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Viewpoint

Personal Health Tracking: A Paradigm Shift in the Self-Care Models in Nursing

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Abstract

The rapidly evolving digital health landscape necessitates updates to existing self-care models in nursing. This viewpoint paper revisits and evaluates prevalent models, recognizing their comprehensive exploration of self-care concepts while also identifying a gap in the incorporation of personal informatics. It underscores the missing link of human-technology interplay, an essential aspect in understanding self-care practices within digital generations. The author delineates the role of personal health tracking in self-care and the achievement of desired health outcomes. Based on these insights, the author proposes a refined, digitized self-care model that incorporates mobile health (mHealth) technologies and self-tracking behaviors. The paper concludes by advocating the application of this model for future mHealth nursing interventions, providing a framework for facilitating patient self-care and improving health and well-being in the era of digital health.

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KEYWORDS

personal health data; personal informatics; self-care; self-tracking; mobile health technology; human-technology; human-computer; human computer interaction; health tracking; framework; frameworks; model; models; mHealth; mobile health; informatics

Introduction

Self-care refers to the personal practices adopted to maintain and enhance health [1], whereas self-management not only covers self-care but also delves into facets like emotional and role management in chronic illness [2]. In nursing, especially concerning chronic conditions, both concepts are crucial, allowing patients to actively engage in their health care and thus improving health outcomes [1]. Dorothea Orem's self-care model [3] has ushered in a significant shift in health care dynamics, emphasizing individual empowerment in managing health and well-being. Rooted in the belief that individuals inherently possess the capacity for self-care, the model contends that they can make informed decisions to improve their own health. Central to this model is the principle of self-care, which sees individuals not merely as recipients of care but as active participants in their own health maintenance. Within this paradigm, the role of nurses evolves from care providers to facilitators, educators, and advocates, empowering patients to cultivate the skills and knowledge necessary for effective self-care [4].

Barbara Riegel's self-care model [5] is a modern theoretical framework that accentuates the importance of self-care in managing chronic illnesses, specifically in the context of heart failure. Offering a holistic view of self-care and its implications on managing long-term conditions and optimizing health outcomes, this model delineates 3 interconnected dimensions of self-care: maintenance, monitoring, and management [5]. These elements collectively foster self-care practices for those grappling with chronic illnesses. Contrary to perceiving self-care as an exclusively individual endeavor, Riegel's model acknowledges the substantial influence of socioenvironmental factors and underscores the crucial role health care providers and support systems play in facilitating productive self-care behaviors. By empowering patients and boosting their confidence in self-care, nurses can stimulate active involvement in health management and engender improved health outcomes.

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The patient-centered approach embodied in current self-care models in nursing has gained significant recognition for promoting individual autonomy and self-determination [6]. In recent years, the advent of mobile health (mHealth) technology and the quantified self movement [7] has expanded the potential of self-care models, enabling individuals to manage and monitor their health using mHealth devices and applications. Consequently, the integration of mHealth technology has contributed to a substantial transformation within the nursing profession's self-care model. This phenomenon has redefined the methods by which individuals manage their health, thereby empowering them to take proactive roles in their health and well-being [8-10]. With the aid of mHealth applications, wearable devices, and other digital tools, patients and caregivers now possess the ability to access real-time health data, personalized health information, and track their progress toward health goals. This new trend has not only bolstered patient engagement and satisfaction but has also unveiled new prospects for health care providers to deliver personalized care [11].

This paper delves into the interplay between mHealth technology and personal health tracking within the self-care models in nursing, introducing the newly emerged digitized self-care model. The author explores the potential advantages and barriers of integrating these advancements into nursing practice, paying particular attention to their effects on patient outcomes, health care accessibility, and the dynamics of the health care provider-patient relationship. By understanding the paradigm shift brought about by these technological advancements, nurses can adeptly integrate and leverage mHealth technology, thus aiding individuals in their pursuit of optimal health and well-being, informed by insights from personal health data in their everyday lives.

Background

The advent of the quantified self movement [7] has paved the way for a novel paradigm, wherein individuals use mHealth technologies to track and scrutinize their daily activities, thereby attaining an enriched understanding of their comprehensive well-being. This movement, embodied in quantified self technologies (QST), hinges on the systematic collection and analysis of personal data. Buchanan and Lockton [12] pinpoint three interconnected attributes intrinsic to QST: (1) feedback, which concerns the provision of information; (2) connectivity, which revolves around how individuals leverage QST to monitor, share, and elevate their health; and (3) intervention, which involves psychological determinants such as user motivation and habitual behaviors. This trend denotes an inclination to quantify everyday activities such as eating, sleeping, and exercising, assigning tangible numerical data to them [13]. By incorporating elements such as activity trackers and digital biomarker collection into their lifestyles, quantified self proponents perceive these as invaluable instