EMR and how the EMR implementation compared with previous workplace changes they had experienced. Nurses also discussed their fears and

frustrations with the changes introduced by the EMR implementation.

Many nurses felt that as a profession, nurses were used to change; however, EMR implementation appeared to have a greater impact on their professional practice than previous changes they had experienced ([Multimedia Appendix 3](#), quotes 64 and 65). Nurses discussed their colleagues' different responses, their resistance to change, and how the change affected other nurses, leading to a loss of confidence. The physical change to electronic documentation on EMR and discontinuation of paper-based documentation appeared to be what mostly challenged nurses, although some nurses noted it was a positive change owing to the reduced incidence of lost information and poor communication ([Multimedia Appendix 3](#), quotes 66-69). Some nurses felt that the changes increased their time spent on documentation, and this was often compared with other EMR systems perceived as easier to use ([Multimedia Appendix 3](#), quotes 70 and 71).

Nurses acknowledged the inevitability of moving to an electronic documentation system, several fears and frustrations with the system and workflows upset nursing staff, including potential negative consequences for themselves individually and for nursing as a profession. Fear of negative consequences owing to changes to the visibility and legality of nursing documentation was often voiced, with nurses' frustration extending to having to use and adapt to a system that they felt was not easy or intuitive to use ([Multimedia Appendix 3](#), quotes 74-78). Unfortunately, despite extensive consultation with nurses across clinical areas throughout the health care organization, some felt there was insufficient nursing input in the development of the EMR. ([Multimedia Appendix 3](#), quotes 79 and 80).

Subtheme 2: What Will Nursing Become?

Subtheme 2: What will nursing become? reflects nurses' concerns regarding perceptions of their roles in this new era of technology use. Nurses expressed concern about the increasing busyness of nurses' work and how the EMR would impact this busyness, and were also unsure how the EMR would change the perceptions and roles of their profession. However, nurses were also grateful to be able to provide their opinions regarding the EMR and to provide feedback and suggestions regarding EMR optimization.

Nurses were worried that their valuable story and insight, which came only from the unique role of providing 24/7 patient care, was missing from the EMR ([Multimedia Appendix 3](#), quotes 81 and 82). To some nurses, their work, and the visibility of

their work had become more task focused with the EMR, and they felt that nursing had become depersonalized. Nurses also expressed the view that some colleagues from other disciplines have different views of clinical documentation on EMR and felt this changed the relationships among professions ([Multimedia Appendix 3](#), quotes 83 and 84). Intradisciplinary relationships were also seen to be affected by EMR, with nurses stating that the previously useful incidental role modeling that came from observing colleagues' nursing documentation, patient interactions, or interprofessional collaboration were gone with EMR ([Multimedia Appendix 3](#), quotes 85 and 86). There were also concerns voiced by nurses that graduate nursing staff or new nurses entering the profession would be limited in their critical thinking owing to their habits of following EMR prompts.

Some nurses felt that their scope of practice was limited owing to the EMR functionality limiting their actions, or the inbuilt automation that accompanies the EMR, which differed from the workflows in practice when paper-based documentation was in use. Despite this limitation, some nurses appreciated the heightened visibility of information within EMR and believed that accountability was beneficial in supporting quality patient care ([Multimedia Appendix 3](#), quotes 87-90).

Nurses were hopeful that having the EMR throughout the health care organization would be an ongoing process of evaluation and optimization. They were grateful to be asked to participate in the research project and felt that this empowered them to provide feedback to the organization. Nurses were also asked how they could continue to develop the EMR, as they felt their voice was missing and wanted to be included in ongoing optimization and use of improvement strategies ([Multimedia Appendix 3](#), quotes 91 and 92).

Facilitators and Barriers to Change

Overview

The second stage of data analysis involved coding and mapping data to the TDF [21] (deductive analysis). A total of 1236 codes were identified and mapped to 13 of the 14 domains of the TDF [21]. Most of these data were related to barriers to nurses' use of the EMR (819/1236, 66.26%), while just over a third were related to facilitators (417/1236, 33.74%). The underlying determinants of nurses' behaviors were identified by mapping the TDF data to their corresponding COM-B [22] model components (capability, opportunity, and motivation). [Table 1](#) presents exemplar quotes and the percentages of total coded barriers and facilitators for each TDF domain.

Table 1. Percentage of total coded barriers and facilitators for each Theoretical Domains Framework (TDF) domain with exemplar quotes (N=1236).

TDF domain	Total coded barriers (N=819), n (%)	Exemplar quotes—barriers	Total coded facilitators (N=417), n (%)	Exemplar quotes—facilitators
1. Knowledge	28 (3.4)	1. “So many mistakes being made as so many ways to interpret” [SP ^a 313]	11 (2.6)	2. “If people know how to use it properly then it’s brilliant” [FG ^b 8P ^c 1]
2. Skills	72 (8.8)	3. “Everyone’s not proficient in EMR ^d and different level experience” [FG6P1]	64 (15.4)	4. “We were actually talking at work um before maybe we needed just another session, like maybe 6 months into EMR, which we are doing now...which is wonderful.” [FG4P1]
3. Social or professional role and identity	82 (10)	5. “I just wonder where the, you know, the future of nursing is going to go if this is if this is how we’re going to do our job. You know, we’re ticking boxes.” [FG16P1]	63 (15.1)	6. “But I think most important thing would obviously still just be the patient care and then your EMR and then I think the fact that you can just double click on things means that you could spend more time with your patient and you’re not stressing about documentation, cause you can always go back to it...you can just do everything you need for your patient and then document everything after.” [FG9P2]
4. Beliefs about capabilities	47 (5.7)	7. “I do default to asking the 20 year olds help me I don’t know where to find that thing. And it actually gives me a feeling of being very disempowered...I was previously a really experienced senior nurse that people would come to for help, and now I’m like, I’m useless at this.” [FG1P1]	29 (7)	8. “Where you feel you’ve done a good thing...where you, you find your worth in your job...if you’ve engaged with someone, and you’ve made a difference, then you go home feeling better about the job that you do.” [FG16P1]
5. Optimism	30 (3.7)	9. “The program is not user friendly.” [SP175]	52 (12.5)	10. “It’s so time efficient. It’s so easy to ah communicate with other team members through EMR um and it’s easy to look up things, everything is on the computer in front of you. So I have really, really loved using EMR.” [FG21P1]
6. Beliefs about consequences	18 (2.2)	11. “It does slow things down when it comes to the double checking and administering the medications.” [FG21P1]	0 (0)	N/A ^e
7. Reinforcement	13 (1.6)	12. “To me if the system’s not as good, if not better than the system we’ve got, not for the coroner, but for each other, then it’s not meaningful, and it’s not worth it.” [FG1P1]	9 (2.2)	13. “And that was the one of the other success to be honest...policies updated.” [FG5P1]
9. Goals	4 (0.5)	14. “I actually don’t know where to give advice on the EMR or where to give feedback on it.” [FG1P2]	21 (5)	15. “It’s most important to be like, very user friendly, so that we can make sure that everything’s documented properly for patients and for their safety.” [FG22P1]
10. Memory, attention and decision processes	106 (12.9)	16. “Sort of find EMR more complicated than it needed to be...there’s more stuff in there then you really need from a day-to-day point of view.” [FG16P1]	67 (16.1)	17. “For the most part, it’s an effective system and helps I think, the teams, nursing, allied health, everyone work a bit more cohesively because it’s all in one spot. And things can’t go missing on EMR, which, which can only benefit patient care at the end of the day.” [FG20P2]
11. Environmental context and resources	250 (30.5)	18. “I feel that my nursing assessment is less valuable, I can only record limited data that fits in to pre-determined tick boxes.” [SP231]	52 (12.5)	19. “Everything is a click away, or a couple of clicks away...information about the patient...rather than rummaging through paperwork and decipher someone’s writing, whether they’ve been referred, whether they’ve been seen, everything’s so yeah, clearer and easy to find” [FG20P1]

TDF domain	Total coded barriers (N=819), n (%)	Exemplar quotes—barriers	Total coded facilitators (N=417), n (%)	Exemplar quotes—facilitators
12. Social influences	27 (3.3)	20. “And I think praising that, and role modeling, that is super important. And I think that’s the risk when you’ve got senior nurses that are not role modeling the appropriate management or the appropriate use of the system.” [FG14P1]	44 (10.6)	21. “But then the other helpful thing is your colleagues...share with your colleagues...because they will know something that you don't know, and you know something that they don't know, and then you communicate and you, you get these things done, and it it's not as difficult.” [FG4P1]
13. Emotion	142 (17.3)	22. “I was in tears, like, three times over EMR...everyone knew I was struggling with EMR.” [FG15P1]	2 (0.5)	23. “With EMR medication mistakes have reduced to such a great extent like personally for myself, I don't have that anxiety anymore that am I looking through the chart properly and not missing anything, EMR is doing that for me.” [FG21P1]
14. Behavioral regulation	0 (0)	N/A	3 (0.7)	24. “I know some, I'm probably one of them still sort of pine a little bit for the paper but I think we, you know, things went missing with paper or things don't go missing on EMR, we have to adapt and move on, we've all sort of resigned ourselves to it.” [FG20P2]

^aSP: survey participant number.

^bFG: focus group interview or individual interview number.

^cP: participant number.

^dEMR: electronic medical record.

^eN/A: not applicable.

Capability

Just over a quarter of the barriers (206/819, 25.2%) and a third of the facilitators (145/417, 34.8%) related to nurses' use of the EMR system were associated with their capability. Barriers were often related to memory, attention, and decision processes (106/819, 12.9% of the total barriers; [Table 1](#), quote 16). For example, cognitive overload attributed to nurses looking for information in multiple areas of the EMR was perceived to impair memory. Nurses also expressed frustration with needing to remember how to use EMR and where to find information. Capability-related facilitators involved skills such as competence and confidence in using EMR, skills development, and time and opportunities for ongoing practice, education, and training (64/417, 15.4% of total facilitators; [Table 1](#), quote 4). Facilitators related to memory, attention, and decision processes were as follows: easier decision-making support with prompts within EMR to assist medication safety; less cognitive burden owing to improved legibility and clarity of patient information within the EMR compared with paper-based documentation; and use of and access to clinical information from anywhere within the health care organization (67/417, 16.1% of total facilitators; [Table 1](#), quote 17).

Opportunity

Overall, 33.8% (277/819) of the reported barriers to and 23% (96/417) of facilitators of nurses' use of the EMR related to opportunity. Barriers related to the environmental context and resources included nurses' difficulty using the EMR, more time spent on the EMR than with their patients, and negative impacts

of the EMR on communication (250/819, 30.5% of total barriers). The layout of the EMR was identified by nurses as problematic owing to multiple areas and ways of inputting information, and lack of standardization between organizations and between clinical areas (eg, critical care and pediatrics). EMR downtime and hardware issues, including slowness of the system, also emerged as barriers to nurses' EMR use. Nurses felt that the EMR restricted their scope of practice; for example, selection of options rather than free-text input and restrictions related to editing or viewing of information within the system ([Table 1](#), quote 18). Absence in the EMR of both patients' and nurses' narratives of care caused concerns about quality of care. Some nurses reported that the EMR contributed to negative impact on communication, with fewer clinician-clinician and clinician-patient interactions. In contrast, environmental facilitators included having a single point of access to clinical information, clinicians documenting contemporaneously, and nurses supporting their colleagues (52/417, 12.5% of total facilitators; [Table 1](#), quote 19). Social facilitators included supportive colleagues and leadership (44/417, 10.6% of total facilitators; [Table 1](#), quote 21).

Motivation

Motivation emerged as the most common behavioral driver among both barriers and facilitators (336/819, 41% of barriers and, 176/417, 42.2% of facilitators). Facilitators included the EMR supporting nurses' professional identity and role by enabling them to do their work and prioritize patient care (63/417, 15.1% of total facilitators; [Table 1](#), quote 6). Time to adjust to EMR and build confidence as well as previous EMR

use were other facilitators of nurses' EMR use. Support and leadership from colleagues, including senior staff and managers, were voiced as important facilitators in supporting nurses' transition to EMR.

Nurses' anxiety about needing to learn and use a new system, stress related to additional pressures in an already busy work environment, and fear and resistance to change with the EMR implementation emerged as emotional barriers to EMR use by nurses (142/819, 17.3% of total barriers; [Table 1](#), quote 22). Nurses' burnout was discussed in the context of the EMR being an additional stressor for already exhausted and stressed nurses (especially older nurses, defined as nurses >50 years of age, and those opposed to using technology).

Discussion

Principal Findings

The implementation and adoption of an organization-wide EMR system was an ongoing and dynamic experience for nurses who had to adapt to new ways of working. Nurses were divided in their positive and negative perceptions of the EMR and how it had impacted their work and their profession. The EMR implementation was a large organizational change that forced some nurses to reflect on their professional roles and identity and how they pictured their work moving forward.

Motivation was the underlying behavioral driver for nurses to use the EMR. Although motivation is a known element of the psychological dimension of user experience [29], many previous EMR nursing studies have simply focused on satisfaction with the system, documentation, and time spent using the EMR as influences on nurses' EMR use [30]. Interestingly, motivation was also the main behavioral driver for nurses in pre-EMR implementation qualitative data from the same health care organization [16] and was found to be an important nurse priority for EMR implementation in a Canadian Delphi study [31].

The use of the COM-B model [22] to understand behavioral drivers for nurses' responses to the EMR implementation identified both reflective and autonomous motivation processes that were influential and may help to explain consequences for nurses' well-being. For example, the positive effect of motivation impacting well-being is greater when the motivation is internally driven (autonomous) rather than externally influenced [32], and autonomous motivation has been found to positively influence both well-being and behavior change in health care settings [29]. Examples of internally driven motivation in this study included nurses' feelings of self-confidence in using the EMR and nurse-led improvements to local EMR use. Externally driven motivation was demonstrated by collegial encouragement and the completion of EMR components for fear of negative consequences. Many nurses in this study indicated low levels of autonomy and negative impact of the EMR. Possible reasons included the EMR being overprescriptive with documentation requirements and automated tasking, low visibility of some key nurses' work, decreased time spent with patients, and not feeling involved in the EMR's development or content. In this study, factors related

to nurse well-being in relation to using EMRs were identified, as well as plausible links between nurse well-being and motivation, helping to fill a gap in the current literature [33].

The loss of nurses' narrative owing to EMR use was raised as a concern for patient safety as well as nursing workforce retention. The absence of some clinical information and nurses' narrative from EMR, as well as concerns about the loss of nurses' professional identity and work visibility, created feelings of poor work satisfaction and may have had negative impacts on patient care delivery. Consistent with previous nursing literature, nurses identified time spent with patients and colleagues as well as reinforcement of their hard work and quality patient care outcomes as influential on their work satisfaction and intention to stay in their roles [34]. Unfortunately, some nurses felt their work had reduced to simply documenting for the sake of "ticking the box" on EMR, which did not fully demonstrate their work or support understanding of what was completed or still needed to be done [35]. Nurses also expressed concern about the loss of patients' narratives in the EMR owing to changed workflows and the potential for negative impacts on patient care owing to a lack of cohesive patient information, an issue that has been previously identified in international literature [36,37].

Social influences, although viewed as an important influence on EMR use by nurses, were expressed as both positive (ie, nurses frequently providing support to each other) and negative (ie, dividing colleagues, assumptions about groups of nurses such as older nurses and younger nurses). The impact of social influences on EMR use by nurses identified in this study is consistent with findings reported in international literature and could be used as leverage by health care organizations to support nurses' adoption and use of EMR [38,39].

End-user buy-in, through the inclusion of nurses during the design and implementation process, was intended to ensure that the system was fit for purpose [40,41]. However, at 12 to 18 months after implementation, many nurses argued that they would benefit from more time to practice and learn EMR. Although an intensive change management, training and education program was delivered to all nurses before EMR, with follow-up support after implementation, nurses identified specific scenarios and varied clinical settings as requiring further supportive measures and ongoing EMR practice. Nurses who self-identified as needing further EMR support, training, or education may benefit from engaging in organizational support available to assist with EMR knowledge or practice gaps [42]. By identifying barriers and facilitators to nurses' EMR use, providing a safe space for nurses to voice their concerns, and feedback loops to communicate findings back to the health care organization, this study has the potential to support Australian nurses' EMR acceptance. Supporting nurses' use, acceptance, and knowledge of EMR may prevent EMR workarounds and deviations in workflows that can result from lack of knowledge, frustration regarding software layout, hardware slowness, and downtimes [43-45].

Nurses were concerned that it took them a long time (up until the time of data collection, ie, 12-18 months after implementation) to adjust to using the EMR in their work. The

ongoing apprehensions about the EMR not meeting their expectations, inconsistent EMR use among colleagues, and cynicism regarding the legal implications of clinical documentation in the EMR indicate that these nurses may still be in the early acceptance phase. Similarly, a large Australian study examining nurses' adoption of health care technology found that competing work demands, insufficient hardware access, and lack of support, as well as age-related decreased confidence and computer knowledge, were the main barriers to adoption [46]. Similarly, an analysis of American nurse and hospital survey data identified EMR usability and the work environment as influential factors in nurses' adoption of EMR [47].

Reflections on the Use of Multiple Methodological and Analyses Techniques

There were several benefits to using multiple data sources (focus group interviews, individual interviews, and free-text comments) and using complementary inductive and deductive analyses. Compared with comments made in the focus group and individual interviews where a researcher was present, many free-text comments were written using very direct and blunt language, a difference that may be owing to the anonymity provided by the survey. Differences in language between the interviews and free-text comments may also be a consequence of the Hawthorne effect. However, nurses who participated in the interviews also expressed appreciation for the opportunity to speak openly and frankly about the EMR.

The opportunities provided by multiple data sources were deemed beneficial in enabling participation and eliciting information from a wide range of participants to obtain a comprehensive understanding. Despite a limitation of survey data collection that clarification about responses could not be sought through further questioning, the free-text data provided important information about nurse workflows and aspects of nursing work not captured elsewhere. The breadth of the responses supports the transferability of the study findings to various health care settings. In addition, the use of multiple complementary data sources supported nurses' participation and contributed honest opinions and perceptions about the effects of the EMR on them professionally and personally.

Using inductive and theory-informed deductive qualitative analyses provided a deep understanding of nurses' perspectives and experiences and behavioral drivers, and issues influencing EMR adoption, and how it impacts their work, workflows, and the nurses personally. These results differ from previous reports in the literature that have typically examined nurses' ease of use of EMR, satisfaction, or specific clinical outcomes related to nurses' work and workflows with EMR systems. This study also fills a gap in the literature of theory-informed investigations of Australian nurses' experiences of EMR.

Limitations and Reflexivity

Limitations of this study relate to the potential for sampling bias and low response rate; a large percentage of nurses were

aged >50 years, which may have influenced data interpretation. As of December 2021, only 36% of registered Australian nurses and midwives were aged >50 years [48]. Furthermore, only 22% (17/78) of the survey respondents who indicated they wished to participate in a focus group or individual interview (ie, by providing their email address at the end of the survey) could be contacted despite 2 follow-up emails. The reason for their nonresponse is not known. They may have been too busy, changed their minds, lacked interest in participating, been averse to a web-based focus group or individual interview, had privacy concerns, or been preoccupied with activities associated with the organization's COVID-19 pandemic response. Strategies to mitigate these concerns included visiting clinical areas in person (when permitted) and explaining that nurses did not need to provide contact details to participate.

COVID-19 pandemic restrictions on research activities at the hospital sites meant that the researcher was only able to attend each hospital site in-person once. During these interactions, ward staff were often willing to briefly and honestly discuss the EMR (with the researcher), but declined to have their comments recorded or transcribed. The potential effects of the COVID-19 pandemic on nurses' experiences of the EMR cannot be directly accounted for; however, nurses made both positive and negative comments related directly to both adapting to the EMR and its implementation in the context of the COVID-19 pandemic. The timing of COVID-19 pandemic restrictions led to an interrupted change management, training, and education program.

Conclusions

Undertaking both inductive and deductive data analyses enabled an in-depth examination of Australian nurses' experiences of an organization-wide full EMR system implementation. The findings revealed that barriers were most frequently related to the domains of environmental context and resources, and most facilitators were related to the domains of memory, attention, and decision processes. Motivation has emerged as the leading factor influencing nurses' EMR adoption behaviors; hence, it should be the main component addressed in future behavior change strategies to improve EMR adoption and optimization. Implementing the EMR before the COVID-19 pandemic was seen as beneficial by some nurses owing to having a planned organizational change and facilitating access to clinical information. In contrast, it was perceived as an additional stressor by some nurses owing to isolation and use of personal protective equipment. For the benefits of EMR systems to be realized to their full potential by nurses, perceptions of the system must change from a system for retrospective documentation requiring completion compliance and taking a nurse away from providing care, to a tool that can facilitate prospective nursing decision-making that enables multidisciplinary care planning, improves clinical practice, and supports nurses' work.

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Authors' Contributions

RMJ worked on conceptualization, methodology, validation, formal analysis, investigation, data curation, resources, writing—original draft, writing—review and editing, visualization, supervision, project administration, and funding acquisition. EM worked on conceptualization, methodology, validation, resources, writing—review and editing, visualization, supervision, and project administration. AMH worked on conceptualization, methodology, validation, resources, writing—review and editing, visualization, supervision, and project administration. ND worked on conceptualization, methodology, resources, writing—review and editing, visualization, supervision, and project administration. BR worked on conceptualization, methodology, validation, formal analysis, investigation, data curation, resources, writing—original draft, writing—review and editing, visualization, supervision, and project administration.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Semistructured interview guide.

[\[DOCX File, 13 KB - nursing_v5i1e39596_app1.docx\]](#)

Multimedia Appendix 2

Nurse participant demographic characteristics (N=146).

[\[DOCX File, 19 KB - nursing_v5i1e39596_app2.docx\]](#)

Multimedia Appendix 3

Illustrative quotes for reflexive thematic analysis themes.

[\[DOCX File, 33 KB - nursing_v5i1e39596_app3.docx\]](#)

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Abbreviations

COM-B: Capability, Opportunity, Motivation-Behavior

EMR: electronic medical record

TDF: Theoretical Domains Framework

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Original Paper

Exploring the Impact of Virtual Reflection Groups on Advanced Practice Nurse Students During the COVID-19 Pandemic: Focus Group Study With Master's Students

Jofrid Berit Høybakk¹, MSc; Andréa Aparecida Gonçalves Nes¹, PhD; Monica Evelyn Kvande¹, PhD; Marianne Trygg Solberg¹, PhD

Lovisenberg Diaconal University College, Oslo, Norway

Corresponding Author:

Jofrid Berit Høybakk, MSc

Lovisenberg Diaconal University College

Lovisenberggt 15B

Oslo, N-0456

Norway

Phone: 47 932 40 395

Email: jofrid.hoybakk@ldh.no

Abstract

Background: In the master's program of advanced practice nursing at a Norwegian university college, the learning activity reflection groups were converted into virtual reflection group (VRG) meetings during the COVID-19 pandemic. Regardless of the students' clinical practices in different hospitals, they could participate in the same VRG meeting on the web together with the educator from the university college, and the clinical supervisors were invited to participate. The students were in the process of developing the core competence required in their role as advanced practice nurses (APNs), and they had increased responsibility in the implementation of the VRG meetings.

Objective: In this study, we aimed to explore how master's students of advanced practice nursing experienced VRG meetings during the COVID-19 pandemic.

Methods: A qualitative exploratory design was adopted using focus group interviews. A group of students in the master's program of advanced practice nursing participated in an interview that lasted for 60 minutes. They had experienced participating in the VRG meetings following a rigorous guide during their clinical practice. The data from the focus group were analyzed using qualitative content analysis.

Results: The main findings of this study highlighted the importance of structure in VRG meetings, the role of increased responsibility in students' learning processes, the development of APN students' competencies, and increased professional collaboration with clinical supervisors. The APN students and clinical supervisors also continued their discussions in the clinical setting afterward, which strengthened the collaboration between students' education in the master's program and their clinical practice.

Conclusions: VRG meetings gave the students the opportunity to lead professional discussions while reflecting thoroughly on the chosen patient cases from clinical practice. They experienced receiving feedback from fellow students, supervisors, and educators as stimulating their critical thinking development.

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KEYWORDS

advanced practice nurse; competence; COVID-19; professional discussions; qualitative study; virtual reflection groups; interviews; learning; development

Introduction

Background

Recently, the world has experienced a pandemic of a new disease, COVID-19, and health professionals, especially nurses, have had to face challenges they had not experienced before [1,2]. The COVID-19 pandemic has brought about radical changes to education systems worldwide. During this period (2020-2022), a rapid increase in distance learning has taken place, in which technology-supported pedagogical methods have been developed, along with the use of digital tools for web-based education and communication between students and educators [2-5]. In a Norwegian master's program in advanced practice nursing, a new alternative learning activity, the virtual reflection group (VRG), supported by technology, was introduced to students during the COVID-19 pandemic [6]. The VRG learning activity aims to enhance students' development of the competencies required in their role as advanced practice nurses (APNs). This advanced competence is necessary for the care and management of patients facing complex health care demands [7,8]. The complicated issues affecting patients with one or several chronic diseases or comorbidities, together with a significant increase in the ageing population, pose several challenges in health care [9,10]. An APN is a generalist or specialized nurse who has acquired the expert knowledge base, complex decision-making skills, and clinical competencies for advanced nursing practice with a minimum of a master's degree [11]. The APN role is in development both internationally and nationally in Norway. Owing to the changing tasks and increased responsibilities expected of nurses in Norwegian hospitals, there is the need for APNs with broad clinical competence at an advanced level. APNs are especially required to care for patients with complex demands, including unresolved or acute clinical problems [12].

The competencies that APN students need to develop during their education include the knowledge to conduct systematic clinical examinations and health assessments, the skills to handle complex patient situations independently, and the ability to assess the severity of the patient's health, including changes over time [13]. Consequently, APN students must develop a professional and autonomous role by acquiring advanced knowledge in critical thinking, clinical decision-making, and comprehensive assessment [7]. The APN core competence also includes leadership, collaboration, guidance, and coaching, along with evidence-based practice [13].

The Norwegian master's program in APN is in line with the European requirements of 120 credits [14]. To improve students' learning process throughout their master's education, constructive alignment is incorporated at the university college as a pedagogical learning model, assuring logical interaction between learning activities, assessment, and learning outcomes [14,15]. The learning outcomes are developed to help students achieve the core competencies necessary to manage complex patient situations [14]. The master's program consists of

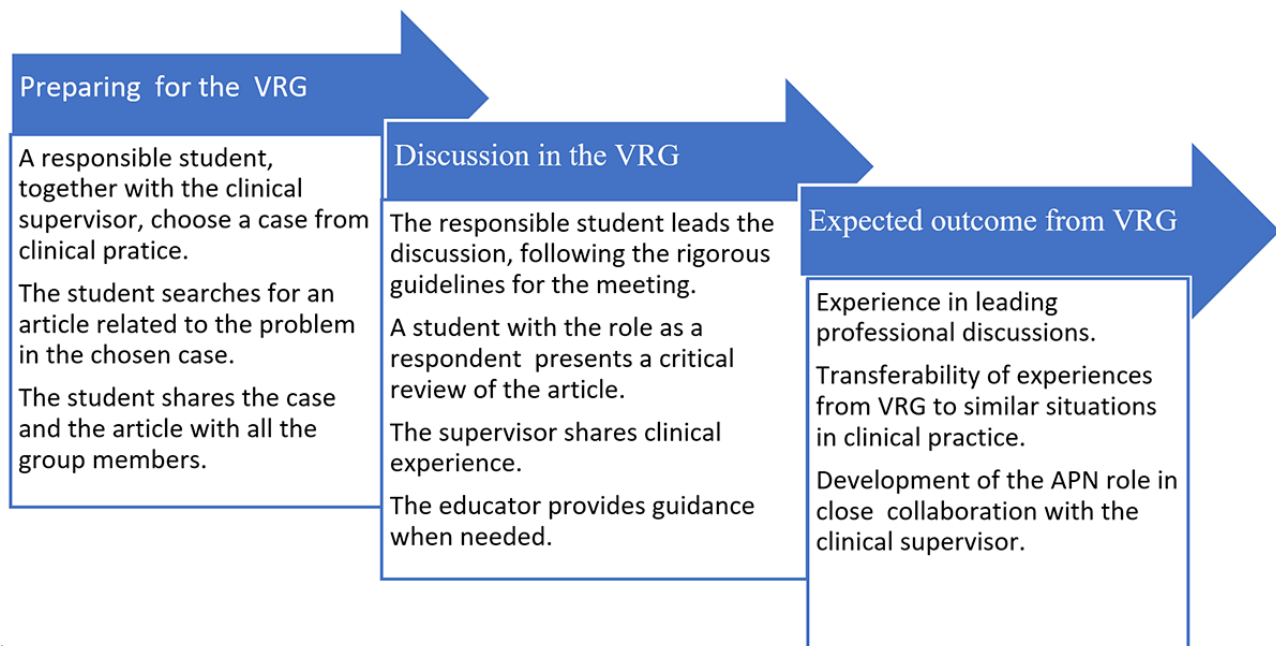
alternating lectures and 3 periods of clinical practicums, from 8 to 11 weeks.

The learning outcomes for students in the clinical practicums were as follows: (1) further develop and act independently based on the knowledge of the role of advanced clinical nurses, (2) justify and argue for one's own choice of action together with others involved, (3) apply knowledge and skills to implement and independently assess the results of knowledge-based nursing practices, and (4) analyze and critically reflect on their own and others' actions in acute, serious, or critical situations [14]. The students are gradually developing the necessary competence to assume the role of APN, supported by a clinical supervisor. To facilitate the integration of theory and experience in clinical practice, APN students participate in reflection groups [14].

The reflection groups are a learning activity that supports the collaborative learning of students, together with their educator, and their clinical supervisors are also invited to participate [6]. Through reflection, the students can express their views and arguments, along with their previous experiences, which the group members can either confirm or challenge [16]. The study by Schön [17] distinguished between reflection-in-action and reflection-on-action concepts. Reflection-in-action means that when something unexpected or problematic happens, the person thinks about it and adapts their actions to the current situation, whereas reflection-on-action means thinking back to what happened in the situation and why it occurred to better understand it. The study by Edwards [18] added 2 more steps to the Schön [17] reflection process: reflection-before-action and reflection-beyond-action. The APN students practice reflection-before-action when they prepare for meeting in the reflection groups. Later, reflection-beyond-action in the reflection groups allows APN students to use an experienced story or case to enhance their self-exploration and awareness, which promotes life-long learning, advances practice development, and leads to transformative learning [18]. Reflection is a particularly important process in developing professional competence in clinical practice [19].

Originally, the reflection group meetings in the master's program were arranged on campus, and therefore, the student's supervisor could not participate [14]. The new learning design with web-based meetings has recently replaced campus-based reflection groups. The web-based VRG meeting, which uses rigorous guidelines, was tested in a pilot project from 2019 to 2020 for APN students in critical care. In 2021, the VRG was implemented in the master's program during the COVID-19 pandemic lockdown [6]. The benefit of the VRG meetings was that even if the students' clinical practice took place in different hospitals, they could participate in the same VRG meeting on the web, together with the educator from the university college, using the digital platform Zoom, and the clinical supervisors could also participate remotely [6]. In these meetings, the students were in the process of developing core competencies for their role as APNs. Their learning process, showing their increased responsibility in VRG meetings, is illustrated in Figure 1.

Figure 1. A model illustrating the learning process and responsibilities of students participating in virtual reflection group (VRG) meetings. APN: advanced practice nurse.



Objective

In this study, we aimed to explore how the APN master's students experienced the VRG meetings during the COVID-19 pandemic. The following were research questions:

- How did the master's students experience the VRG meetings in the development of their competence as an APN?
- How did the master's students experience the collaboration with the clinical supervisor in conducting the VRG?

Methods

Design

This study used a qualitative exploratory design with focus group interviews. An advantage of using focus group interviews is that they provide the group dynamics and synergies for accessing rich information from the students [20,21]. The interactions between the participants in the focus group can provide insight into a range of students' opinions, perceptions, and attitudes, which might be less accessible in individual interviews [20]. The group dynamics and interactions were expected to help the master's students clarify their experiences in participating in VRG meetings during their clinical placement.

Setting and Participants

This study was conducted at a Norwegian university college with students in a master's program in advanced practice nursing

during the COVID-19 pandemic. All students participated in a VRG using rigorous guidelines [6]. They had completed the third placement of their clinical practice in different hospitals and units in East Norway, and they were invited to participate in the study after receiving both oral and written information. A total of 6 female students gave their informed consent to participate in the focus group interview.

Data Collection

The focus group interview was conducted in October 2021, immediately after the students had completed their clinical practice, which included participating in the VRG. The focus group interview was performed on-site in a meeting room at the university college, with the participants seated around a table to indicate the equal importance of each participant's contributions. Neither the moderator (MTS) nor the comoderator (MEK) was responsible for educating the master's students, which encouraged an honest and open dialogue during the interview. The open-ended questions of the interview guide (Textbox 1) were developed to answer the research questions.

During the interview, the participants were encouraged to ask questions, exchange anecdotes, and comment on each other's experiences and views, and the group dynamics helped the participants to create narratives [20,21]. The interview was audio-recorded and lasted for 60 minutes, which is a common duration of a focus group interview [20].

Textbox 1. The interview guide.

<p>Main questions:</p> <p>Can you talk about your experiences participating in the virtual reflection group (VRG) meetings?</p> <ul style="list-style-type: none"> • What are the benefits and limitations of the VRG meetings? • What was your experience of following a guide for conducting the VRG meetings? • What learning outcomes did you achieve from the VRG meetings regarding the development of your role as an advanced practice nurse (APN)? • How did the professional discussion contribute to your development as an APN? <p>Supporting questions:</p> <p>Different roles are included in the implementation of a VRG: What expectations did you have in advance regarding</p> <ul style="list-style-type: none"> • leading the professional discussion when conducting the VRG? • including the clinical supervisors in the discussion to share their experiences? • your role as respondent?

Ethical Considerations

The study was approved by the faculty at the university college and registered at the Norwegian Centre for Research Data (reference number NSD 578229). All participants provided informed consent to participate in the focus group interviews, and they were assured of full confidentiality and anonymity [21]. The moderator (MTS) and comoderator (MEK) ensured that no names or other personal information remained in the audiotape.

Data Analysis

The data from the focus group interviews were transcribed verbatim by the first author (JBH) as a starting point for further

analysis. All authors took part in the process of data analyses and read transcript data several times to gain insight into the content. The data were analyzed inspired by Graneheim and Lundman [22], using qualitative content analysis.

In the first step, the data were divided into meaning units related to the purpose of the project. The identified meaning units were then condensed into descriptions close to the text. In the second step, the underlying meanings of the condensed meaning units were interpreted, and all authors agreed upon the division of the results into subthemes and themes. During the analysis, we moved forward and backward among the meaning units, subthemes, and themes [22,23]. An example of the step-by-step analysis used to develop the theme of the *VRG meeting structure* is presented in [Table 1](#).

Table 1. Example illustrating the analysis process from meaning unit to theme.

Meaning unit	Condensed meaning unit description close to the text	Interpretation of the underlying meaning	Subtheme	Theme
Participating in the VRG ^a meeting by presenting the case and leading the meeting	Following the rigorous guidelines provided structure when conducting the VRG meetings	Using rigorous meeting guidelines contributed to the distribution of the disponible time and clarified the roles for participants	Following a rigorous guideline for the VRG meeting	VRG meeting structure
Digital communication in groups may inhibit the spontaneous, unstructured discussion via Zoom, as everyone who participated had to wait for their turn to speak	Challenge leading a web-based discussion and being responsible for all the participants in the discussion	Following the guideline ensured that all group members were included in the discussion. Waiting for one’s turn to participate in the discussion gave time for reflection.	Following a rigorous guideline for the VRG meeting	VRG meeting structure
Useful to follow the guideline, got more responsibility for the implementation of the reflection groups.	The guidelines gave structure when leading the discussion in the meeting.	The student was responsible for leading the professional discussion, with reflection on the experienced case.	Delegation of responsibility to the VRG members	VRG meeting structure
In the VRG, we went through both the article and the patient case. We also started a discussion about the case.	It was instructive both to present the patient case and to be the respondent.	Both the roles of leading the discussion and being a respondent increased the student’s responsibility when conducting the VRG.	Delegation of responsibility to the VRG members	VRG meeting structure

^aVRG: virtual reflection group.

Trustworthiness

All authors have extensive research experience. The second author (AAGN) worked in an undergraduate nursing program, whereas all the other authors worked in a postgraduate critical care nursing education program. The first author (JBH) is in an assistant professor program, and the others are associate professors. The moderator and comoderator, in line with Polit and Beck [21], limited their reactions to the participants and tried to avoid influencing the answers, both verbally and nonverbally. The participants talked at length about their experiences and were not afraid to express their diverse perceptions. The comoderators took notes during the interviews to supplement the verbal transcripts in the analysis discussions.

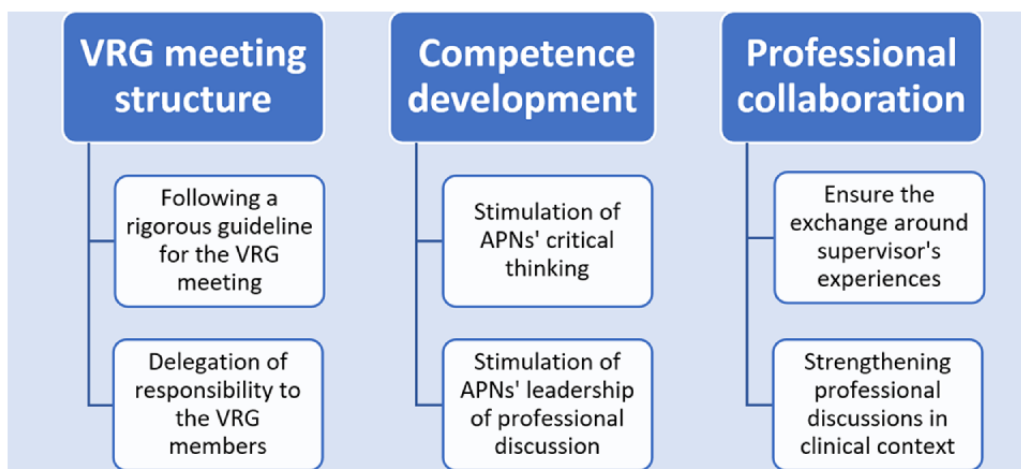
The different levels of expertise deepened the transparency of the results in this study, as all the authors participated in the analysis and agreed on the results.

Results

Overview

This study explored how APN master's students experienced participating in a VRG meeting during the COVID-19 pandemic. We identified 3 themes and 6 subthemes in the data, as illustrated in Figure 2. To ensure anonymity when presenting the results, references to individual participants' statements use nonidentifying letters (A-F), representing the individual APN student.

Figure 2. Results with themes and subthemes. APN: advanced practice nurse; VRG: virtual reflection group.



VRG Meeting Structure

Preparing for the VRG Meeting

The responsible student experienced the importance of having enough advance time to prepare the selected patient case together with the clinical supervisor and to look for a research article that could highlight the chosen patient situation. The flexibility to choose the time for the VRG meeting was also important to facilitate and ensure supervisor participation. Furthermore, the responsible student described the case with anonymized information and saved it on a secure digital learning platform (Canvas). The group members accessed the patient case in advance in preparation for the VRG meetings.

Following a Rigorous Guideline for the VRG Meeting

In the data, we found that all the participants became familiar with the new structure to follow during the VRG, as outlined in the meeting guideline. They found it useful to follow the rigorous meeting guideline in terms of providing structure when conducting the VRG meetings using web-based digital communication. The students felt that the guideline reinforced their responsibility to be prepared for their different roles, including the responsible student, the respondent, and the remaining students in the VRG, together with the clinical supervisor and educator. One of the participants compared the experiences of the regular reflection group and the VRG meeting, stating the following:

I achieved more learning outcomes now, participating in VRG meetings by presenting the case, leading the meetings and also, as a respondent, giving feedback on the research article related to the patient case. I think I gained many more benefits from this type of reflection group. [Participant C]

It appears that using a rigorous meeting guideline contributed to the distribution of disposable time and clarification of the participants' roles.

The students perceived both benefits and challenges of VRG meetings. One student stated the following:

Digital communication in groups may inhibit the spontaneous, unstructured discussion via Zoom, as everyone who participated had to wait for their turn to speak, in contrast to being in the same physical room. [Participant C]

However, there were also descriptions related to the benefits of waiting for one's turn to speak: "What you say may be more thoughtful, but you may also censor yourself because you have thought too much about it" (Participant D).

Furthermore, as the reflection groups took place digitally, some students missed meeting each other face to face, which provides opportunities for spontaneous discussion. In addition, the experience of safety in the group was perceived as important. The confidence in each other was generated by previous contact

with group members. Following the guideline ensured that all group members were included in the discussion.

Delegation of Responsibility to the VRG Members

The participants experienced as positive the distribution of different roles and responsibilities for the VRG members. In every meeting, a different student was responsible for presenting the chosen case and leading the discussion, whereas another student was the respondent, providing critical feedback on the chosen article. The remaining students participated in the discussion together with the clinical supervisor and the educator. One of the students elaborated on the roles:

In our reflection group, we went through both the article and the patient case. Further, we started a discussion about the case, which was the reflection itself. I expected responses on the case and the chosen article I had presented. [Participant B]

The responsible student gained experience in finding and choosing relevant research articles that highlighted a patient's case. The student in the respondent's role was learning to be critical of research. Both students learned to evaluate and reflect on the research articles in addition to knowing how and where to apply the acquired knowledge in an educational and clinical context.

One of the students in the respondent role reported about focusing on the chosen research article:

The respondent role was limited to giving feedback on the relevance of the selected research article to the chosen patient case and its methodological approach, and not so much focus was given to the content of the chosen patient situation. [Participant D]

Another student reported that the achievement of the learning outcomes was possible because of the delegated responsibilities regarding leading the meeting and being a respondent:

Both roles increased (the student) responsibility when conducting the VRG, and it was instructive both to present the patient case and to be the respondent. [Participant A]

When leading the discussion, students experienced that the guideline provided a structure for the meeting and helped a great deal with the distribution of the tasks. The students experienced that the meeting guidelines provided a clear structure for the distribution of time and responsibilities when conducting the VRG meeting. The student responsible for presenting the case was also responsible for leading the professional discussion through reflection, which occurred after the respondent's feedback on the chosen research article for the studied patient case.

Competence Development

Preparing for Leading the VRG Meeting

Preparing in advance for the VRG meetings, together with the clinical supervisor, stimulated the students' reflection, especially when describing the patient situation. During the VRG, the

students acquired experience in leading academic discussions and were challenged in their development of critical thinking.

Stimulation of APNs' Critical Thinking

The students experienced an increased focus on the APN role in the VRG meetings. They were in the last of the 3 periods of clinical practice and had achieved advanced knowledge and developed the competence to make complex clinical decisions and use critical thinking at a higher level. They reported the development of academic argumentation by participating in the VRG meetings:

I like to argue, which becomes much easier when you can use research to justify the issues. For example, when it comes to change in routines... [Participant B]

In the data, we found that the students were more self-confident with the competence they acquired through their master's education, which was an ongoing process. They found that the VRG meetings were useful as they were challenged to argue and express their opinions on different issues concerning clinical patients, which stimulated their development of critical thinking. The flexibility and safe environment of the VRG meetings were also underlined. They could join in a discussion based on their clinical practice, and they could stay in it even if their arguments were flawed. In addition, they felt more confident in their competence regarding ethical issues with reflection on ethical dilemmas from clinical practice.

The students reported how the content of the VRG meetings, which were based on actual patient cases, relevant research articles, and feedback from their peers, stimulated their reflection skills and increased their knowledge:

To elaborate a patient case and find a relevant article that you will receive feedback on stimulates reflection: Is the case I have written good enough? Is the research I have found good enough? It is an advantage to get a "second opinion" from another APN who looks at the content with different eyes than I do. [Participant C]

The students reflected together, thus contributing to their different opinions, whereas one of the students gained experience in leading the discussions.

Stimulation of APNs' Leadership of Professional Discussion

The students were responsible for leading the VRG meetings, and they facilitated an in-depth discussion of the presented patient case. They acquired experience in leading professional discussions according to the meeting guidelines. They also reported positive and instructive experiences from receiving feedback on the article and leading the discussion focused on the chosen patient situation.

The data show that some of the participants were afraid and insecure in leading the VRG meeting, as they were responsible for presenting the case to their fellow students, clinical supervisors, and educators. A student (Participant F) reported that it was useful to be a little insecure while practicing the leading role in front of the other group members. Another

student reflected on the uncertainty they experienced leading the professional discussion in the VRG meetings:

The first time, I was unsure about my leading role in relation to the educator role, about how strong a position I should take in leading the discussion.
[Participant D]

Another student experienced that it was a challenge to lead the virtual discussion with fellow students because of the need to pay attention to the task at hand and, at the same time, ensure that everyone had the chance to say something in the discussion. They perceived that the size of the VRG was important to ensure the achievement of learning outcomes, as 1 student commented:

I think practising in a small group is good, compared to a large group, which can be scary. Small groups, where you are confident in each other, are fine.
[Participant A]

They found that the sensation of safety related to small groups increased the activity and gave all members an opportunity to speak. One student (Participant B) expressed that she dared to say more in a small group and with people that everyone knew.

Participating in VRG meetings gave the students the experience of leading professional discussions. One student (Participant F) mentioned that these experiences were useful in developing their competence as future APNs. In the VRG meeting discussions, they experienced keeping their focus on the APN role and responsibilities in close collaboration with their clinical supervisor.

Professional Collaboration

Ensure the Exchange Around Supervisor's Experiences

The clinical supervisor participated in the VRGs and shared experiences that challenged the students to think critically about how to apply research in clinical practice. The VRG meeting structure made the participation of the clinical supervisor possible to the benefit of the responsible student and the other students. The students gave positive feedback regarding their experiences in collaboration with the clinical supervisor in terms of preparing for VRG meetings and leading professional discussions. The students perceived it as very useful to get feedback directly from the supervisors, who could contribute their clinical experience and identify the relevance of the chosen research article to the selected patient case. One student elaborated on the benefit of having the clinical supervisor as a participant in the VRG meeting, stating the following:

It helps to get a different view of the case. The supervisor can participate and give input on how it works in everyday life, justifying why it works and why they do things the way they do. [Participant F]

Another student chose a case in collaboration with the clinical supervisor, in which the topic was pain, and she elaborated on the learning outcomes:

The more I read, the more exciting it became. It was interesting to get feedback from the respondent on the case. I heard several points of view on how we could choose to solve the situation. To discuss around

a case was very instructive, and several thoughts came up. It was an exciting case. [Participant C]

When selecting cases from clinical practice, the students had to select a research article that could clarify the chosen case. They experienced excellent collaboration with their clinical supervisors, who helped them find a relevant research article for the chosen patient case. One student experienced it in the following manner:

The clinical supervisor came up with unique points of view from the unit the case was drawn from and could explain the background, why it had turned out the way it had, and what choices were made that the rest of us could only comment on; it was absolutely valuable. [Participant D]

The students felt that the clinical supervisor could bring out other points of view on the case, as seen from the practice side, and elaborate on and justify the assessment and management that were done based on an APN's role and responsibilities.

The students experienced that the supervisor's input was valuable to the choice of the research article. This input was based on a critical assessment of the research article that evaluated its relevance to the chosen patient case. One of the students (Participant D) stated, "There was a good collaboration with the practice supervisor who helped me find a relevant research article that could highlight the chosen patient case."

Another student (participant B) stated, "To get feedback from the supervisor on research related to the patient case, for example, if it was a good article or if I should choose something else." The students felt that they gained relevant competence to develop as an APN from their experiences of participating in the VRG meetings regarding linking research to clinical situations.

Strengthening of Professional Discussions in Clinical Context

According to 1 student (Participant E), the topics that were raised in the VRG meetings had ripple effects on clinical practice, as the supervisors brought the topic back to their units. One student (Participant F) illustrated these effects by referring to the topics raised by the supervisors about their clinical practice that were discussed in the VRG meetings. The supervisors from clinical practice who participated in the VRG meetings also showed commitment, as 1 student elaborated on as follows:

The supervisor later discussed in clinical practice the topic that had been chosen (for the VRG) and afterwards how the situation had been followed up.
[Participant A]

Another student reflected on the compliance between the possible procedure discussed for the patient case based on the research article and the procedure performed by the supervisor in clinical practice:

My supervisor found the topics I raised in the VRG interesting. I located a research article with a few points that interested the clinical supervisor, and the

supervisor brought this knowledge back to the clinical practice. [Participant D]

In the VRG meetings, APN students, clinical supervisors, and educators had the experience of reflecting on clinical practice situations. They linked relevant research-based knowledge to current patient cases from the unit. The discussions in the VRG meetings positively influenced decision-making related to patient cases in clinical practice, which strengthened the professional discussion related to the clinical context.

Discussion

Principal Findings

This study aimed to explore how APN master's students experienced VRG meetings, which were implemented for all master's students during the COVID-19 lockdown. By participating in the VRG meetings and experiencing different roles, the APN students increased their responsibility, both by leading and taking part in professional discussions about issues derived from clinical practice. The APN students experienced rigorous guidelines as useful for organizing meetings with a structure that facilitated the distribution of time [6]. The students took turns assuming responsibility for leading the meeting discussions, which they reported as a useful experience in preparing for their role as APNs. As described in the literature, leading professional discussions is one of the core competencies required in the APN role, and the meetings allowed students to develop advanced abilities in leadership and collaboration [13], a skill that was identified in a previous study to be highly important in APN education [7]. The students reported that they experienced increased learning outcomes by participating in VRG meetings and collaborating in various roles.

By changing from on-site meetings at the campus to distance learning through web-based meetings that followed rigorous guidelines in conducting the VRGs, the students took on increasing responsibility, which improved their learning process and learning outcomes in the clinical practicum. These findings are in line with the results of another study that explored how students adapted to the changes associated with the pedagogical transition to distance learning and use of digital tools because of the COVID-19 pandemic lockdown [3]. The students were trained in digital communication, distance learning, and the use of digital tools during the lockdown [1,2,4,5]. Our APN students also experienced the COVID-19 pandemic by reducing the face-to-face physical contact between them in different clinical placements and the contact between the students and educators, results that are in line with other studies [2,5]. In addition, the students participating in the VRGs experienced that it could be challenging to discuss issues in a digital setting rather than face to face, as spontaneous responses in the discussions were less likely [2]. Despite the challenges in web-based communication, the students pointed out some advantages. In the VRG meetings, the students followed rigorous guidelines, including waiting for their turn to speak while others were talking. By waiting for their turn, the students experienced extra time to reflect on the issues they were discussing, which they experienced as a benefit.

The results of this study show that by participating in VRG meetings, the APN students were challenged to reflect on the

competence they had developed in their master's education. They also experienced increased awareness of the APN's role in complex patient situations during clinical placement. Preparing the case in advance of the VRG meeting contributed to the students' in-depth knowledge, as they used the content from a research article for professional argumentation in discussions regarding the chosen patient situation. These results coincide with a review highlighting the importance of helping students to understand and enhance the APN role by using advanced knowledge and research in their professional development [7]. Furthermore, our study found that the students felt more confident in their competence regarding ethical issues. In general, nurses' reflections on ethics lead to greater self-confidence by clarifying their role and helping them find solutions to improve their clinical practice [24]. Moreover, competence in systematic reflection is necessary when working in clinical practice environments [25]. Reflection in groups has a particularly important role in developing one's professional practice, and reflection-beyond-action can help students understand clinical situations by using a story in the context of a past experience. Reflection on clinical issues is also important in life-long learning for the further development of professional competence [18]. Participating in VRG meetings and reflecting on clinical issues improved the APN students' ability to achieve a deeper understanding of complex patient situations.

The results show that the discussions in the VRG meetings stimulated the APN students to develop their critical thinking skills, as they received feedback from other group members. The APN students need to be trained in critical thinking because it allows them to actively participate in their learning process in developing competence as an APN [7]. Critical thinking is the process by which the students form a reflective judgment about what to believe or what to do in a given context [1]. Critical thinking is defined by the American Association of Colleges of Nursing as all or part of the process of questioning, analysis, synthesis, interpretation, inference, inductive and deductive reasoning, intuition, application, and creativity, which leads to clinical judgments and safe clinical decisions [4]. Another study found that the greatest development of competence was in relation to direct clinical practice. Although the students entered the program with different levels of competence, this was largely equalized during their education in the master's program [26]. The data from the focus group in our study showed that the learning outcomes from the VRGs strengthened the students' critical thinking skills in the process of developing their competence, in particular by taking increased responsibility for leading professional discussions.

The discussions in the VRGs promoted the strengthening of the collaboration between education and clinical practice. Implementation of the reflection groups as VRGs facilitated participation of the clinical supervisors together with the responsible student, meeting the group of students from other placements in different hospitals and the educator on the web in the meeting. The clinical supervisor who participated contributed to the updated clinical experiences in the professional discussion, which the students experienced as having a positive influence on their process of developing competence as an APN. The clinical supervisor contributed to

the discussion with practical experiences to help students better understand the challenges APNs face in complex patient situations with a strong medical focus. APN students also need to learn medical subjects while maintaining a holistic approach that includes providing patient-centered care, which is the foundation of nursing [7]. Developing clinical decision-making is another important aspect of clinical competence [26,27]. APNs are experts in nursing who have extended their medical knowledge while retaining their unique nursing character [7]. In the process of helping students develop their professional APN role, the clinical supervisor acts as a role model in connecting medical topics to the assessment and management of the clinical situation in the chosen case.

The VRGs had implications for clinical practice as the supervisors, together with the students, continued their professional discussions after the meetings. The students reported in the focus group that the supervisors followed up in clinical practice on the issues from the discussions and the challenges identified in the VRG and together they continued to further reflect on and beyond the situations in the clinical unit [17,18]. During their reflections on the chosen case, the students gained a deeper understanding of the situation by developing increased situational awareness, as supported by the clinical supervisor. An important learning outcome in the master's program is to achieve increased situational awareness in complex patient situations [14]. The students had useful experiences cooperating with the supervisor in linking research to the chosen situation from practice when preparing for the VRG meetings. Together, they brought the new knowledge back to the clinical practice for further assessment and implementation, which gave the APN students useful and relevant experiences in preparation for the APN role. Developing evidence-based practice through the critical assessment of research is part of an APN's core competence [13]. The APN students are, according to the results from a Swedish study, engaged in the process of gaining a more advanced identity for the APN role, which is based on both practical and theoretical knowledge [27]. Developing the role as an APN includes advanced knowledge in critical thinking, clinical decision-making, and comprehensive assessment [7,8]. In professional discussions in the VRGs, the APN students took on increased responsibility in collaboration with the clinical supervisor in preparing the case. Together, they followed up on the issues from their reflections by continuing professional discussions in clinical practice. The students' experiences from their reflections in the VRGs increased their competence in preparing them for the APN role.

The study has implications for practice, as the results provide useful information that supports the use of the VRG, which

increases the possibility of clinical supervisors joining the meetings and supports the students in developing their new APN role. The digital competence achieved throughout the COVID-19 lockdown will prove useful when continuing to conduct VRGs after the pandemic, and further use of VRGs will continue to strengthen the collaboration between health care institutions that offer clinical practice and educational institutions that are responsible for ensuring the quality of nursing education.

Limitations

This study has some limitations, as only 1 focus group interview was conducted. The interview was completed after the last period of the students' clinical placement during an APN master's program, with 6 students enrolled in this course participating in the focus group interview. However, although it was only 1 interview, it generated rich data that provided sufficient information power [28]. The 6 students had experience with different clinical placements in different hospitals and were divided into different groups for the VRGs. Only students were selected as respondents for this study. Including clinical supervisors in this study could have provided useful information from their point of view.

Conclusions

Reflection groups were implemented as VRG meetings using web-based communication during the lockdown because of the COVID-19 pandemic. The rigorous guidelines for the VRGs ensured a solid structure for the meetings, and professional discussions stimulated APN students' critical thinking and the development of competencies. The participants responsible for the VRG meetings experienced increased responsibility as they were in charge of organizing the meetings, chose a patient case, and found research related to the patient case. The students in the respondent role reported their development of critical assessment in the clinical and research contexts, as they were responsible for giving feedback on the chosen patient case and the research article. This study found that participating in VRG meetings challenged APN students to reflect on the competence they had developed in their master's education. They experienced achieving increased awareness of the APN role in complex clinical patient situations during clinical placement. As the VRG meetings were web-based, the clinical supervisor could participate with the educators and students from placements in different hospitals. The clinical supervisors contributed by sharing their actual experiences, which improved the professional discussions. The APN students and clinical supervisors continued the discussions in the clinical settings afterward, which strengthened the collaboration between education in the master's program and clinical practice.

Conflicts of Interest

None declared.

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Abbreviations

APN: advanced practice nurse

VRG: virtual reflection group

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Original Paper

Nurse-Led Virtual Delivery of PIECES in Canadian Long-Term Care Homes to Support the Care of Older Adults Experiencing Responsive Behaviors During COVID-19: Qualitative Descriptive Study

Anna Garnett¹, MSc, PhD; Denise Connelly², BScPT, MSc, PhD; Marie-Lee Yous³, MSc, PhD; Lillian Hung⁴, PhD; Nancy Snobelen⁵, MBA, DHA; Melissa Hay⁶, BSc, MPT, PhD; Cherie Furlan-Craievich⁷, RD; Shannon Snelgrove⁸, BA, RN; Melissa Babcock⁷, RPN; Jacqueline Ripley⁸, RPN; Pam Hamilton⁹, BA; Cathy Sturdy-Smith¹⁰, BA, MSc; Maureen O'Connell¹¹, BHSc

¹Arthur Labatt Family School of Nursing, Western University, London, ON, Canada

²School of Physical Therapy, Western University, London, ON, Canada

³School of Nursing, McMaster University, Hamilton, ON, Canada

⁴School of Nursing, University of British Columbia, Vancouver, BC, Canada

⁵Registered Practical Nurses Association of Ontario (WeRPN), Mississauga, ON, Canada

⁶Health and Rehabilitation Sciences, Western University, London, ON, Canada

⁷Vision 74 Inc, Sarnia, ON, Canada

⁸Copper Terrace Long-term Care Home, Chatham, ON, Canada

⁹Pieces Canada, Kingston, ON, Canada

¹⁰Pieces Canada, Owen Sound, ON, Canada

¹¹Pieces Canada, Barrie, ON, Canada

Corresponding Author:

Anna Garnett, MSc, PhD

Arthur Labatt Family School of Nursing

Western University

1151 Richmond St

London, ON, N6A 3K7

Canada

Phone: 1 519 661 2111

Email: agarnet6@uwo.ca

Abstract

Background: Worldwide, the COVID-19 pandemic has resulted in profound loss of life among older adults living in long-term care (LTC) homes. As a pandemic response, LTC homes enforced infection control processes, including isolating older adults in their rooms, canceling therapeutic programs, and restricting family member visits. Social isolation negatively impacts older adults in LTC, which may result in increased rates of anxiety, depression, physical and cognitive decline, disorientation, fear, apathy, and premature death. Isolation of older adults can also cause an increase in responsive behaviors (eg, yelling, hitting, calling out) to express frustration, fear, restricted movement, and boredom. To respond to the challenges in LTC and support frontline staff, older adults, and family members, a novel registered practical nurse (RPN)-led delivery of the PIECES approach for addressing responsive behaviors among older adults with dementia using virtual training/mentoring was implemented in Canadian LTC homes. PIECES employs a person- and family/care partner-centered collaborative team-based approach to provide education and capacity-building for nurses; engages families as active participants in care; and embeds evidence-informed practices to provide person- and family-centered care to older adults with complex needs, including dementia.

Objective: The aim of this study was to describe the experiences of LTC staff, family/care partners, and older adult research partners with implementation of a novel RPN-led virtual adaptation of the PIECES care-planning approach for responsive behaviors in two Canadian LTC homes during the COVID-19 pandemic.

Methods: Using a qualitative descriptive design, two focus groups were held with three to four staff members (eg, RPNs, managers) per LTC home in Ontario. A third focus group was held with three PIECES mentors. Individual semistructured interviews were conducted with RPN champions, family/care partners, and older adult research partners. Research team meeting notes provided an additional source of data. Content analysis was performed.

Results: A total of 22 participants took part in a focus group (n=11) or an in-depth individual interview (n=11). Participant experiences suggest that implementation of RPN-led virtual PIECES fostered individualized care, included family as partners in care, increased interdisciplinary collaboration, and improved staff practices. However, virtual PIECES, as delivered, lacked opportunities for family member feedback on older adult outcomes. Implementation facilitators included the provision of mentorship and leadership at all levels of implementation and suitable technological infrastructure. Barriers were related to availability and use of virtual communication technology (family members) and older adults became upset due to lack of comprehension during virtual care conferences.

Conclusions: These findings offer promising support to adopting virtual PIECES, a team approach to gather valuable family input and engagement to address residents' unmet needs and responsive behaviors in LTC. Future research should investigate a hybridized communication format to foster sustainable person- and family-centered care-planning practices to include active collaboration of families in individualized care plans.

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KEYWORDS

long-term care; older adults; families; responsive behaviors; qualitative; COVID-19; PIECES; nurse(s); care home; infection; therapeutic; anxiety; depression; cognitive; fear; death; dementia; communication; technology

Introduction

Globally, the COVID-19 pandemic has resulted in death and decline in the physical, mental, and behavioral health of older adults in long-term care (LTC) [1,2]. This population has been more vulnerable to the COVID-19 virus than the general population in part due to their living situation, advanced age, less robust immune system, and increased likelihood of having multiple comorbidities [3]. In Canada, two-thirds of COVID-19 deaths were among older adults in LTC from March 11, 2020, to May 8, 2020 [1]. In the early stages of the pandemic, LTC homes prioritized containing the spread of COVID-19 through strict infection control processes, which included isolating older adults in their own rooms, pausing therapeutic activities, and imposing restrictions on visits by family members. These measures meant that many older adults experienced prolonged periods of seclusion and a loss of social engagement. The social isolation of older adults in LTC homes was further exacerbated by government-mandated restrictions on in-person gatherings, which compounded the already stringent restrictions in place across many LTC homes [4].

Outcomes of social isolation among older adults include a heightened risk of experiencing anxiety, depression, physical and cognitive decline, and premature death [5-7]. Other impacts include worsening apathy and boredom [8,9]. Many older adults' family members provide up to 30% of care, including assistance with personal care, nutrition, as well as social stimulation and emotional support [10]. These family members are also recognized by the LTC home staff as key partners in the care of older adults; however, current practice models used to guide care planning and delivery do not readily include them as active team members [11]. As a result, prohibiting caregivers from in-person visits with older adults in LTC in the earliest waves of the pandemic served to exacerbate older adults' social isolation and the subsequent health and behavioral consequences.

Prior to the pandemic, 50% of older adults with dementia in LTC experienced responsive behaviors (eg, yelling, restlessness, hitting) in response to unmet needs such as pain, boredom, thirst, and hunger [12]. Multiple factors within LTC contribute to disproportionate responsive behaviors, including lack of staff education, inadequate skills, lack of support from leaders in management, and insufficient staffing resources [13]. Isolation of older adults with dementia can lead to higher incidences of responsive behaviors with a resultant increased use of antipsychotic medications by LTC staff [14]. During multiple waves of COVID-19, increased incidence of responsive behaviors in older adults in LTC was documented with the concomitant widespread isolation resulting from infection control processes and restrictions on in-person gatherings [15,16]. Approximately 51% of family members have reported an increase in responsive behaviors in persons with dementia since the pandemic started [15]. This exacerbation in behaviors highlights the need for interventions to support older adults and the care staff, and calls attention to the need to engage all persons caring for them (eg, older adults, families, frontline staff) in care-planning processes (eg, team-based) and policy development (eg, infection control and family as essential care partners, not visitors).

An example of a team-based care-planning model is PIECES, which consists of a holistic, relationship-based, and evidence-informed team approach to collaborative assessment and shared care designed for use by interdisciplinary teams to address the complex physical and mental health (eg, cognitive, emotional, social, psychological) needs of older adults [17]. Understanding what matters to the person and family is central to the PIECES model. The PIECES approach includes the following components in assessing the individual: Physical, Intellectual, and Emotional health; maximizing the Capabilities of an individual to support quality of life; integrating the living Environment of a person; and encompassing a person's Self, including beliefs, culture, and life story [17]. PIECES has been

implemented across Canada by interdisciplinary teams and in diverse settings, including acute care, LTC, home and community care, complex continuing care, and mental health settings, to put a plan in place to address responsive behaviors.

The PIECES approach educates staff to recognize and address mental health challenges and responsive behaviors, leading to more thorough assessments using a variety of existing tools, strengthening partnerships between LTC homes and external resources, and improving family satisfaction with care delivery [18,19]. In acute care settings, PIECES enhances collaboration between different disciplines, promotes individual assessments of older adults, and facilitates problem-solving to address behaviors [19,20]. By virtue of its person-centered design, the PIECES approach is well-suited to be delivered by registered practical nurses (RPNs), as the largest regulated frontline staff in LTC homes [21] who are most familiar with the older adults' day-to-day behavioral expressions and changes. In-person delivery of PIECES has been demonstrated to improve the recognition and early management of responsive behaviors and communication between staff and family; however, it has not previously been implemented virtually [20]. Virtual care is well-placed to support interdisciplinary team-based care planning by enhancing team communication, providing continuity of care, and facilitating collaborations between specialists such as geriatricians, physicians, and mental health experts [22-24]. Moreover, virtual care may offer novel training and leadership opportunities for frontline RPNs to lead care discussions involving multiple parties (eg, family care partners, health care providers, older adult LTC residents) regardless of their physical location.

During the COVID-19 pandemic, an urgent need emerged for increased support for older adults experiencing responsive behaviors in LTC [22]. This study employed a virtual adaptation of PIECES [17] training using Personal Health Information Protection Act–approved Zoom videoconferencing technology. Synchronous meetings using virtual technology for RPNs to conduct individualized family care conferences with the family off-site, the older adult, and other health care team members (on- or off-site) were used to create an integrated care plan. This virtual PIECES intervention, shepherded by an on-site RPN champion from within the partner LTC home, provided the health care team with care protocols, supported by behavioral support staff, to maintain quality in care practices during the COVID-19 pandemic and inclusion of family in care decisions.

PIECES-trained staff completed PIECES referrals for residents experiencing responsive behaviors with the collaboration of other staff members (eg, personal support workers, social workers, recreational therapists, nurses) in the LTC home. RPN champions then contacted family members to schedule a virtual family care conference to discuss the behaviors of residents and to put in place a plan of care to address these behaviors. The RPN champion, PIECES-trained staff, family member, and resident (if able and willing) were present at the care conferences held by Zoom. PIECES-trained staff or RPN champions followed up with families to provide telephone or in-person updates regarding the outcomes of strategies put in place to address responsive behaviors. The role of PIECES mentors was to provide PIECES training for LTC staff, debrief with

PIECES-trained staff and RPN champions, and address any questions. Understanding the facilitators and barriers to virtual PIECES implementation is an important future step to sustain and spread virtual care delivery. The purpose of this study was therefore to describe experiences and implementation facilitators and barriers in delivering a novel RPN-led virtual adaptation of the PIECES care-planning approach to address behavioral expressions in two Canadian LTC homes during the COVID-19 pandemic.

Methods

Study Design

This study used a qualitative descriptive design, which allows for the provision of a detailed description and low-inference interpretations of data, defined as remaining close to the words of participants [25]. The Consolidated Criteria for Reporting Qualitative Research (COREQ) statement was used as a reporting guideline (see [Multimedia Appendix 1](#)) [26].

Setting

Two LTC homes in Ontario, Canada, were involved to inform and host implementation of a virtual PIECES intervention. There was no pre-established relationship between the research team and the LTC homes prior to the study. Both sites are considered as mid-sized privately owned LTC homes (138 and 146 beds, respectively) that have been in operation for more than 30 years; one home operates as a for-profit venture and the second as nonprofit, offering varying services (eg, family physician, nursing and personal care, housekeeping, meals, laundry, leisure activity programming, nutritional services, and services within the community such as physiotherapist, social worker, X-ray, and ultrasound services).

Sample and Recruitment

Study participants consisted of RPN champions, PIECES mentors, PIECES-trained LTC staff of various disciplines (eg, nursing, nutrition, recreation, behavioral management), family/care partners, and older adult research partners. The older adult research partners who participated in this study were selected based on the clinical judgment of the director of care in the LTC home. The director of care has a nursing background and purposely selected the two residents to be research partners, as they were able to understand the purpose of the study and contribute through virtual means. Convenience sampling [27] was used to select these participants. The participants were key stakeholders in implementing virtual PIECES at the LTC homes and family/care partners, who were active members of virtual care conferences to provide the family/resident story and to discuss mitigating the responsive behaviors of older adults. Participants were invited to engage via email or by phone. Participants were able to read, understand, and speak English. The sample size was not predetermined. However, review of qualitative descriptive studies showed that most studies included 11 to 25 participants [28]. The sample size was deemed sufficient once diverse data were obtained and overlapping data indicated the approximation of data saturation [29,30].

Data Collection

Study processes were explained to all participants who then provided written consent for their involvement in the study. All focus groups and interviews were conducted using Zoom videoconferencing by two female postdoctoral fellows with experience in qualitative research (MLY, MH). A total of three focus groups were held. Two focus groups were held with three to four PIECES-trained staff of each LTC home (ie, one focus group per LTC home). A focus group was also held with the three PIECES mentors. Since the PIECES mentors regularly engaged with the LTC staff members (eg, behavioral management lead, registered dietitian, RPNs, managers) throughout the implementation of virtual PIECES, their perspective was important to inform understanding of the facilitators and barriers to this process. These focus groups were 60-80 minutes in length. Individual semistructured interviews were conducted with RPN champions, family/care partners, and older adult research partners. These interviews lasted between 30 and 70 minutes, and no repeat interviews were conducted. Focus group and interview guides (see [Multimedia Appendix 2](#) for sample questions) were developed through a review of the literature on various concepts, including PIECES, virtual care conferences, responsive behaviors, older adults, and LTC, and feedback of the research team members. Participants were asked about their experiences with the virtual PIECES intervention, implementation facilitators and barriers, and recommendations for improvement of the intervention. Interviews were recorded, anonymized, and transcribed verbatim. Field notes were documented by two interviewers with training in qualitative data collection methods (MLY, MH) throughout meetings and interviews.

Data Analysis

Qualitative content analysis was used to summarize data and form interpretation of key messages as well as provide rich, detailed descriptions of the entire data set [25]. This inductive analytic method allows for identifying, describing, interpreting, and summarizing emerging patterns within the data while ensuring themes are linked to the voices of participants [31-33]. Open coding was used to develop themes, which offered a general description of the experience [34]. Analysis of interview transcripts, as well as observational field notes, allowed the research team to explore organizational factors, implementation process, team engagement, experiences in using technology, and the virtual care planning from the perspectives of key stakeholders. Preliminary codes and themes were generated by two research team members (MLY, AG) and then consensus of thematic inclusion was reached with all research team members. Data analysis included reflexive participant collaboration

wherein RPN champions, PIECES mentors, LTC staff, and older adult research partners provided ongoing feedback on interpretations to support participant validation in the presenting of findings [35,36].

Rigor and Trustworthiness

Approaches were used to uphold rigor and trustworthiness in qualitative research, including addressing Lincoln and Guba's [37] criteria: credibility, transferability, dependability, and confirmability. Investigator triangulation of research team members with experience supporting older adults and family/care partners in LTC, addressing responsive behaviors, and qualitative research ensured credibility of the findings. This strategy was also found to complement and support the validation of data [37]. Comprehensive and detailed descriptions of the setting and sample of the study were used to ensure that the findings were transferable [37]. The research team ensured that processes of the study were informed logically by conducting a comprehensive review of the existing literature to determine gaps in the literature.

Ethical Considerations

Ethics approval was granted from the local University Ethics Boards (#118629 and #H21-01428). All participants received a written introduction to the study and an informed consent form written in lay language, which they signed prior to participating in the study. Study IDs were assigned to participants to maintain anonymity and participation was voluntary. The three core principles—respect for persons, concerns for welfare, and justice—of the Tri-Council Policy Statement [38] were enacted throughout the study. A Can \$25 gift card (approximately US \$20) was provided to all nonacademic research team participants in recognition of their study participation.

Results

Demographic Characteristics

A total of 22 participants took part in a focus group (n=11) or interview (n=11) during the midstage of virtual PIECES implementation. Most of the participants were female (90.9%). Both older adult research partners were male. They were involved in reviewing information and providing feedback on research outputs such as manuscripts and presentations. There was diverse representation of team members. LTC staff had various roles within the LTC homes (see [Table 1](#)). Limited demographic information was collected as not to burden participants in addition to the time they had already contributed to the study.

Table 1. Descriptive characteristics of the participants.

Variable	Participants, n
Gender	
Female	20
Male	2
Role	
Family/care partner	7
LTC ^a staff (eg, behavioral management lead, registered dietitian, RPN ^b , manager)	8
PIECES mentor (eg, physiotherapist, psychogeriatric resource consultant, manager of specialized geriatric services)	3
RPN champion	2
Older adult research partner	2

^aLTC: long-term care.

^bRPN: registered practical nurse.

Themes

Overview of Themes

Resultant themes were grouped according to: (1) participant experiences, (2) implementation facilitators, and (3)

implementation barriers of the virtual adaptation of the PIECES approach (see [Textbox 1](#) for an overview of themes). The two LTC homes are identified as Site 1 and Site 2, respectively, and participant IDs are used when providing direct quotations.

Textbox 1. Overview of themes.

<p>Experiences</p> <ul style="list-style-type: none"> • Virtual PIECES provided individualized care for older adults • Families recognized as partners in care through virtual PIECES • Virtual PIECES led to greater interdisciplinary collaboration • Virtual PIECES improved the practice of long-term care (LTC) staff • Virtual PIECES contained limited opportunities for families to provide feedback on outcomes <p>Implementation facilitators</p> <ul style="list-style-type: none"> • Huddles were helpful for interdisciplinary team involvement • Mentorship provided support and encouragement for staff to deliver virtual PIECES • Leadership in all forms was key to implementing virtual PIECES • Equipping LTC homes with technological infrastructure was essential <p>Implementation barriers</p> <ul style="list-style-type: none"> • Availability and use of virtual communication technology • Concerns surrounding the presence and involvement of older adults at virtual care conferences
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Experiences

Experiences Subthemes

Overall participating family/care partners, LTC staff, RPN champions, PIECES mentors, and older adult research partners reported positive experiences engaging with the virtual adaptation of the PIECES approach. Emergent themes of their experiences with virtual PIECES demonstrated that it: (1) provided opportunities for individualized care for older adults, (2) recognized families as partners in care, (3) led to greater interdisciplinary collaboration, (4) improved the practice of

LTC staff (eg, communication with family), but (5) contained limited opportunities for families to provide feedback on outcomes.

Virtual PIECES Provided Individualized Care for Older Adults

Virtual PIECES was perceived by family/care partners, staff, older adult research partners, and PIECES mentors as a way to ensure that older adults were provided with individualized care to meet their needs and abilities. Family/care partners felt that, through virtual PIECES, staff were making greater efforts to relate to older adults on a more personal level.

I think it [Virtual Care Conference] was more personalized for mom because the annual meeting, it's just more or less an update for me to let me know her weight and when they bathe her and what her diet is and how physiotherapy is going so that's mainly what that annual meeting is about but this meeting a couple of Fridays ago was more on a personal level and an emotional level just trying to get in touch with mom as far as her personality goes rather than her physical care. So that was nice. [Site 1, FCP 2]

PIECES conversations helped to build trust with older adults, which led to greater family satisfaction with care. Some family/care partners stated that they learned more about their family member through virtual care conferences, such as the occurrence of new behaviors and the severity of depression. Staff perceived that interactions with family/care partners and older adults were more positive through PIECES and they took more time to get to know older adults. Staff who participated in PIECES had knowledge regarding the older adults' preferences that were shared with them by family members during care conferences. This enabled the staff to share the older adults' preferences with other staff members so they could better meet the older adults' needs on a consistent basis. These staff also tailored their care to optimize independence among older adults as much as possible. "Capabilities too, like if she's [older adult] capable [to instill her own eye drops] and she can do it and she wants to stay as independent as possible that makes her feel glad that she can maintain that" [Site 1, Staff 1].

Videoconferencing used in delivering PIECES provided comfort for older adults, which enabled them to discuss their care with staff in the presence of a family/care partner.

So specifically with one of our PIECES referred resident, this resident did attend the care conference and she was delighted and eager to see her family. It was lovely to see their interactions so it was nice to kind of observe that interaction between the family member and the resident. We were able to discuss and involve that resident in her care and her actions so that was really nice to be able to involve the resident because that is in our bill of rights that each resident, they have the right to receive their own care and be involved in their own care plan. [Site 2, Staff 1]

RPN champions noted that there was improved rapport between family care partners, older adults, and staff as a result of individualized care delivered using virtual PIECES.

Families Recognized as Partners in Care Through Virtual PIECES

In the implementation of virtual PIECES, families were formally recognized as care partners. Family/care partners appreciated that PIECES staff sought their input and were asking questions about their older adult family members. Families believed that their perspectives were being heard by staff and that staff implemented specific actions to address their feedback.

I just feel like any other conversations that we had regarding mom were kind of like dismissed or ignored

and not even brought in the loop about things that were happening so I think this has been huge that calls are made, that people are talking to me about it and saying this is what we're seeing, what is your feedback? How can we help with that? How can we do this so that the staff isn't frustrated, your mom's not frustrated and we're all working together, that makes sense to me but that's not how it was so I feel like finally that's what's happening [Site 2, FCP 3]

Prior to virtual PIECES, some family/care partners had limited interactions with LTC home staff unless an emergency arose. As a result of virtual PIECES, family/care partners felt they were welcome to call staff and ask questions about their family members. Staff and RPN champions similarly acknowledged the value of seeking input of families in care planning and to ensure that families' concerns are being acted upon.

I mean family has always been part of the team and with our care conferences, our annual care conferences and family has always been encouraged to come in. I definitely think PIECES has enhanced that family portion and definitely has enlightened the family on the different lens that we are looking at from a health perspective. [Site 2, Staff 1]

Using videoconferencing for care conferences allowed family members to participate in care planning regardless of their physical location.

Virtual PIECES Led to Greater Interdisciplinary Collaboration

Virtual PIECES enabled greater interdisciplinary collaborations to provide care for older adults in LTC: "I think that a multidisciplinary approach to our intervention gives us the best information that we can. It helps solve our investigation from all sorts of perspectives and viewpoints" [Site 2, Staff 1]. The success of the intervention was perceived by LTC staff, RPN champions, and PIECES mentors as involving various disciplines (eg, nursing, directors of care, recreational therapy, housekeeping).

Everybody, absolutely everybody is part of the team from the directors to the cleaning lady, the PSWs [personal support workers], the nurses, the RNs [registered nurses], physios, the kitchen staff, the laundry staff. Everybody is working in conjunction to make their home the best possible experience for them so I see everybody involved. [Site 1, FCP 2]

Staff perceived that they were better able to work with different services such as Behavioural Supports Ontario to address responsive behaviors of older adults. At Site 2, the Geriatric Mental Health Outreach team was so impressed with the implementation of virtual PIECES that they reached out to staff to inquire about the referral processes used.

Virtual PIECES Improved the Practice of Staff

LTC staff, RPN champions, and PIECES mentors perceived that virtual PIECES encouraged more holistic assessments as routine practice in addressing responsive behaviors:

You get the chance to look at the person holistically and see what we're missing and then the PIECES assessment helps you do that and it takes you through physical and emotional cognitive abilities. So then by going step by step, you can actually say okay, I'm missing this person or I'm missing this step, they're not on the nursing rehab program, I've missed the pain component. I think it's just highlighted it and making it actionable. [Site 2, RPN Champion 1]

LTC staff had a better understanding of triggers, were less task-oriented, and better able to prioritize care. They became more confident in addressing behaviors and were now looking for inconsistencies in resident assessments. "We check for irregularities...dehydrated she could get confused and agitated because she's not eating and not drinking. We addressed that because of PIECES" [Site 1, Staff 2]. Staff were more knowledgeable in seeking input from families and communicating with them. This helped fill a gap in LTC about how best to involve older adults and families in care. Staff experienced resilience in moving forward with PIECES despite COVID-19 challenges. The PIECES-trained staff team was seen by other staff members as experts.

Virtual PIECES Contained Limited Opportunities for Families to Provide Feedback on Outcomes

Although virtual PIECES involved family, there was a lack of feedback opportunities for family/care partners regarding what actions have been taken as a result of meetings. Family/care partners were interested in knowing whether suggestions were being used by staff and whether the older adults' behaviors had improved.

All I would say is maybe more feedback or more detail of what is being done. We had no idea about, we didn't know about virtual [PIECES] being used or what it is was or how it was used...All we got in the conference was that the social worker spends an hour a day with her, that's all we got. What they do in that hour, I have no idea. [Site 2, FCP 5]

One family/care partner suggested that a phone call would suffice to provide an update. One PIECES mentor similarly recognized the need to seek feedback from families on the implementation process of virtual PIECES.

The one thing I did want to mention is how critical it is in their organizations that they've gone back to their family, the families who have been part of this to kind of use as a reference check for their implementation process so I didn't want to forget them because they have been a big part in the implementation in their respective organizations [PIECES Mentor 3]

Implementation Facilitators

Implementation Facilitators Subthemes

Implementation facilitators of the virtual adaptation of the PIECES approach themes included: (1) huddles were helpful for interdisciplinary team involvement, (2) mentorship provided support and encouragement for staff to deliver virtual PIECES,

(3) leadership in all forms was key to implementing virtual PIECES, and (4) equipping LTC homes with technological infrastructure was essential.

Huddles Were Helpful for Interdisciplinary Team Involvement

Huddles (ie, LTC staff unit-specific meetings) to engage the interdisciplinary team in virtual PIECES were formally implemented at Site 2. These were helpful in discussing older adults with new responsive behaviors to better understand their past history.

[RPN Champion] had one [huddle] the other day. We were just discussing a new resident and some care approaches too and just like background information on her so just to better understand how to properly care for her and manage her behaviors. [Site 2, Staff 2]

The huddles were found to be a helpful strategy in relieving staff of the burden to seek individual input from various disciplines in their completion of assessments as all staff members were gathered in one meeting. This was especially important when staff were faced with limited time and heavy workloads.

Those huddles are definitely very beneficial. A great way to get information to front line staff very quickly to a mass audience so that huddle and identifying the short form, we really can review and complete a short form in a short amount of time with a multidisciplinary team. The short form essentially can be completed with the input from all the team members at a huddle and there's multidisciplinary team members coming as well. There was dietary, management, front line, PSWs, RPNs, RNs. [Site 2, Staff 1]

Mentorship Provided Support and Encouragement for Staff to Deliver Virtual PIECES

Virtual PIECES delivery was made possible through mentorship provided by managers, senior staff members, and PIECES mentors. PIECES mentors were found to be excellent support for staff as they were experts in PIECES, provided encouragement, and celebrated staff accomplishments.

I was hesitant. [PIECES mentor 2] was very helpful. She really got us through this and I told her now I'm writing a book of [PIECES mentor 2] like focus on her positives and priorities and so I have her now in the back of my mind and saying these things and I carry that out on the floor when I'm working and I thought no matter how fast the pace is, taking a few minutes of extra time, I think that's really what we're taking away from this and I think it's a constant learning, I know more this week than last week and I think there are more residents in each Zoom meeting we've had [Site 1, Staff 1]

PIECES mentors ensured that information was consistently delivered across homes. LTC home administrators were supportive of staff and RPN champions, and made certain that they were provided with dedicated time to participate in training

of PIECES and complete assessment forms. A natural partnership occurred between Site 1 and 2 as a result of the virtual PIECES implementation, and both sites supported each other through sharing of resources such as financial report templates and algorithms that worked well for implementing virtual PIECES.

[Manager] has been involved and she's done a lot of offering ideas and asking for what I would think if I was on the unit. She's done a lot of the process planning and has said do you think that would work or not. And then you guys as well and also collaborating with [Site 2], it has been useful to hear their ideas and how they're doing it. It has been very helpful. I think we've adapted to some of their ideas and maybe vice versa, I don't know if they've used any of our ideas but their algorithm really helped get ours going because I think we had a hard time starting it. [Site 1, RPN Champion 1]

Leadership in All Forms Was Key to Implementing Virtual PIECES

The key to implementing virtual PIECES was the support provided by various leaders such as managers and RPN champions. Staff perceived that RPN champions were excellent role models for the rest of staff. Some staff members also assumed the role of leaders in implementing virtual PIECES and led team huddles.

I know [Site 2 Staff 2]'s here for one of her resources shifts and she was doing that, formally huddling the staff and you could see that she was quite confident and knowledgeable and asking questions to kind of help her to understand what was happening. [Site 2, RPN Champion 1]

Managers and administrators of LTC homes were very supportive of staff in implementing virtual PIECES and saw a need for the intervention due to the increase of responsive behaviors.

The support from leadership and they've had tremendous support and that needs to be on an ongoing way...What is going to be so essential is the ongoing support from leadership and a commitment and this is with all organizations and however big or large the team and whether along continual care, that leadership continues pave the way for the implementation in practice and there has certainly been tremendous leadership support that's just so critical as we move forward [PIECES mentor 1]

Equipping LTC Homes With Technological Infrastructure Was Essential

Staff were able to implement virtual PIECES with the support of their managers and administrators with regard to access to technology and training: "I was not very familiar with Zoom...We've come a long way from not knowing how to plug in the TV" [Site 1, Staff 1]. Videoconferencing was new for many older adults, families, and staff. Over time, and with the technological support and resources, families and staff have become more confident in using Zoom for meetings: "I don't

know whether it was a 1- or 3-month difference...so we are making headway with Zoom and I think people are becoming more used to the virtual communication" [Site 2, Staff 3]. Managers recognized the need to ensure that equipment is being stored securely, devices are connected, and clear instructions/resources are provided for staff and families in using technology: "[Manager] is really instrumental as to finding a place to store the technology, getting it in place, writing out the templates for the staff so I feel that was really well managed" [Site 2, RPN Champion 1].

Implementation Barriers

Implementation Barriers Subthemes

Despite the numerous facilitators and positive experiences with the virtual adaptation of the PIECES approach, there were some barriers reported, including: (1) availability and use of virtual communication technology, and (2) concerns surrounding the presence and involvement of older adults at virtual care conferences.

Availability and Use of Virtual Communication Technology

Virtual PIECES was generally well-received by older adults, family/care partners, and staff. Some family/care partners were comfortable in using virtual communication technology for work-related meetings and other events. Other family/care partners were unfamiliar with the technology.

I had to get help with my daughter, she helped set me up but I'm learning. I will learn eventually how to do it myself, it's just going to take me awhile, I have to see it and do it a few times but I'm finally getting the hang of using my phone regularly, it's an iPhone. I know how to make phone calls and I know how to go online but it's hard. [Site 1, FCP 6]

The study team offered tech support (ie, information technology [IT] squad for a driveway visit) to support family members, but this was declined by participating family members. Other participants recalled minor issues with technology such as connectivity challenges leading to frozen screens or no sound available during family care conference meetings.

Sometimes there's technical difficulties so there could be no sound on one meeting and then another meeting we couldn't get a picture so when things work out just so, you've really climbed a mountain and things are great so the challenge would be more so just the technical aspect of things. [Site 2, Staff 1]

Concerns Surrounding the Presence and Involvement of Older Adults at Virtual Care Conferences

While staff and family/care partners appreciated the involvement of older adults in care planning, the extent of meaningful engagement at virtual care conferences may depend on individual circumstance. Staff and family/care partners perceived that advanced cognitive impairment among older adults may cause them to be upset during meetings as they may not be able to comprehend conversations.

Having the resident present, sometimes it's harder though depending how advanced their dementia is,

like sometimes it's very upsetting to some residents but if they are able to understand what's happening, it's like an interaction so really, very helpful, that the volume is up and the screen is large and if you figure things out, it runs very smoothly...I think the challenges really happen when residents aren't willing to stay because this has been upsetting to them, like we had one, and she said that is not my daughter, what have you done to my daughter, and it got to be too much, so we had to remove her. [Site 1, Staff 1]

Some issues raised were of a sensitive nature, such as new behaviors, and this may have been upsetting for older adults to hear. The sensory impairments of older adults were also perceived by family/care partners as impacting their ability to participate in virtual care conferences due to decreased hearing and sight.

How do you get the nuances of a virtual call when you're 80 and you've never done it and you can't hear very well or your hearing's not as great so I think for us it was probably easier to have the call with [Site 2 Staff 1] with mom not there to actually talk about the issues and I know it's hard, I mean it is good to have mom's perspective but I also do think that [Site 2 Staff 1] also sees her and talks to her too. [Site 2, FCP 3]

Discussion

Principal Findings

To our knowledge, this is the first study to explore the experiences and implementation barriers and facilitators of a virtual adaptation of the PIECES approach in an LTC setting. Overall, virtual PIECES was well-received by participating family/care partners, LTC staff, PIECES mentors, RPN champions, and older adult research partners. Participants described how virtual PIECES supported care planning to address responsive behaviors and provided an opportunity to offer individualized care within the challenging context of the COVID-19 pandemic. Study findings suggest that virtual PIECES has value beyond the pandemic and is an important approach to engage family/care partners in LTC homes who may otherwise be excluded from care processes. LTC staff and family/care partners described how virtual PIECES helped them to provide care that was individually tailored to the life stories, preferences, and abilities of older adults.

Collaboration between family/care partners and LTC staff helped facilitate successful responses for older adults who were experiencing responsive behaviors. Prior research has shown that family members are well-positioned to support LTC staff in recognizing changes in an individual's health because of their extensive familiarity with them [39]. Benefits of virtual care conferences, such as ease of access and inclusivity, were also appreciated by family/care partners and LTC staff. Family/care partners felt they could contribute important information to inform the older adult's care and were also given opportunities to learn about care provision by the LTC home. Despite the well-known benefits of family involvement in care-planning

processes in LTC, research conducted in the United States found that only 16% of family/care partners participated in care-planning processes [40]. Older adults with more advanced forms of cognitive impairment may require greater involvement of family in care planning as they are unable to verbally communicate their needs and wishes, yet half of older adults in LTC with severe cognitive impairment do not have a family/care partner involved in their assessments [40]. Steps to foster person- and family-centered care can involve collaborative discussions that engage family members through interprofessional education for LTC staff and through the provision of opportunities for staff and family to attend care conferences [41,42]. Interventions in LTC that involve partnerships between family and staff often lead to positive outcomes such as improved quality of life for older adults and decreased burden and depression for caregivers [43,44]. Furthermore, these successful interventions also encouraged multiple key stakeholders to help engage family in care planning [43].

In this study, participants perceived that virtual PIECES, with its emphasis on inclusive and regular engagement and communication, enhanced individualized care for older adults experiencing responsive behaviors. Family/care partners felt that LTC staff knew the older adults on a more personal level and engaged with genuine interest to improve care delivery. This helped to strengthen and build trusting relationships between LTC staff, families, and older adults. Older adults who were unable to take part in virtual care conferences were well-represented by family/care partners who advocated for them, discussed medications and potential triggers for responsive behaviors, and could represent the older adults in decision-making processes, which are all key components of person- and family-centered care [45]. Positive relationships between older adults, family, and staff, as well as regular communication are necessary for collaborative decision-making regarding care [46,47]. Moreover, older adults and/or their families should be engaged in the development of personalized care plans in LTC [40]. Findings from this study highlight the important role that LTC leadership has to facilitate different approaches to person- and family-centered care, a finding that is also documented in the research literature [41]. Virtual communication technology, as implemented in this study, is a recognized tool to support older adults' social connections with their family members [16].

Our findings further demonstrated that the virtual care conferences and team huddles implemented as part of virtual PIECES facilitated the ability of family/care partners and LTC staff to develop care plans to address responsive behaviors. Virtual care conferences held either by video or teleconference have been found to reduce stress among families and providers and increase the confidence of staff in addressing responsive behaviors [48]. Research on a video-consultation program to link health experts with multidisciplinary LTC staff to develop care plans to address responsive behaviors resulted in new recommendations that were followed for 72.3% of older adults [49]. However, despite being invited to participate in care-based discussions to address older adults' behaviors, families rarely participated [49]. This finding suggests there is a need for

improved communication, education, and efforts to foster an inclusive environment so that families are familiar and comfortable with the meaningful role they can have at care conferences. Going forward, it will be important to evaluate the impact of interventions including virtual PIECES on resident outcomes in LTC, such as quality of life, responsive behaviors, agitation, pain, and depression, and fostering LTC staff and family/care partners relationships.

Ensuring that LTC homes had sufficient technological infrastructure was necessary for the successful implementation of virtual PIECES in this study. Family/care partners and LTC staff experienced challenges with the virtual communication technology at varying points, which included a lack of familiarity and receiving insufficient training to use the technology. Identified benefits of using technology to implement virtual PIECES included the ease of providing mentorship through virtual platforms and the facilitation of education to enhance staff practice. This research also highlights policy implications, including an identified need to provide support to families and staff in LTC to use technology, and ensuring that financial and human resources are available to offer technology as a mode of communication for all older adults and families during the pandemic and beyond. Integral to this process would be addressing aspects of equity; providing dedicated funding and IT resource personnel to assist families in accessing internet-based platforms. LTC homes should promote the use of technology among families by conducting online case conferences and family council meetings. Further, it will be important to ensure that diversity and inclusion are considered in the promotion and use of technology for family engagement. This may require closed captioning, an interpreter, language translation, and/or inclusion of culturally relevant care elements in LTC care models. Videoconferencing rather than telephone calls should be encouraged so that emotional connections and familiarity are nurtured by being able to recognize people on screen, and to see facial expressions and nonverbal cues [50]. They should ensure that homes have good quality WiFi in all locations—internal and external to the building—that staff receive technological training and support, and that LTC staff job descriptions recognize the role of staff to assist older adults and family/care partners to engage with technology [16]. Findings from this study suggest that family/care partners are interested in the outcomes of virtual conferences and value opportunities to provide feedback. Henceforth, family/care partners should have opportunities for structured and predictable communication where they can connect with both older adults and the LTC staff [50]. During and beyond pandemics and outbreaks, there would be a benefit to having key staff members assigned as primary contacts for family/care partners to facilitate ongoing tailored communication using video, telephone, or email [51].

Strengths and Limitations

This study exhibits numerous strengths, including participants from key stakeholder groups representing multiple roles within the LTC home; participation of older adults and family/care partners in collaborating in research; in-depth exploration of experiences with the virtual care-planning process, including

facilitators and barriers related to implementation of virtual PIECES; and the use of several strategies to ensure the trustworthiness and rigor of the study findings. Moreover, this is the first known study to implement a virtual adaptation of the PIECES approach in LTC. Limitations identified were the inclusion of only two LTC homes located in Ontario, Canada; the use of single interviews that may have constrained the ability to capture implementation experiences over time; and a lack of participant demographic information such as ethnicity, age, education level, years living in the LTC home, and family/care partner support. Most of the participants in this study were female. This finding is consistent with the gender distribution in LTC, as 90% of paid staff in LTC are women [52].

In an ideal situation, a randomized controlled trial would have been conducted, but given the constraints and challenges of COVID-19, this was an opportunity to explore a useful tool in a different format. In future research, studies could look to compare the usual PIECES format versus virtual PIECES. Family/care partners were provided with a one-page summary describing the virtual PIECES intervention. Despite receiving this information, some family/care partners were still unsure about the purpose of virtual PIECES. Future studies, especially those that include partnering with families and residents, should ensure that participants have full understanding of interventions and be provided with opportunities to ask questions. A potential strategy could be introducing the intervention at family and resident council meetings to offer opportunities for dialogue and clarification.

Conclusion

This study entailed implementing a recognized clinical care planning tool (PIECES) in a virtual format to support the care of older adults experiencing responsive behaviors in LTC within the context of the COVID-19 pandemic. Findings suggest that virtual videoconferencing approaches to team-based care planning can be successfully implemented in LTC, and provide increased opportunities for engagement and inclusivity for LTC staff, family members, and older adults living in LTC. These findings are important because they indicate that family members can continue to be engaged in the care of older adults despite pandemic or outbreak situations, which may necessitate constraints on in-person participation. Moving forward, future research should explore how to effectively embed virtual care-planning processes more broadly into the policy and procedures of LTC homes, including understanding the required infrastructure, training, and supports needed to optimize inclusivity and equity. Important next steps could explore how virtual team-based care-planning approaches could potentially be used in remote locations to increase access to health care specialists such as geriatricians and nurses with geriatric specialization, and to foster engagement of family/care partners who may be unable to participate in person due to work or geographic limitations. Moreover, more research is needed to understand how virtual technology (eg, translation software) could increase engagement for older adults and family/care partners who are from linguistically and culturally diverse populations.

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Conflicts of Interest

NS is a research consultant contracted to WeRPN to design and implement WeRPN's research strategic plan to encourage and pursue research involving registered practical nurses. She served as a member of the research team as in-kind resources from WeRPN to support the research and conduct knowledge translation and exchange activities for WeRPN members and non-members.

Multimedia Appendix 1

Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist.

[[DOCX File, 22 KB - nursing_v5i1e42731_app1.docx](#)]

Multimedia Appendix 2

Sample focus group and interview questions.

[[DOCX File, 24 KB - nursing_v5i1e42731_app2.docx](#)]

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Abbreviations

COREQ: Consolidated Criteria for Reporting Qualitative Research

IT: information technology

LTC: long-term care

PSW: personal support worker

RN: registered nurse

RPN: registered practical nurse

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Original Paper

An mHealth App-Based Self-management Intervention for Family Members of Pediatric Transplant Recipients (myFAMI): Framework Design and Development Study

Riddhiman Adib^{1*}, MS; Dipranjan Das^{1*}, MS; Sheikh Iqbal Ahamed^{1*}, PhD; Stacey Marie Lerret^{2*}, PhD

¹Department of Computer Science, Marquette University, Milwaukee, WI, United States

²Department of Pediatrics, Medical College of Wisconsin, Milwaukee, WI, United States

* all authors contributed equally

Corresponding Author:

Stacey Marie Lerret, PhD

Department of Pediatrics

Medical College of Wisconsin

8701 West Watertown Plank Road

Milwaukee, WI, 53226

United States

Phone: 1 4142663944

Fax: 1 4142665781

Email: slerret@mcw.edu

Abstract

Background: Solid-organ transplantation is the treatment of choice for children with end-stage organ failure. Ongoing recovery and medical management at home after transplant are important for recovery and transition to daily life. Smartphones are widely used and hold the potential for aiding in the establishment of mobile health (mHealth) protocols. Health care providers, nurses, and computer scientists collaboratively designed and developed mHealth family self-management intervention (myFAMI), a smartphone-based intervention app to promote a family self-management intervention for pediatric transplant patients' families.

Objective: This paper presents outcomes of the design stages and development actions of the myFAMI app framework, along with key challenges, limitations, and strengths.

Methods: The myFAMI app framework is built upon a theory-based intervention for pediatric transplant patients, with aid from the action research (AR) methodology. Based on initially defined design motivation, the team of researchers collaboratively explored 4 research stages (research discussions, feedback and motivations, alpha testing, and deployment and release improvements) and developed features required for successful inauguration of the app in the real-world setting.

Results: Deriving from app users and their functionalities, the myFAMI app framework is built with 2 primary components: the web app (for nurses' and superadmin usage) and the smartphone app (for participant/family member usage). The web app stores survey responses and triggers alerts to nurses, when required, based on the family members' response. The smartphone app presents the notifications sent from the server to the participants and captures survey responses. Both the web app and the smartphone app were built upon industry-standard software development frameworks and demonstrate great performance when deployed and used by study participants.

Conclusions: The paper summarizes a successful and efficient mHealth app-building process using a theory-based intervention in nursing and the AR methodology in computer science. Focusing on factors to improve efficiency enabled easy navigation of the app and collection of data. This work lays the foundation for researchers to carefully integrate necessary information (from the literature or experienced clinicians) to provide a robust and efficient solution and evaluate the acceptability, utility, and usability for similar studies in the future.

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KEYWORDS

pediatric patients; transplant; mobile health; mHealth; family self-management; smartphone

Introduction

Solid-organ transplantation is the treatment of choice for children with end-stage organ failure [1,2], such as heart, lung, liver, kidney, pancreas, and small bowel failure. Although transplantation is now a routine surgical procedure throughout hospitals in the United States, it is only a treatment, not a cure. In 2020 alone, approximately 2000 children in the United States received a transplant [3]. The benefits of transplantation are limited by risks of the immediate procedure and chronic immunosuppression [4,5], making the posttransplant period critically important. Posttransplant challenges include the provision of focused discharge plans, family functioning, and family member roles after transplant, which are continuously being explored for pediatric transplant recipients [6-8].

The at-home daily management of posttransplant pediatric patients is of utmost importance and can impact patient and family coping [9]. Families must learn to adjust to multifaceted lifestyle changes and care, such as precise administration of multiple medications, management of abdominal drains and enteral tube feeding, or central line care. These actions, along with planning of follow-up care for laboratory studies and clinical appointments, make family life complex. These challenges are some of the factors that may place patients at risk for readmission in the first 30 days after hospital discharge [10,11]. Parents of pediatric liver and kidney recipients with higher stress levels (self-reported) find greater difficulty with medication administration [12,13]. However, frequent and focused communication and support from the health care team improves postdischarge health outcomes in different patient groups, including patients with heart failure [14], acute kidney injury [15], and type 2 diabetes [16]. As self-management strategies using a mobile health (mHealth) intervention improve overall health outcomes for adult lung transplant patients [17], the same should hold true for pediatric transplant patients.

Considering current technological advancements globally, researchers have been exploring the potential of commonly available smartphone apps for the provision of better and improved health care and support [18-23]. For medically complex adult patients, regular contact and communication through the use of smartphone apps improve general health conditions [24,25]. This creates a provision for providing mHealth interventions through effectively designed smartphone apps that support the interactive partnership between family members and the health care team [26]. A few examples include improvement of well-being [27,28], obesity treatment [29,30], and recovery from alcoholism [31,32]. In addition, patients undergoing transplantation have been identified as an ideal population to utilize and perform mHealth research [33]. Therefore, this is an opportunity to build a smartphone-driven app framework to provide connected health management solutions and support family members of pediatric transplant recipients.

This paper reports the outcomes of the design and development of a smartphone-based intervention app for an mHealth family self-management intervention (myFAMI) for families of pediatric transplant recipients. The research project was initiated

by a collaborative team of health care providers, pediatric nurses, and computer scientists. The myFAMI protocol is described in the protocol manuscript [34]. The features and functionalities of the developed myFAMI smartphone app and associated software framework are reviewed. We outline the key points in designing such an app, the challenges, and the strategized development procedure. The motivation for this project was to leverage the usage of consumer digital health care and its potential for supporting transplant families after hospital discharge. myFAMI was designed to support the exchange of information between the caregiver (family) and the health care team (nurses). The aim of this research is to use the action research (AR) methodology to build a well-designed and evidence-based mHealth intervention app (myFAMI).

Methods

The myFAMI software framework was designed using the AR methodology [35,36] based on prior research motivations and completed through separate stages of research and development: research discussions, feedback and modifications, alpha testing, and deployment and release improvements.

Design Motivation

The initial discussion for provision of the intervention for family members included building cellular text-based information provision. Although the usage of cellular text seems feasible and reliable, it was not comprehensive to complete the full list of our requirements for this research project (ie, capture of survey completion time, assure individual notification receipt). Lessons from previously completed text-based interventions [37,38] helped the research team plan for commonly known issues. The research team collaborated biweekly over 3 months to discuss all functionalities, use cases, user bases, and the timeline.

The collaborative research team comprised health care providers, nurses, and computer scientists. The team planned a randomized controlled trial (RCT) with myFAMI [34] as the treatment and standard postdischarge follow-up care as the control. The intervention promoted daily communication, facilitated through a smartphone app, which led the research team to the design and development of such an app framework. Family units of pediatric transplant recipients (heart, kidney, liver transplants) from four major US-centered pediatric transplant programs were recruited for the study. Inclusion and exclusion criteria were used to select a bias-free population group and were randomized to reduce bias [34].

The research problem for this part was to develop a software framework that was:

- Available for all (most) smartphone users (Android and iOS)
- Available for the survey submission (within the time frame)
- Able to notify users for survey submission through smartphones
- Technically error free (minimal to no bugs in the software)

The primary design motivations were:

- Easier connectivity with the nurses: Family members needed to connect with the nurses on a daily basis, and the primary point was to have easier and fluent connectivity with nurses.
- Interesting and colorful: To avoid monotony, the app needed to feel interesting and look colorful to the end users.
- Error free and easy to use: Since the intervention is technology assisted, getting an error during live use would add bias to the study results. For this reason, the app needed to be absolutely error free and intuitive to use.

Although the focus was on the end users, that is, family members of pediatric patients, the framework was developed in such a way that nurses and system admins could easily use and navigate the system with personalized access. The set of requirements defined the ideal app for this purpose and guided the research team in designing the final framework.

Action Research Methodology

The AR methodology [35,36] was adopted for the design of the myFAMI framework to support the collaborative research between a team of providers, nurses, and computer scientists. The AR methodology [39,40] is the study of technology, its applications in the real world, and the practical real-world consequences of those technology-assisted actions. Our research aimed to follow the set of research approaches under AR, with a focus on technology design.

Within AR, the researcher tries to provide a service to a research client (in our case, nurses), as well as simultaneously add to the

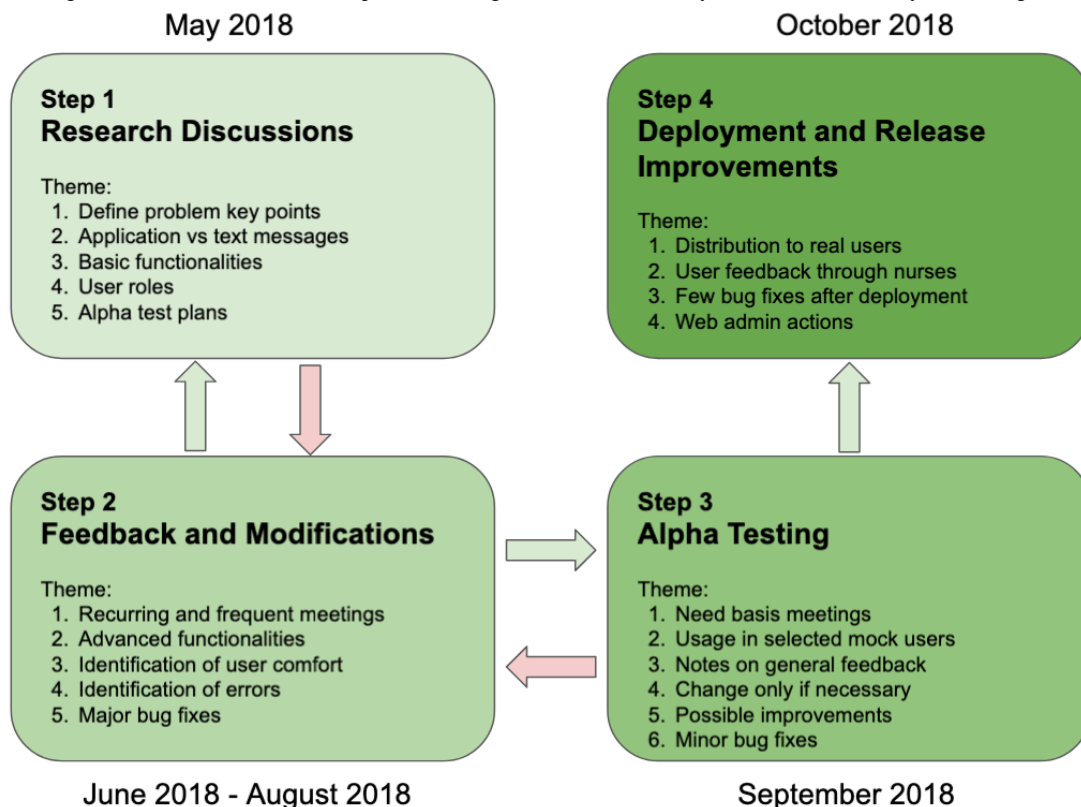
knowledge in that particular domain (in our case, discharge support in pediatric solid-organ transplantation patient family members). AR aims to both improve the client of the study as well as obtain further insights into the design, which is one of the key appeals of AR. As described in detail in the Results section, myFAMI was designed with 3 level of access roles to the app framework, and specific functionalities in each access were curated with care from individuals within that access level. Upon collection of requirements, the research team had recurring meetings to decide on a set of features that is feasible within the development timeline yet significantly boosts the productivity of the complete procedure with minimal steps. All the webpages and app pages went through multiple iterations of feedback, and following the AR methodology, changes were made based on that feedback.

Within the app design phase, the key idea was to focus on the ease of use of the technology. Any research team can prototype an idea and build an app framework; however, the framework will only become useful and meaningful when it is used in practice, and AR focuses on practice.

Research Stages

A multidisciplinary research team, including health care providers, pediatric nurses, and computer scientists, worked collaboratively to conceptualize and generate the smartphone app framework. Figure 1 portrays the workflow of the development process, that is, the workflow and timeline of the design and development process of the myFAMI app framework.

Figure 1. Workflow and timeline of the design and development process of the myFAMI app framework. Bidirectional arrows represent moving back and forth between stages, and unidirectional arrows represent moving forward with time. myFAMI: mHealth family self-management intervention.



Stage 1: Research Discussions

Based on the literature review, expertise-based knowledge of pediatric transplantation and previous experience of the development of app frameworks, the research team initiated relevant research discussions. The primary focus of these discussions included deciding on the most important features, defining the problem key points, laying out basic functionalities, deciding on the best intervention method (text message vs smartphone), confirming user roles, and laying out alpha testing plans and timelines. A limited number of research meetups were conducted to decide on the key points in this context.

Stage 2: Feedback and Modifications

In the next stage, the computer scientists in the team started building the minimum viable product (MVP) [41], while the nurses continued to evaluate it. At this stage, the team had more frequent meetings and decided on advanced functionalities for the app. Transplant family members were not involved in this stage; however, they contributed to the final shape of the MVP in the later stage of development (stage 4). The meeting discussion points frequently moved back and forth between stages 1 and 2 and explored potential factors to improve efficiency, user comfort features, and potential errors. This led to some major bug fixing on the app framework.

Stage 3: Alpha Testing

In this stage, the major task was to test the apps for any potential bugs or errors. The nurses took turns in role-playing and went through each section of the apps. A few issues were identified: (1) A check for enabling in-app notifications was needed in case any notification through the apps was missed; (2) test pagers were missed a few times, which was resolved promptly; and (3) the slider for survey response in the iOS app was accidentally set at 2 at startup, which was fixed. All the issues were resolved to prepare the framework for final deployment. The research team also decided on ways to download user data and portray them in the admin panel at this stage.

Stage 4: Deployment and Release Improvements

After completion of the alpha testing stage, the myFAMI app framework was deployed in the field. Although the initial deployment to the real world (running the public server, releasing the app in the respective app store, ie, Google Play Store and Apple App Store) was completed at this stage, access to the participants continued over time based on the timeline of the intervention protocol. Minor changes were made at this stage based on feedback from the 2 participating transplant families (as beta testers) of the trial: (1) In the earlier version, the word “emesis” was used and changed to “vomiting” in later releases, and (2) some other texts required rewording to properly express the true content, such as the notification response “You should expect a phone call” was changed to “Thank you for your participation. You may be contacted by the study team to discuss one or more of your concerns.” These minor changes significantly improved the overall user experience and concerns expressed by the participants.

System Component Description

Users and Their Roles

The target audience of the intervention app was family members of pediatric transplant patients. From the app development perspective, to make the intervention effective, we included 3 types of users in the app ecosystem:

- **Participants:** By “participant,” we refer to the family members of the pediatric transplant patients. Since they were “participating” in this intervention, we used this term, contrary to other options, such as “patients” or “users.” Participants only had access to the smartphone apps and were unaware of the other components. The primary role of the participants was to check in daily in the myFAMI smartphone app and to complete the required survey on the pediatric transplant patient’s health status and coping difficulty.
- **Nurses:** Nurses in the hospitals were one of the key user groups in our framework. Nurses were primarily responsible for responding to trigger alerts by the participants. Because of this, nurses’ access was limited only to the myFAMI web admin panel.
- **Superadmin:** On the highest level, the superadmin had access to the database itself and app codes required for the registration of participants to the myFAMI smartphone app. The superadmin access was limited to a small number of people, the project principal investigator (PI), and the app management team. The research assistant and the PI’s role was to preregister the participants through the superadmin access. The superadmin access was provided through the admin panel generated by the Django web framework (Django Software Foundation), and it was minimally used except in cases of emergencies.

App Components and General Functionalities

myFAMI is a multicomponent, user-centered app with multiple modular fragments efficiently tied together and available on both Android and iOS platforms. The prime components of the framework are:

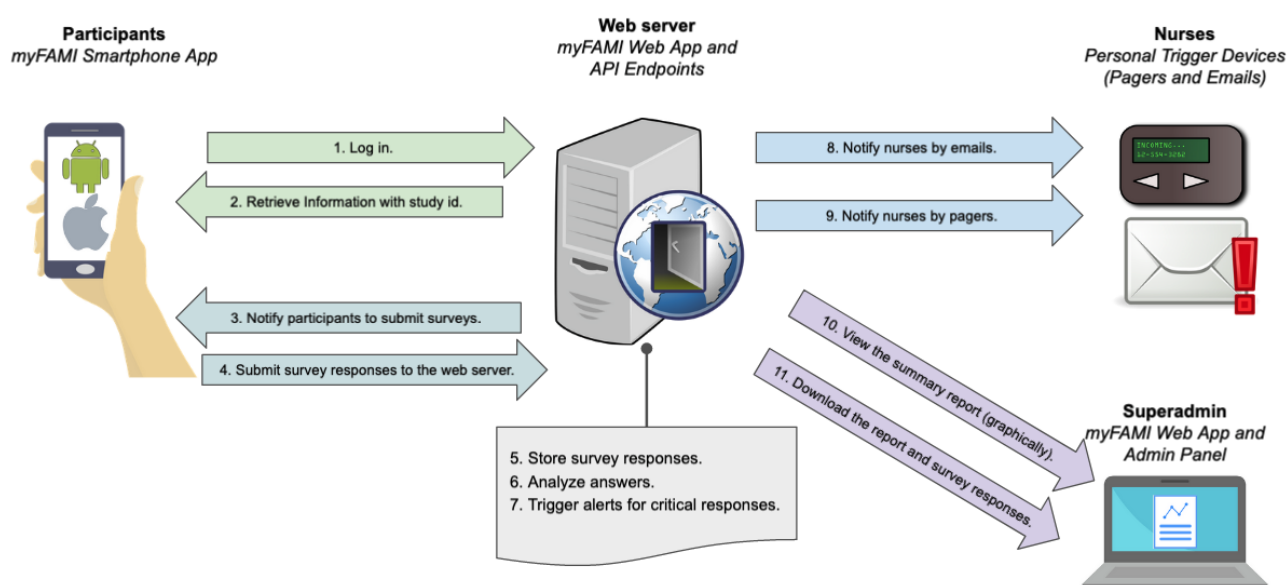
- The web app (for nurses’ and superadmin usage) with Application Programming Interface (API) endpoints (for web server connectivity with the smartphone app)
- The smartphone app (for participants’ usage).

The participants are registered through the web app and use the smartphone app, which stores and retrieves information on the web server, as required.

The process starts when a family agrees to be a participant in the study after discussion with the physician. The participant is registered by the research assistant or the PI through the myFAMI web admin panel. Each participant’s personal information is stored privately within REDCap [42], where only the research team has access to it. Individually, each participant is connected through a unique “study id,” which is only known to the nurses and unknown to the participants. While registering to the system, the participants are also provided access to the myFAMI smartphone app, although its access is not granted until the patient is released home with the family.

A general overview of the day-to-day operation of the myFAMI app ecosystem is shown in Figure 2. It portrays step-by-step communication stages between the participants, the web server, nurses, and the superadmin.

Figure 2. Interaction between app components and users' actions. API: Application Programming Interface; myFAMI: mHealth family self-management intervention.



Per protocol of the designed intervention (described in detail in Lerret et al [34]), at day 1 after hospital discharge, the myFAMI participants (intervention group) are granted access to the myFAMI smartphone app through the myFAMI web app. The participants log in to the myFAMI smartphone app, and their specialized access token is stored on the smartphone. This token is used throughout the study to authenticate their identity and access to the server. Every day at 8:00 AM local time, the web server pushes notifications to the participants for a reminder to submit survey responses. After the participants submit their responses, the response is sent to the web server, stored, and further analyzed to identify the immediate potential problem. If a potential problem (eg, serious deterioration of health outcome measures) is identified, the web server automatically triggers an alert notification to the nurse team. This alert contains information about the issue for the specific participant. The nurse then responds by calling the participant within 2 hours to discuss the potential problem. If no alert is triggered, no action is taken, and the response is simply stored in the web server for later reviewing by the research team.

Based on the action cycle and study protocol planned, a set of basic requirements were decided by the collaborative research team for the myFAMI app ecosystem. The goal was to build all the basic functionalities, distribute the functionalities as best fitted, and later improve based on discussions in iterations. The basic requirements discussed were:

- Participant actions:
 - Register and log in.
 - Receive a notification for a reminder.
 - View, answer questions, and submit the survey.
- Research team actions:
 - Log in to the admin panel.
 - Register new participants.

- View participant details, survey submission dates, and individual survey responses.
- Download and visualize survey response data.
- Update alert trigger communication media: pagers, phone numbers, or emails.

Factors to Improve Efficiency

One key feature of our study was a focus on specific components that would add ease of access and usability for the participants using the myFAMI smartphone app. Any generic smartphone app would be able to collect relevant data needed; however, in many studies, we face the issue of missing data [43]. A main reason for this issue is the lack of human-centered design in smartphone apps [44] and apathy toward responding correctly. To mitigate these issues and to motivate the participants to regularly and easily submit responses, we focused on a few factors that improve overall efficiency. These features included improvements to the participant experience to make it easy and intuitive to take actions in the app. In our case, we improved on the following:

- Personal encouragement messages: To avoid monotonicity of daily push notifications in the myFAMI smartphone app, we added a variety of motivating text messages. Personalized text messages have been shown to improve the overall user response in smartphone interventions [45,46]. The personalized messages in myFAMI are related to the number of days passed past discharge and adding a personal tone to the scheduled notifications. A few examples are:
 - “Welcome to Day 1 of the transplant study. Please complete the questions on the app by 10:00 AM today. Thanks for your participation.”
 - “Good morning! Due to popular demand, we have your questions for today! Please view now.”

- “Only 1 more week to go! Check out today’s questions! Thanks for helping with this study.”
- Clean and clear progress bar: During early testing of the myFAMI smartphone app, we explored test users not answering all questions, because of not remembering how many questions need to be answered in a complete survey daily. In the first phase, we added a textbox saying “Question 1 of 8.” However, it still did not change much, since users do not always read all the texts. Since a visual cue is better than a textual cue [47], we added a clear progress bar along with that, which visually shows how much of the survey is left. This feature helped participants in getting an idea of the end line for the daily surveys.
- Easily interpretable responses: In specific questions (eg, “Does your child have a fever?”), when the participants responded “Yes,” we aimed to ask them additional questions on the actions taken. This is part of the train-up completed prior to releasing, and since this is a standard follow-up question, asking about it helps the nurses make a decision and reach back to the participants with further information. In its response, that goal was to incorporate easy-to-understand responses that make the survey submission more personal and like a conversation. A few examples are:
 - “I have not done anything different.”
 - “I have given a medication.”
 - “I have changed the diet.”

Results

Principal Findings

Here, we describe the complete end product of the myFAMI app as a result of the AR methodology maintained through our design and development process. First, we discuss an overview of the app framework, followed by a description of 2 complementary app components, the admin web app with API endpoints and the smartphone app. Our final product, as targeted, successfully presents myFAMI and works great as a communication bridge between family caregivers (participants) and nurses.

Web App and API Endpoints

The web app (for nurses’ and superadmin usage) with API endpoints (for web server connectivity with smartphone apps) is the main power source of myFAMI. The web app runs directly on the web server and connects the myFAMI smartphone app with the web server through API endpoints. API endpoints signify a set of connections between computer programs, more commonly a software interface to connect with another software [48]. The myFAMI web app is written in pure Python language on the Django web framework [49]. The Django web framework is wildly popular in the software development community and has been used to develop popular web services [50], such as Instagram, Mozilla, and Pinterest. A few benefits [49,50] of the Django web framework to build web apps are as follows: (1) Django provides an easy user authentication protocol, (2) Django has built-in admin panel support for easier and faster development, and (3) Django follows the model-view-template

(MVT) pattern and handles the controller by itself, allowing developers to easily code and prototype with fewer errors.

The primary focus of the myFAMI web app is threefold: (1) provide access to daily operation for nurses, (2) provide access to superadmins for smooth operation and overview, and (3) keep API endpoints running for the myFAMI smartphone app. We broadly categorize and describe specific features for individual groups within the myFAMI web app.

Screenshots of individual modules of the myFAMI web app are presented in [Figures 3-8](#), along with a brief discussion below. Personalized information is redacted through color coding (red represents the myFAMI web app username, orange represents personalized information by participants, blue represents a unique appcode for participant access control, brown represents a unique study id for the participant, purple represents original survey responses, green represents true time, and yellow represents communication endpoints).

For the superadmin access level, the main features of the myFAMI web app are based on component creation:

- Registration of a new hospital center: We started participant registration at 1 major US pediatric transplant center and later added 3 other large centers for the study. The centers are located in different time zones, so the superadmins had to create “Hospital” entities through the myFAMI web app along the studies. The time zone was significant since it allowed us to notify participants from different locations to get smartphone notifications daily at the same time (8:00 AM).
- Registration of a new nurse: Several registered nurses were employed for the study. One of the key features of the myFAMI web app is to register new nurses to the system and provide them credentials so that they can log in to (and log out of) the myFAMI web app, as well as start receiving trigger alerts (discussed later in the Smartphone App: Android and iOS section).
- Update communication for alerts: The myFAMI web app also has a Settings page for communication endpoints. Two email and pager numbers for the PI and the team of research nurses are set for receiving the triggers, and the numbers are not hard-coded but are rather set up as a changeable field for flexibility and easier adjustments driven by the study ([Figure 8](#)). The trigger emails/texts contain specific information about the participant survey responses.

We broadly categorized the features in the myFAMI web app for nurses into 4 groups:

- Registration of participants: Nurses can log in to the myFAMI web app to register new participants ([Figure 3](#)). They can also enable/disable the app access from their end, as well as register participants to receive daily notifications for the smartphone app.
- View participants and survey responses: Nurses (and researchers) can obtain an overview of the total list of participants under individual study centers ([Figure 4](#)) and also go to a specific participant’s profile ([Figure 5](#)). The option to view individual survey responses ([Figure 6](#)) is

- also available to make better inferences about the next course of action.
- Overview of data: For researchers, we included 2 individual options to download the aggregated dataset from the admin panel. One download option was for researchers where the responses were stored as plain text, and the other download option was for the statistician where the datasets were coded by numbers (along with a codebook provided). This was helpful since data could be accessed and visualized while the study was ongoing.

- Graphical representation: For data visualization, a graphical overview of all survey responses by a single participant (Figure 7) is provided in the myFAMI web app. The feature is immensely helpful and helps nurses obtain a quick overview of the past status of the pediatric transplant patient at home.

Finally, we list selected significant API endpoints with actions on the web server as well as the smartphone, and their rationale as well, as shown in Table 1.

Figure 3. Web app screenshot: registration of new participants in the myFAMI web app. myFAMI: mHealth family self-management intervention.

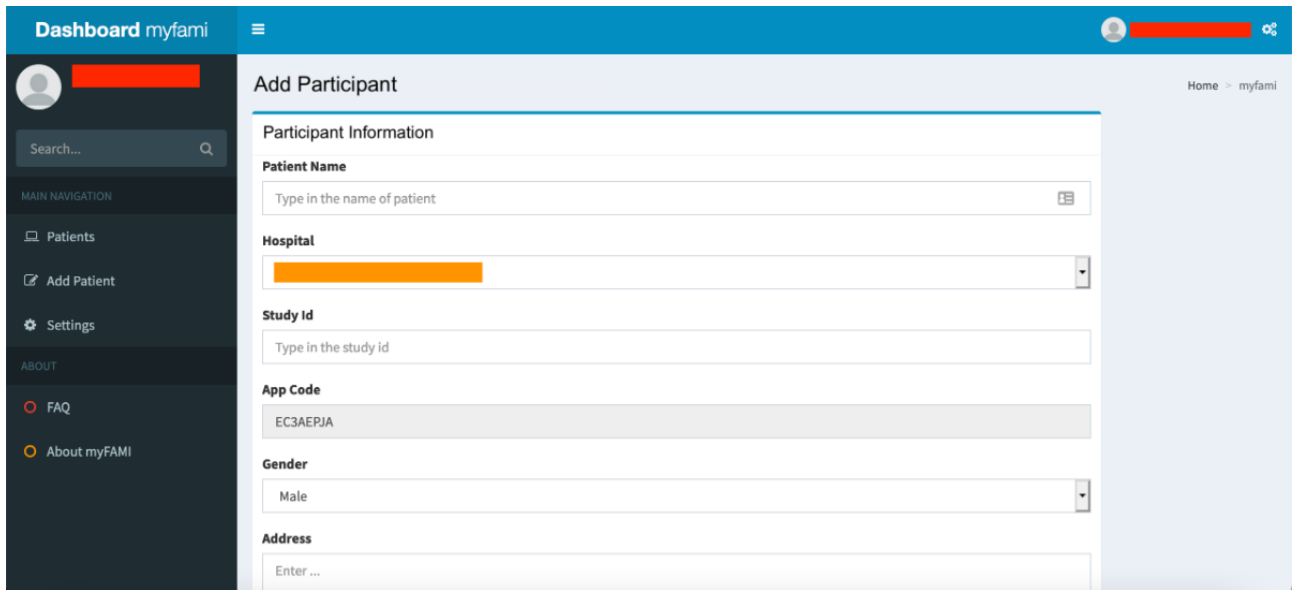


Figure 4. Web app screenshot: dashboard after log-in by researcher. myFAMI: mHealth family self-management intervention.

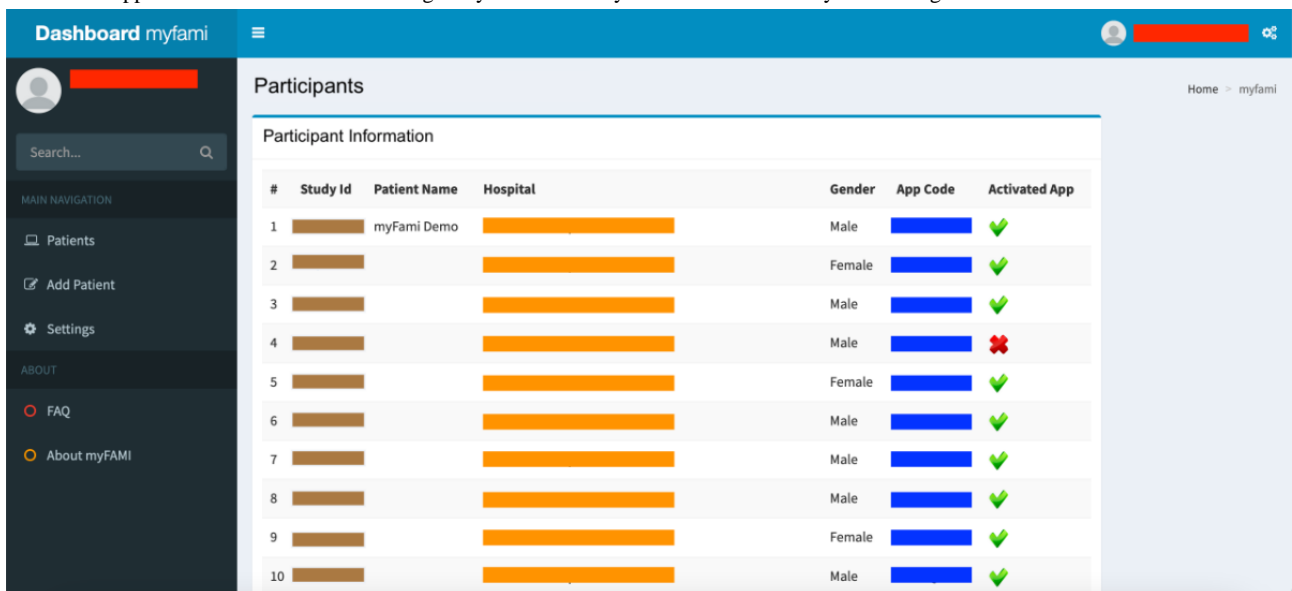


Figure 5. Web app screenshot: specific participant details. myFAMI: mHealth family self-management intervention.

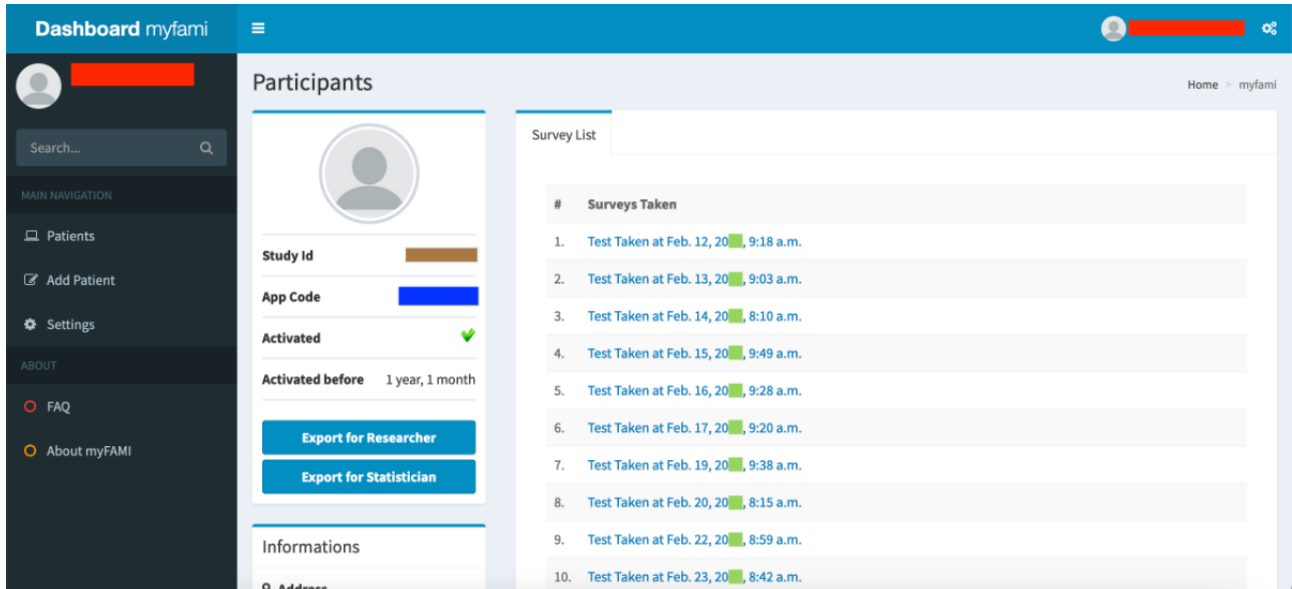


Figure 6. Web app screenshot: single survey response by a single participant. myFAMI: mHealth family self-management intervention.

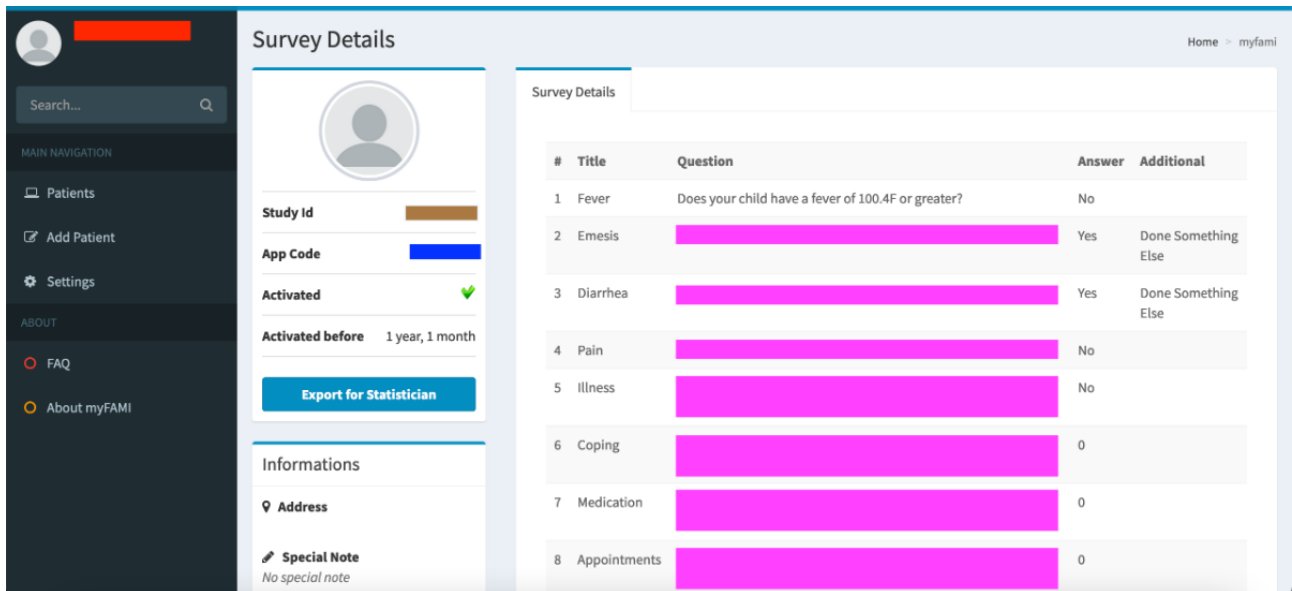


Figure 7. Web app screenshot: graphical summary of all survey responses by a single participant. myFAMI: mHealth family self-management intervention.

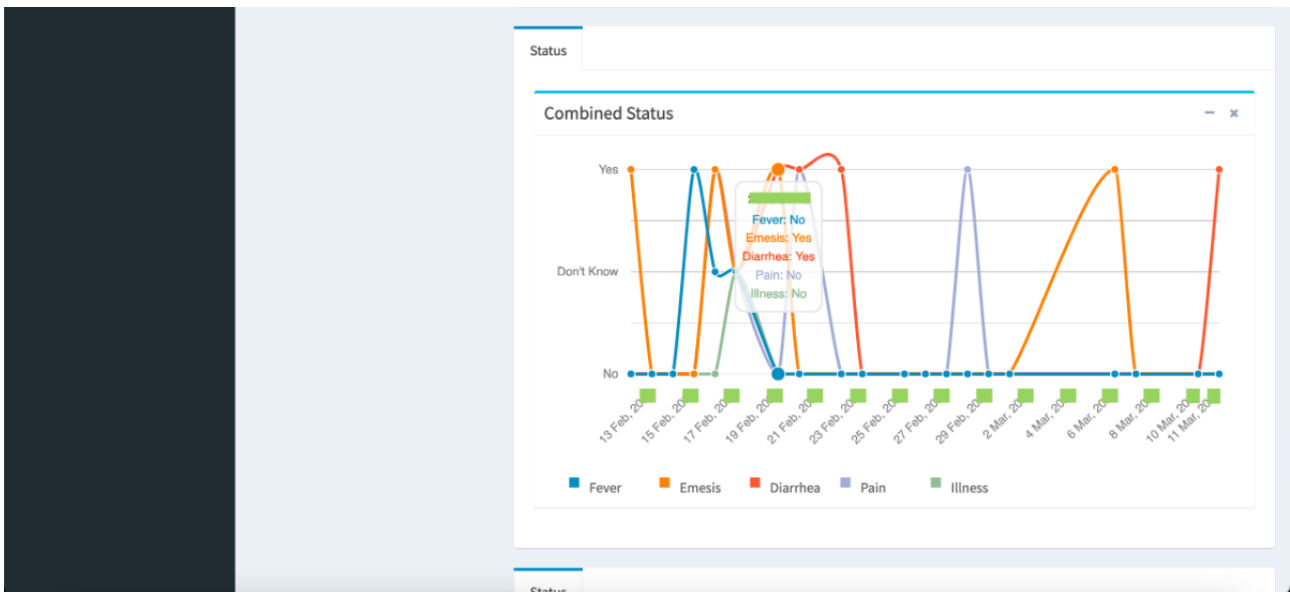


Figure 8. Web app screenshot: update page for communication endpoints (pager numbers and emails). myFAMI: mHealth family self-management intervention.



Table 1. Web API^a endpoints with functionality description, rationale, and action on smartphones.

API endpoint	Functionality	Action on smartphone apps	Rationale
<base_url>/appcode/verify/<str:appcode> ^b	Verify appcode	Activates a specific user based on the appcode	After installing the myFAMI ^c smartphone app, participants are authorized for the survey through a unique appcode. The API endpoint validates individual appcodes and stops intruders/accidental users who get access to the myFAMI app through app stores.
<base_url>/token/upload/<str:platform>/<str:appcode>/<str:token>	FCM ^d token upload with platform information (iOS/Android)	Collects a unique FCM token from the smartphone and uploads it to the web server	The token is used by the FCM service to send daily notifications to the appropriate recipient. The API endpoint uploads a unique FCM token to the myFAMI web server.
<base_url>/user/verify	User authentication	Collects log-in credentials and checks with the web server	The API endpoint checks log-in credentials of the participants and allows them access to the myFAMI smartphone app.
<base_url>/survey/save/<str:appcode>	Save survey responses	Saves the daily survey response	The API endpoint stores daily survey responses by participants and stores them on the web server.
<base_url>/send/notification	Send push notifications from the FCM server to the myFAMI smartphone app	When a push message is received from the FCM server, shows the notification to the participant using the app	When called, the API endpoint pushes a notification prompt to the FCM server, which pushes a notification to the individual's smartphone. Participants in the intervention group received daily notifications for 30 days.

^aAPI: Application Programming Interface.

^bThe “str” in the endpoint signifies a string code in the codebase.

^cmyFAMI: mHealth family self-management intervention.

^dFCM: Firebase Cloud Messaging.

Smartphone App: Android and iOS

Although the myFAMI web app keeps running in the background for smoother operation of the intervention, the myFAMI smartphone is the user interface that the participants respond to and interact with. The myFAMI smartphone is built for 2 individual platforms, Android and iOS, to cover the broad range of smartphones the participants might have. For easier availability, the apps are made available in both app stores (Google Play Store and Apple App Store). Android and iOS are the two most popular smartphone operating systems currently and hold over 99% of market users as of 2021 [51]. In case a participant did not have any of these 2 types of smartphones, they were provided with one with the myFAMI app installed.

Both versions of the myFAMI smartphone app are identical and built with native code support, in Android Studio using the Android software development kit (SDK) [52] with Native Java as the programming language [53] and in XCode [54] with Swift programming language [55]. Both the programming languages are widely adopted in the programming world, and the SDKs have been maintained for a long time by the Android community and Apple.

The prime feature of the myFAMI smartphone app is easier connectivity with the web server, through (1) a reminder to complete the survey questions with daily notifications sent from the web server and (2) capturing of the user response to the survey and storing it on the web server.

For the smartphone apps, we summarize the prime features:

- Participant access: The participants can log in to the myFAMI smartphone app through provided credentials.

The app access is provided on the day of patient's hospital discharge; however, the app is not activated yet until the next day. When the nurses activate the specific app access (through the appcode in myFAMI web app), the participants get access to the intervention and can submit survey responses. The personalized study id for an individual participant is not shown in the myFAMI app.

- Survey notifications: Participants receive a daily reminder notification at 8:00 AM local time for the 30 days of intervention. The notification is shown by the myFAMI smartphone app and takes participants directly to the submit survey page. The notification is sent from Firebase Cloud Messaging (FCM) [56] servers through the myFAMI web server and is a key component of the myFAMI app framework. For every day, there is a personalized message for the notification (discussed in the Factors to Improve Efficiency section).
- Survey submission: The prime task of the participants in the myFAMI smartphone app is to complete the daily survey and submit it. The survey starts the next day after installation (day of patient's hospital discharge) for 30 consecutive days and contains 8 questions as part of the intervention. The questions have a clear progress bar on top to understand the progress level of the survey, a clear description, and colorful illustrations (collected from royalty-free image websites) relevant to the questions. Participants can submit once a day starting at 8:00 AM local time and cannot submit more than once a day. In this study, participants were encouraged to submit responses between 8:00 AM and 10:00 AM local time. After 30 days of the intervention, the app shut off submission of further surveys.

The daily survey for participants consists of 8 specific questions regarding the health status of pediatric transplant patients. The daily survey is based on myFAMI [34], which is built upon individual and family self-management theory, with a focus on family self-management of pediatric transplant recipients at home.

The first 5 questions focus on clinical symptoms (ie, fever, vomiting, diarrhea, pain, and illness) because these can result in hospital readmission. Family members have 3 response options (ie, yes, no, and don't know). A response of yes or don't know prompts a trigger alert for the nurse to call the family for further discussion and an additional question to gather more

data and inform the trigger alert conversation with the family. The last 3 questions assess difficulty with coping, administering medications, and attending hospital appointments. These difficulty questions are measured with a Likert scale of 0 to 10, where 0 represents no difficulty and 10 represents a great deal of difficulty. Any response of 3 or greater prompts a trigger alert for the nurse to call the family for further discussion (trigger notification); see Table 2.

An outline of individual questions, response options, and the rationale is discussed in detail [34]. Screenshots of selected pages of the myFAMI smartphone app are presented in Figures 9-12.

Table 2. Outline of individual questions in the myFAMIa smartphone app, with responses and trigger components.

Concern	Response type	Response options	Additional question (if answered yes or don't know)	Trigger
Fever	3 survey options	Yes/no/don't know	Please provide additional information (select only one option): (a) I have not done anything different. (b) I have administered a medication. (c) I have changed the diet. (d) I have done something else.	Yes/don't know
Vomiting	3 survey options	Yes/no/don't know	Please provide additional information (select only one option): (a) I have not done anything different. (b) I have administered a medication. (c) I have changed the diet. (d) I have done something else.	Yes/don't know
Diarrhea	3 survey options	Yes/no/don't know	Please provide additional information (select only one option): (a) I have not done anything different. (b) I have administered a medication. (c) I have changed the diet. (d) I have done something else.	Yes/don't know
Pain	3 survey options	Yes/no/don't know	Please provide additional information (select only one option): (a) I have not done anything different. (b) I have administered a medication. (c) I have changed the diet. (d) I have done something else.	Yes/don't know
Illness	3 survey options	Yes/no/don't know	Please provide additional information (select only one option): (a) I have not done anything different. (b) I have administered a medication. (c) I have changed the diet. (d) I have done something else.	Yes/don't know
Coping	Likert scale	0 (no difficulty) to 10 (great deal of difficulty)	N/A ^b	≥3
Medication	Likert scale	0 (no difficulty) to 10 (great deal of difficulty)	N/A	≥3
Appointments	Likert scale	0 (no difficulty) to 10 (great deal of difficulty)	N/A	≥3

^amyFAMI: mHealth family self-management intervention.

^bN/A: not applicable.

Figure 9. Homepage view of the app, with name and address redacted.

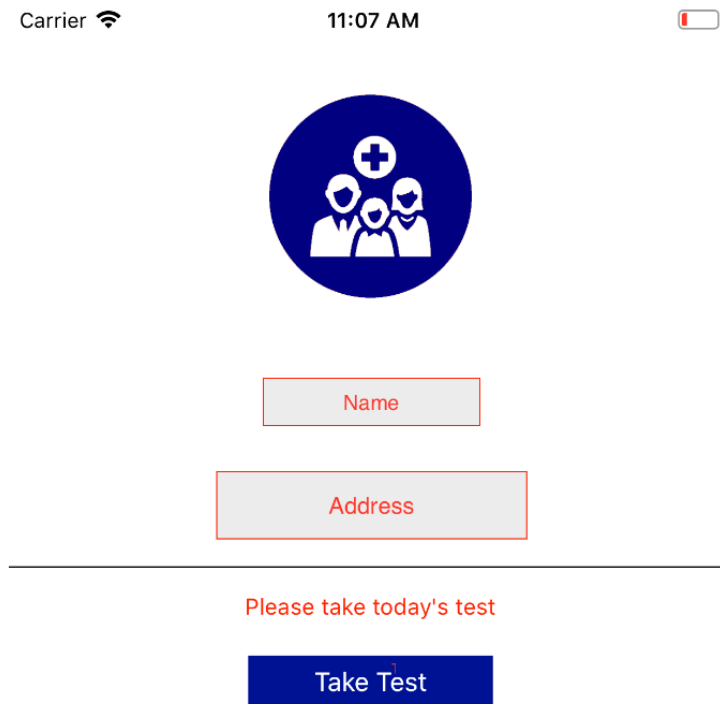


Figure 10. First question of the survey with specific question, relevant colorful illustration, and clear progress bar.



Figure 11. Interpretable responses as follow-up for selecting "Yes" or "Don't know" in the previous question.

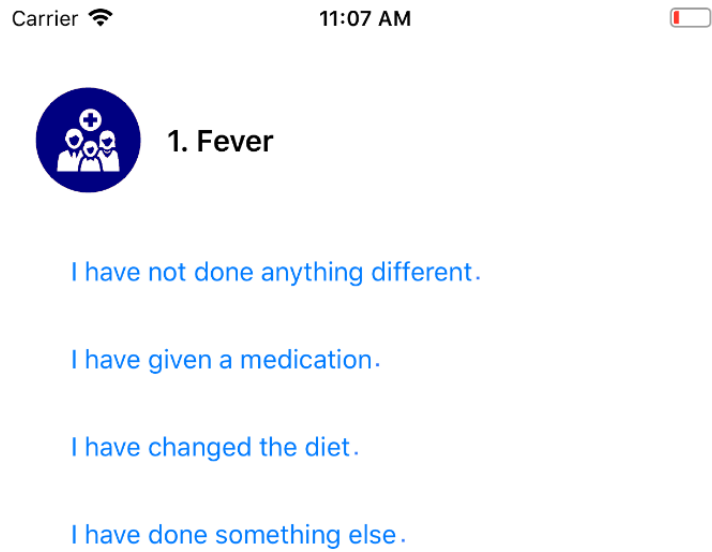
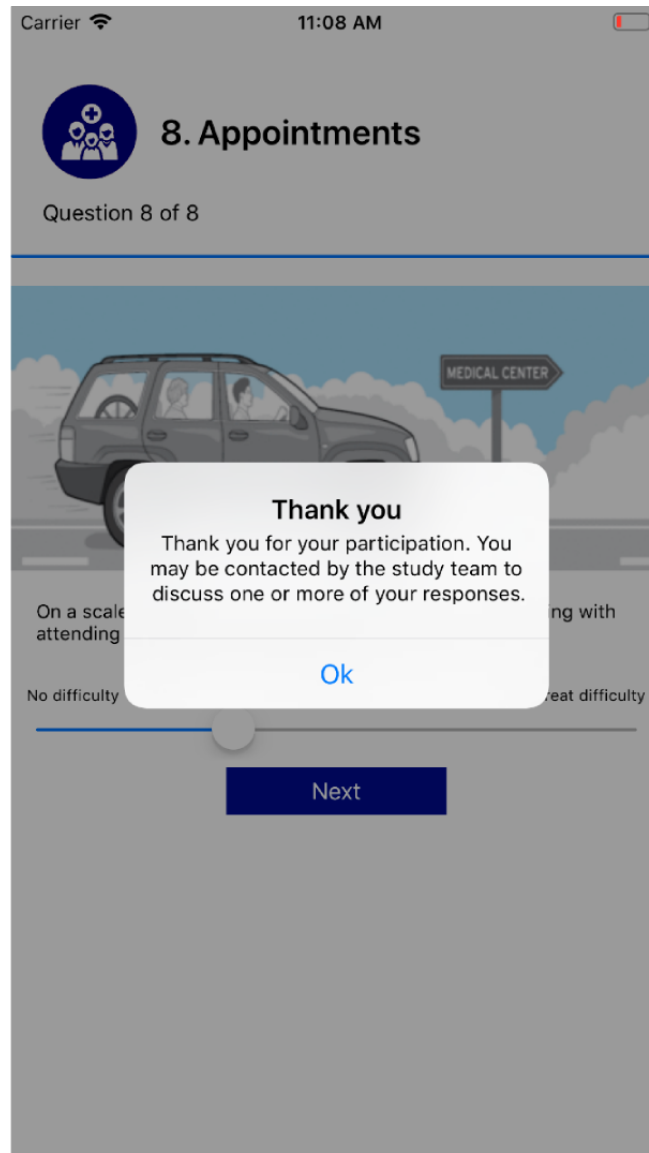


Figure 12. "Thank you" message after successful completion of survey submission.



A key component of the myFAMI app framework is the trigger alerts sent to the nurses. A preidentified response of yes or don't know for the first 5 symptom-related questions or a response of 3 or greater to the last 3 coping-related questions in the myFAMI web server sends a trigger alert to the study nurses. A notification with participant details and the survey response is sent to the communication endpoints, including 2 emails and 2 pager numbers (PI and study nurses) for a prompt response. The trigger alert notifies the nurses and tracks the participants who may benefit from a phone call from one of the study nurses. A brief overview of the trigger alert process is also detailed in [Figure 1](#).

Discussion

Principal Findings

We discussed the final design of the myFAMI app framework in detail, with a technical breakdown of the ecosystem. In this section, we present our principal findings from planning, designing, developing, and executing the myFAMI app framework. The general acceptability and usability portray the potential to involve more family members of pediatric transplant patients for further research. The major strength of our design process is the integration of the AR methodology with theory-based intervention [57], in the context of transplant patient care, along with the application of specific factors to improve efficiency in order to improve the usability of the app. However, there are minimal differences in the content and execution of the proposed framework, which were limitations of our integrated process.

Strengths

The key strength of the research conducted for myFAMI is the process of integrating theory-based intervention [57] with the AR methodology [39,40]. myFAMI is the first of its kind intervention—the first RCT on the efficacy of a theory-based intervention on pediatric transplant patients' and families' postdischarge adjustment at home. The myFAMI app framework needed to be fluent and flawless to be able to handle the intervention over 4 major US-centered pediatric centers. We emphasized on adding action, reaction, and adjustment cycle to the software framework to fit in with the AR methodology, as well as prepare a robust app ecosystem for myFAMI.

Second, the identification and incorporation of factors to improve efficiency in the myFAMI app framework improved the overall user experience. Since the myFAMI app framework had 2 different sections (web app and smartphone app) and user groups (nurses and family members), we had to consider the unique user experiences, comfort, appropriate features, and communication format. Personal encouragement messages helped the participants remain on track with survey submissions as well as avoid the monotony of the daily survey submission. The focus was a friendly support system for the family. While completing the survey using the smartphone app, a clean and clear progress bar provided a sense of completion. Finally, the options for additional questions are framed in such a way that the survey feels like a conversation and the automation of the process seems less mechanical.

Another key strength of the design process was the iterative research discussions and opportunity to discuss concerns. The complete framework went through several software versions before the final MVP, which is in the essence of the AR methodology. For example, initially the image related to the question on diarrhea had an image with a person sitting on a toilet. Upon discussion, the image was replaced. The research meetings helped both the provider and computer scientists in planning a better software solution; the provider learned about the intricate process of software development and technology, and the computer scientists learned about a medical intervention conduction protocol. This reflexivity is one of the core components of the AR methodology and is generated in a better pool of knowledge, which can be impactful for future research as well.

Finally, automated visualization of aggregated survey responses was meaningful for the research team to monitor. A line chart for temporal data is a clean and straightforward visualization; however, it allowed for detecting a pattern out of individual pediatric patient responses. Our future exploration includes complex data visualization on aggregated patient subgroups.

Limitations

Our proposed myFAMI app framework is highly effective in capturing responses for a smartphone-based intervention; however, there are limitations. As a software application, there were minor bugs identified during the deployment of the solution. Although alpha testing captured about 95% of commonly faced issues, new sets of issues arose when the app was deployed in the real world [58]. Even after rigorous testing, we faced random issues, including empty notifications triggered in the app. It is important to identify and resolve random bugs in the event notification prompting at the local time of the server, not the participant. One important limitation with app design was that pediatric transplant patient family members only provided feedback during beta testing. Transplant team members (nurses and doctors) were included in earlier development phases (ideation and alpha testing). Future projects should consider family member inclusions in the ideation phase of similar app development. Another key issue was to ensure that the survey response was not submitted accidentally. The protocol ensured the survey was actually submitted by the participant and not accidentally. To mitigate this, log-in credentials were required by the app for each submission; however, alpha testing showed that this reduced survey responses. Later, this security check was removed and a single prompt ("Are you sure you want to submit?") was used to minimize accidental submissions.

Future Directions

Our research completes a working prototype for myFAMI using smartphones; however, there are unexplored future directions that could improve the user experience as well as aid future researchers explore a similar problem domain. Primarily, for our myFAMI smartphone app, the survey questions would be randomized to reduce the risk of bias introduced by the survey question order [59] or survey fatigue [60]. Individual sets of images can be selected and shown in random in place of one single image for each question to avoid monotony. Additionally, different sets of colors or patterns of stripes for the myFAMI

smartphone app need to be added as the color scheme, making it suitable for the color-blind population [61]. Second, for the myFAMI web app, better visualization tools (circular area chart or violin plot in place of a line plot) could be incorporated to improve the researchers' experience. Finally, for myFAMI in general, a communication protocol for reconnection and encouragement can be established in case a participating family frequently misses survey submissions. Positive reinforcement is already added in the smartphone app ("You are doing great" after survey submission).

Conclusion

In this paper, we presented an overview of the design and development of the myFAMI app framework. We discussed relevant factors to improve efficiency, development features,

and general insights by conducting a smartphone-based intervention for families of pediatric transplant recipients. Based on the literature review, this is the first study that evaluates a smartphone-based intervention to improve family self-management for family members of children who received a heart, kidney, or liver transplant. Our study portrays a need for strong collaboration between computer scientists, expert providers, and nurses in addressing technical difficulties and making it a successful intervention through the AR methodology. This study also lays the foundation for researchers to carefully integrate necessary information (from relevant stakeholders, their experience, or the literature) to provide a robust and efficient solution and evaluate the acceptability, utility, and usability for similar studies in the future.

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Conflicts of Interest

None declared.

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Abbreviations

API: Application Programming Interface
mHealth: mobile health
MVP: minimum viable product
MVT: model-view-template
myFAMI: mHealth family self-management intervention
PI: principal investigator
RCT: randomized controlled trial
SDK: software development kit

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Original Paper

Personality, Attitudes, and Behaviors Predicting Perceived Benefit in Online Support Groups for Caregivers: Mixed Methods Study

Athena Milios^{1,2}, MSc; Ting Xiong^{2,3}, MSc; Karen McEwan², BA; Patrick McGrath^{1,2}, PhD

¹Department of Psychiatry, Dalhousie University, Halifax, NS, Canada

²Centre for Research in Family Health, Izaak Walton Killam Health Centre, Halifax, NS, Canada

³Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, ON, Canada

Corresponding Author:

Ting Xiong, MSc

Centre for Research in Family Health

Izaak Walton Killam Health Centre

5980 University Ave

Halifax, NS, B3K 6R8

Canada

Phone: 1 877 341 8309 ext 7

Email: ting.xiong@dal.ca

Abstract

Background: Online support groups (OSGs) are distance-delivered, easily accessible health interventions offering emotional, informational, and experience-based support and companionship or network support for caregivers managing chronic mental and physical health conditions.

Objective: This study aimed to examine the relative contribution of extraversion, agreeableness, neuroticism, positive attitudes toward OSGs on social networking sites, and typical past OSG use patterns in predicting perceived OSG benefit in an OSG for parents and caregivers of children with neurodevelopmental disorders.

Methods: A mixed methods, longitudinal design was used to collect data from 81 parents across Canada. Attitudes toward OSGs and typical OSG use patterns were assessed using the author-developed Attitudes Toward OSGs subscale (eg, "Online support groups are a place to get and give emotional support") and Past Behaviors in OSGs subscale (eg, "How often would you typically comment on posts?") administered at baseline—before OSG membership. The personality traits of extraversion, agreeableness, and neuroticism were assessed at baseline using the Ten-Item Personality Inventory. Perceived OSG benefit was assessed using the author-developed Perceived OSG Benefit scale (eg, "Overall, did you feel supported by other members in this group?"), administered 2 months after the initiation of OSG membership.

Results: A hierarchical regression analysis found that extraversion was the only variable that significantly predicted perceived OSG benefit ($R^2=0.125$; $P<.001$).

Conclusions: The key suggestions for improving future OSGs were facilitating more in-depth, customized, and interactive content in OSGs.

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KEYWORDS

online support groups; personality; support group; online support; peer support; caregiver; caregiving; caring; mother; father; usage pattern; extraversion; neuroticism; neurotic; agreeable; benefit; eHealth; Canada; North America; parent; neurodevelopment disorder; attitude; online behavior; emotional support; perceived benefit

Introduction

Background

Online Support Groups (OSGs), or internet support groups, are health-focused online communities accessible through specific

websites or social networking sites (SNS). OSGs are increasing in use with the development of SNS, because they provide a means for caregivers to build social support networks [1]. Different channels of OSGs may influence OSG use and behaviors. For example, OSG users in closed groups via SNS may have higher levels of and more positive self-disclosure

than those on public forums [2]. Overall, participating in OSGs can help caregivers promote their well-being [3], facilitate information exchange and interaction [4,5], reduce depressive symptoms, and improve the quality of life [6].

A major advantage of OSGs, among other distance-delivered health interventions, is that they are accessible to a wide range of individuals seeking support to manage their health and well-being, in addition to being very cost-efficient for the health care system [7]. OSGs facilitate access to psychological (emotional) support, informational support, and companionship [8]. OSGs have shown great promise; however, further investigation is needed to assess factors influencing participation and user well-being, as measured by self-assessed or perceived benefit from the group [9,10]. Many previous efforts in understanding OSGs do not use well-validated measures to predict or assess the characteristics of those who participate and benefit from OSGs [11]. Demographic variables such as socioeconomic status and gender do not provide a complete enough measure to explain why and how much people participate in and benefit from OSGs [1].

Personality as a Predictor of OSG Use and Benefit

The personality traits found to be of the highest relevance in predicting OSG use and perceived benefit were extraversion [12], agreeableness [13-15], and neuroticism [14,16]. The openness and conscientiousness personality traits were not widely found to be predictors of OSG use or benefits. More specifically, Pornsakulvanich [13] found that of the Big Five personality traits, agreeableness positively predicted satisfaction (a construct closely related to perceived benefit) from online social support. Agreeableness is characterized by cooperativeness, generosity, sympathy, and altruism [17]. Agreeableness has been shown to predict SNS use; for example, it is related to the number of pages viewed by SNS users [14,15]. Moreover, SNS (eg, Facebook) users in general (not just OSG users) also tend to be more extroverted than nonusers [12,14]. Extraversion is characterized by sociability, assertiveness, and the ability to experience positive emotions [17,18]. Extroverts tend to belong to more Facebook support groups [19] and are more likely to use SNS to establish social connections and friendships [15,20]. Furthermore, Moore and McElroy [21] found that neuroticism was associated with SNS (Facebook) use. Neuroticism is associated with distrustfulness, sadness, anxiety, embarrassment, and poor stress tolerance [17,18,21].

Attitudes as a Predictor of OSG Use and Benefit

Overall attitudes toward SNS (not just OSGs specifically) can predict how often people use social media to find social support [13]. Attitudes toward SNS can also predict satisfaction with perceived support from SNS [13].

Behaviors as a Predictor of OSG Use and Benefit

Caregivers of patients with autism spectrum disorder who participate in OSGs have positive views regarding OSGs and high levels of support satisfaction from the groups [22]. Coulson [23] found that OSGs help provide patients with both informational and emotional support and that participation in OSGs benefits patients with inflammatory bowel disease by

helping members to be more positive and improve their sense of well-being.

Demographics as Predictors of OSG Use and Benefit

Choi and colleagues [1] examined 5 components related to OSG participation: (1) demographics, (2) reading behaviors, (3) posting behaviors, (4) perceived roles in OSGs, and (5) values sought from OSGs. They found the most sought values in OSGs to be emotional support, experience-based informational support, unconventional informational support, and medical fact-based informational support. Lurkers (ie, passive OSG participants) demonstrate less extroverted behavior than posters, which could mean that lurkers possess certain preexisting characteristics or traits that make them less likely to actively participate in OSGs compared to posters [24]. Lurkers are also generally less satisfied with their OSG experience and benefit less from OSGs than those who actively post [8,24,25].

Objective and Hypotheses

The main objective of this study was to examine how (1) personality, (2) attitudes toward OSGs, and (3) typical behaviors in OSGs explain perceived OSG benefit. This objective was evaluated through an OSG we developed via SNS (ie, Facebook). More specifically, the goal was to determine the relative contribution of the personality traits of extraversion, agreeableness, and neuroticism, as well as attitudes toward OSGs and typical past OSG use behaviors, in predicting perceived OSG benefit (the outcome variable). To be able to predict OSG participation and the health benefits that typically ensue, a reliable and validated measure of potential predictors such as personality factors, attitudes toward OSGs, and OSG use is needed.

It was hypothesized that extraversion, agreeableness, and neuroticism would be significant predictors of perceived benefit from the current OSG. A positive attitude toward OSGs was also expected to predict perceived OSG benefit [13,26]. Finally, it was hypothesized that past typical OSG use would predict perceived benefit from the current OSG.

Methods

Participants

The 2 intervention arms of an internet-based, 3-arm randomized controlled trial (RCT) [27] for caregivers of children with neurodevelopmental disorders and challenging behaviors formed the sample of the study. The control arm of the RCT did not receive invitations for OSG. The participants were 81 parents and caregivers of children aged 4-14 years, who are diagnosed with a neurodevelopmental disability including autism spectrum disorder, attention-deficit/hyperactivity disorder, cerebral palsy, Down syndrome, epilepsy, fetal alcohol spectrum disorder, global developmental delay, intellectual disability, learning disability, and spina bifida. Participants were recruited nationally in Canada through service provider clinics and organizations, emails, social media campaigns, posters, and brochures. No extra incentive was provided for taking part in the study. Informed consent was obtained through a web-based consent form administered through the mystudies.ca website. Participants were informed about the length of the survey, the

purpose of the study, the investigator team, and data storage place and plan, and their questions about the study were answered before giving consent to the study. Access to the participants' data was restricted to the trained staff of the research team via institutional laptops or computers with antivirus software. The completion rate was 50.6% (81/160) of the eligible participants who received the emails containing the surveys.

Procedure

This study used mixed methods—there were both quantitative and qualitative components. Upon completing the pre-OSG baseline survey ([Multimedia Appendix 1](#)), participants were invited to join the closed Facebook OSG corresponding to their arm of the RCT program (either coached or self-managed) and provided with a welcome message containing guidelines for group participation. The surveys of the study were not advertised externally due to the closed membership of the OSG. After 2 months of OSG membership, the Perceived OSG Benefit scale ([Multimedia Appendix 2](#)) was administered. Both surveys were completed through the REDCap software (REDCap Consortium) [28], and the surveys were closed, which means that invitation links were shared with participants via email. Filling in the survey was entirely voluntary, and choosing not to participate did not influence any treatment that the participants were entitled to in the RCT.

OSG Content

The OSGs were both asynchronous web pages for text-based, peer-to-peer networking. There was a parent facilitator in each group welcoming new parents and encouraging positive discussion. This facilitator was also a parent of a child with a neurodevelopmental disorder and had experience using OSGs. The parent facilitator posted regularly to help members engage with module content and encourage them to practice the skills they were learning with their children; the overall purpose of each OSG was to connect parents, providing a platform for them to discuss specific topics and skills (eg, parenting strategies) as they were learning them, as well as to ask questions and share personal experiences. Parent facilitators received remuneration for their time. The OSG followed a relatively unstructured format—the role of the facilitator was simply to encourage discussion based on what members seemed interested in discussing, but there were no specific guidelines for the topics that had to be discussed as long as the issues were loosely related to the program and were appropriate based on the guidelines for group participation that they were given when they first joined the group.

Scale Development

To solicit items for the surveys, a literature search of OSGs for illnesses was conducted. Based on this search, a pre-OSG survey containing Likert-style responses was developed, called Personality, Attitudes, and Behavior around Health Forums (see [Multimedia Appendix 1](#)), to assess personality and attitudes toward OSGs and typical OSG use behaviors. To measure perceived group benefit, a survey was developed and named Perceived OSG Benefit ([Multimedia Appendix 2](#)). Both surveys were assessed by a panel of 10 health psychology experts and

a panel of 10 parent advisors to improve the clarity of the items, solicit additional scale items, and assess the face and content validity of the items in each scale. Each member gave their independent assessment of whether the items in each scale were interrelated and whether they were true measures of the construct each subscale was designed to assess. The experts also commented on the practicality of the tools. Feedback regarding ambiguous, repetitive, or undesirable items was provided. The feedback was used to create a revised draft. The use of reverse-coded items was minimized for clarity purposes, to avoid cognitive burden for participants, and to reduce respondent fatigue [29].

Measures

Demographics and Past OSG Behaviors

The first section of the baseline survey asks about demographic variables (ie, age, gender, duration of illness, and length of previous experience with OSGs). The next 4 questions ask about the nature of their typical participation patterns in OSGs (eg, their frequency of posting, commenting, and reacting to and viewing posts) based on all previous OSGs the parents have joined. An example of the questions is “How often would you typically comment on posts?”

Personality

The Ten-Item Personality Inventory includes 10 questions assessing the Big Five personality traits [30]. It has shown good construct validity and consistency reliability in a range of samples [30]. This study used the subscales to assess extraversion, agreeableness, and neuroticism. The items were each scored on a scale from 1-7, and their average was subsequently calculated for each trait. In this study, the internal consistency was 0.77 for extraversion, 0.52 for agreeableness, and 0.43 for neuroticism.

OSG Attitudes

The OSG attitudes subscale contains 10 questions related to attitudes (ie, beliefs and expectations) toward OSGs, including motivations for why an individual may want to use an OSG. There are questions regarding attitudes toward the usefulness of OSGs in providing various types of social support: emotional support (ie, “Online support groups are a place to get and give emotional support.”), medical and health-related informational support, and experience-based informational support [1,8,13,31,32]; the perceived trustworthiness of OSGs [1,31]; its usefulness for hope [23,24]; connection and friendship [33]; perceived enjoyment [13]; reducing isolation; raising awareness surrounding chronic illness [33]; and the sense of community [31].

Perceived OSG Benefit Scale

The Perceived OSG Benefit scale assesses to what extent participants perceived benefit from the OSG. The first 9 questions were adapted from previous literature and are rated from 1 to 5 on a Likert-type scale, with higher scores indicating higher perceived benefits. They ask about the perceived benefits of the OSG regarding providing support [22,33] (ie, “Overall, did you feel supported by other members in this group?”); meeting participant needs [34,35]; solving problems [22,35];

increasing parental hope [23]; reducing caregiver distress [22]; increasing self-efficacy [22,36]; well-being [23]; sense of community [31]; and overall satisfaction [1]. Question 10 (open-ended and qualitative) asks if there is anything else participants would like to add about how the group helped (or did not help) them.

Data Analysis

For the quantitative data, an a priori power analysis was performed using G*Power statistical software (version 3.1) [37]. The required sample size was calculated to be 80. Only individuals who completed all measures were included in the analyses. The psychometric properties of the 3 author-constructed scales (ie, OSG Attitudes, Past Behaviors, and Benefits) were assessed by internal consistency (ie, Cronbach α coefficient) and construct validity (ie, exploratory factor analyses).

A multiple hierarchical linear regression was performed to analyze the proportion of variance that the outcome variable was accounted for by each predictor (independent) variable. The 5 predictor variables were the total scores for extraversion, agreeableness, neuroticism, attitudes toward OSGs, and typical past OSG use behaviors; the outcome variable was perceived OSG benefit. The regression assumptions of (1) normally distributed residuals (the error terms must be normally distributed), (2) homoscedasticity (the variance of the errors must be roughly constant around the least-squares line), (3) linearity (the predictor variables must have a linear relationship with the outcome variables), (4) no multicollinearity, and (5) the absence of influential outliers were checked before running the regression to confirm that the data were suitable for a regression analysis.

The qualitative data were analyzed using an inductive thematic analysis by AM [38]. The main themes were extracted from each participant's written (open-ended) response, following the steps outlined by Braun and Clarke [38]. In the first step, each response was read multiple times to get a general feel for the content. In the second step, the data were systematically reduced into smaller chunks by looking for emerging issues within each response. In the third step, preliminary themes were extracted. In the final step, the responses were all reviewed and compared among each other to develop and solidify common themes and subthemes [38,39].

Ethics Approval

This study was approved by the Research Ethics Board at the IWK Health Centre (1023970). The study was performed in accordance with the guidelines and regulations from the Research Ethics Board of IWK Health Centre. In addition, informed consent was obtained from the participants, and the respondents were fully informed of the purpose and procedures of the study. They were also assured of the confidentiality of information.

Results

Descriptive Statistics

The descriptive statistics (Table 1) revealed some interesting findings: notably, the entire (81/81, 100%) sample was female; most (33/81, 41%) have had their child's diagnosis for over 5 years; and roughly half (39/81, 48%) had been using OSGs for over 3 years, meaning that they were experienced OSG users.

Table 1. Demographic characteristics and online support group (OSG) use behaviors (N=81).

Demographic variable	Participant, n (%)
Age of caregiver (years)	
18-29	5 (6)
30-49	67 (83)
50-64	8 (10)
≥64	1 (1)
Gender of caregiver	
Male	0 (0)
Female	81 (100)
Intervention group	
Coached	40 (49)
Self-managed	41 (51)
Time since child's diagnosis (years)	
<1	19 (23)
1-3	18 (22)
3-5	11 (14)
>5	33 (41)
Length of time accessing OSGs (years)	
<1	21 (26)
1-2	21 (26)
3-4	18 (22)
≥5	21 (26)
Frequency of creating posts in OSGs	
Once a month or less	47 (58)
Every other week	15 (18)
Weekly	16 (20)
Daily or almost daily	3 (4)
Commenting frequency on posts	
Once a month or less	24 (30)
Every other week	26 (32)
Weekly	14 (17)
Daily or almost daily	17 (21)
Reacting (like, dislike, and love, etc) frequency to posts	
Once a month or less	18 (22)
Every other week	11 (14)
Weekly	21 (26)
Daily or almost daily	31 (38)
Viewing frequency of posts	
Once a month or less	2 (2)
Every other week	3 (4)
Weekly	14 (17)
Daily or almost daily	62 (77)

Psychometric Properties of Author-Constructed Scales

The internal consistency reliabilities of the Perceived OSG Benefit scale, the Attitudes Toward OSGs subscale, and Past Behaviors in OSGs subscale were Cronbach $\alpha=0.93$, 0.78 , and 0.82 , respectively. Exploratory factor analyses were conducted to explore the factor structure and preliminarily assess the construct validity of the Attitudes Toward OSGs subscale and the Perceived OSG Benefit scale. Both scales revealed 1 principal component (construct), and each item had clear conceptual coherence with the main construct (latent variable) it was designed to measure (ie, attitudes toward OSGs and perceived OSG benefit). The items in the Attitudes Toward OSGs survey were part of a larger measure, “Personality, Attitudes, and Behaviors around Health Forums.” The eigenvalue was 4.0 , and the principal factor extracted explained 39.8% of the variance in the latent variable (positive attitudes toward OSGs). Factor analyses of the Perceived OSG Benefit scale also led to the extraction of 1 main factor (construct), providing evidence that the construct of self-reported OSG benefit is in fact unidimensional, meaning all the items in the self-reported OSG benefit survey were designed to assess benefit derived from OSGs. The eigenvalue for the principal factor was 6.1 ; this factor explained 68.3% of the variance in the latent variable (perceived OSG benefit) and was therefore considered an excellent approximation of what this survey was designed to measure, supporting its construct validity.

Regression Analysis

Before performing the regression analysis, the correlation matrix among all the variables was examined. The correlation between extraversion and perceived OSG benefit was the only significant correlation (at the 0.01 level, 2-tailed)—the Pearson correlation coefficient for these 2 variables was 0.35 . After the regression analysis was performed, extraversion was found to be the only major predictor of self-reported OSG benefit ($R^2=0.125$; $P<.001$). Even though the 5 predictor variables all together significantly predicted perceived OSG benefit (ie, the overall

regression model was found to be significant; $P=.02$), extraversion was the only significant predictor of self-reported OSG benefit, explaining 12.5% of the variability in this outcome variable. The other 4 predictor variables combined only explained 3% of the variance (agreeableness: $P=.36$; neuroticism: $P=.68$; positive attitudes toward OSGs: $P=.35$; typical past OSG use pattern: $P=.33$).

Neither positive attitudes toward OSGs nor typical past OSG use patterns significantly predicted perceived benefit from the current OSG, meaning that neither of these hypotheses (hypothesis 2 and hypothesis 3) were supported.

Qualitative Results

The last question on the Perceived OSG Benefit scale (“Do you have anything else to add about your experience using the group or how the group helped or didn’t help you? If so, could you provide some examples of how the group had an impact on you?”) was answered by 73 (90%) out of 81 participants; 65 of the responses were relevant to the question being asked. Table 2 displays the main themes extracted and the number of participants who considered the theme important or relevant. A list of suggestions was also compiled, based on the open-ended responses of improvements suggested by the parents and caregivers, which could be useful for creators or facilitators to improve health and well-being–related outcomes from future OSGs.

The main theme was the lack of engagement, activity, and interaction, particularly from the OSG moderators, due to the paucity of posts; they are more likely to be irrelevant and for the OSG to be dismissed by its members ($n=27$). Main suggestions for improving future health-related OSGs were (1) posting psychoeducational content directly related to the needs of the patients/caregivers in the OSG; (2) expanded, larger groups could be more helpful due to acquiring more resources and diversity of opinions; and (3) more in-depth, proactive discussion generated by the moderators.

Table 2. Main themes and suggestions for the benefits of future health-related online support groups (OSGs; n=65).

Themes and suggestions	Participant, n	Illustrative quotes
Negative OSG themes		
The lack of engagement, activity, and interaction, particularly from the OSG moderators, due to the paucity of posts; they are more likely to be irrelevant and for the OSG to be dismissed by its members	27	“There just wasn’t a lot of conversation happening in my group. It was very small, and the content of the posts was largely composed of introductions.”
The lack of awareness of the OSG, lack of ability to use the social networking sites on which the OSG was hosted (Facebook), or difficulty navigating the OSG’s page (lack of digital literacy)	6	<ul style="list-style-type: none"> • “I’m not typically an online/Facebook user.” • “I don’t really go on Facebook. I finally went on and signed up.”
The lack of interpersonal connection and relevance of posts in the OSG; comments were found by some members to be superficial (lacking reflection or insight), general, and impersonal	6	<ul style="list-style-type: none"> • “I found it hard to connect as I’m used to being on my own as a single parent. Most were in relationships and felt I couldn’t relate.” • “Real connection is difficult to establish online.”
Positive OSG themes		
Feeling connection, encouragement, positivity, and reassurance from the OSG	4	“It’s good to relate to other parents who are having some of the same experiences as I.”
Felt welcome to share in the OSG and appreciated reading about situations or experiences that others shared for learning purposes	3	“Reading about others’ struggles or experiences is helpful as I don’t feel like it’s just my family that struggles. I also like that people have posted articles or videos that have been helpful and align with the skills we are learning.”
The OSG was well moderated, and shared experiences, and invited feedback and conversation	2	“I do appreciate that it is well moderated.”
Main suggestions for improving future health-related OSGs		
Posting psychoeducational content directly related to the needs of the patients/caregivers in the OSG	N/A ^a	“I think that it would be more interesting if the moderator posted content that directly relates to what we cover in our phone conversations.”
Expanded, larger groups could be more helpful due to acquiring more resources and diversity of opinions	N/A	“I find the larger the group within a community (such as Calgary or Alberta Autism), the better. It allows for enough similarity of situation and enough diversity of thought.”
More in-depth, proactive discussion generated by the moderators (eg, asking questions that patients/caregivers can respond to) to engage members and encourage their input to posts (patients/caregivers who are putting themselves out there by creating posts want to feel heard and empathized with)	N/A	“It could be a better source of support if there was more discussion generated by the moderators and more input from the participants.”
More sharing of personal experiences, as well as sharing more complex, deep, and vulnerable posts	N/A	“I’d like to see more controversial comments. I found comments to be very one-note and fluffy. I like sharing/hearing personal stories, it would just be nice for them to go deeper. I also didn’t feel comfortable sharing in this type of setting. It made me question whether comments would be genuine and whether my opinions would be taken well. I didn’t feel the ‘opportunity cost’ was there in terms of energy it would require to share/feel my opinions were interpreted correctly vs. benefit I’d receive.”
Making OSGs more targeted, so that there is a stronger “common denominator” among the members; mandating regular posting if patients/caregivers want to stay in the group to increase their motivation to engage	N/A	“I am part of other groups where parents with kids with the same diagnosis are together and those groups are FAR more supportive and informative.”
Mandating regular posting if patients/caregivers want to stay in the group, in order to increase their motivation to engage.	N/A	“I don’t feel like we are all engaging in it enough because it’s voluntary. If everyone was told to post once a week about an experience or to comment it would be more interactive.”

^aN/A: not applicable.

Discussion

Findings and Implications

This study used a longitudinal mixed design to investigate the predictors of perceived benefits from OSGs among 81 parents of children with neurodevelopmental disorders and challenging behaviors. For this study, we developed and evaluated the Perceived OSG Benefit scale. A secondary analysis generated experiences and suggestions for OSG designs.

Our study yielded 3 principal findings. First, extraversion significantly predicts self-reported OSG benefit in a sample of caregivers of children with neurodevelopmental disorders and challenging behaviors.

Second, suggestions for future health-related OSGs for caregivers were made. They include customizing psychoeducational content; expanding the size of the OSG; more in-depth, proactive discussion; and more sharing of personal experiences and complex, deep, and vulnerable experiences. The qualitative data helped us understand what worked and what did not work in the OSGs.

Lastly, the Perceived OSG Benefit scale created in this study was found to have excellent internal consistency reliability, face validity, and content validity (ie, accurately, dependably, and effectively measuring the full depth and breadth of the construct it was designed to measure), which means it can be used by future researchers to measure benefit from other health-related OSGs. It can be used in the planning, facilitation, and assessment of future OSGs, to help clinicians and other facilitators run these groups in a way that leads to the greatest improvement in health and wellness-related outcomes of the patients/caregivers in the group. Improving the facilitation of OSGs could help caregivers build socioemotional connections and reduce their stress levels and isolation.

Limitations and Future Directions

The primary limitation of this study was that the caregivers participating were also completing a separate intervention, which may have confounded the assessment of perceived benefit from the OSGs. The membership of the OSGs in this study depended on the affiliated intervention; therefore, their experience with the intervention might have impacted their attitudes to and perceived satisfaction with the OSGs. Another limitation is that the author-developed surveys used in this study had not been previously validated, so their generalizability (external validity) to OSGs for other parent or caregiver populations has not yet been determined. Furthermore, the internal consistency of the agreeableness and neuroticism sections of the Ten-Item Personality Inventory was poor. Future research should examine whether these traits predict OSG benefit using a longer, more thorough assessment of the Big Five personality traits (with higher internal consistency reliability), such as the Big Five Personality Inventory (a 50-item measure) [17]. The sampling

method and design of the study may limit the generalizability of our findings. First, this study only examined the OSGs on Facebook as an example, whereas the other OSG users on public forums or websites may show different behaviors and patterns. Second, the OSGs designed in the study may have empowered extroverts to benefit from the group, and they may be more likely to participate in the web-based study. Future studies should use more rigorous designs, such as randomized controlled trials, to test this effect.

Since the preliminary validation of both author-created surveys was successful, they may be used by future researchers and clinicians to identify who would be more likely to participate in and benefit from OSGs. These assessments could then guide clinicians (and other facilitators) in tailoring the design of their OSGs to the specific strengths and vulnerabilities of the members. A flexible, caregiver-centered facilitation of OSGs could be more effective in improving the health and wellness outcomes of those who have preexisting characteristics that predict that they are less likely to benefit from OSGs, such as being introverts. Future research could test various methods (eg, post recommendations and reminders) of engaging caregivers who are less likely to participate in and benefit from OSGs (eg, introverts). Future designs of OSGs should boost their positive effects in both introverts and extroverts and empower both “posters” and “lurkers” to receive high levels of social support, such as posting useful information via OSG moderators.

Future research should further test and validate these author-created surveys in other populations, both for caregivers and patients dealing with a range of different health conditions. More research is also needed to examine why and how extraversion predicts greater perceived benefit (but also actual benefit) from OSGs, as well as using a larger scale (such as the Big Five Personality Inventory) to more thoroughly assess extraversion, agreeableness, and neuroticism in relation to increased OSG benefit. Future studies could also expand on the qualitative findings of this study and test the 6 recommendations for improving health-related OSGs provided by these parents and caregivers.

Conclusions

This study designed and evaluated the Perceived OSG Benefit scale and used a longitudinal design to examine the predictors of OSG benefits. We identified extraversion as a significant predictor of benefits from current OSG designs. Qualitative results yielded the current experiences and suggestions of OSG among parents of children with neurodevelopmental disorders, including customizing psychoeducation; expanding the size of the OSG; more in-depth, proactive discussion; and more sharing of personal experiences and complex, deep, and vulnerable experiences. This study lays a foundation for future studies that aim to study OSG benefits and customize OSG designs for parents of children with neurodevelopmental disorders.

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Data Availability

Deidentified data sets used and analyzed during this study are available from the corresponding author on reasonable request with the permission of the Research Ethics Board of the Izaak Walton Killam (IWK) Health Centre.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Personality, Attitudes, and Behavior around Health Forums survey.

[[DOCX File, 23 KB - nursing_v5i1e36167_app1.docx](#)]

Multimedia Appendix 2

Perceived OSG Benefit scale. OSG: online support group.

[[DOCX File, 15 KB - nursing_v5i1e36167_app2.docx](#)]

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Abbreviations

OSG: online support group

RCT: randomized controlled trial

SNS: social networking sites

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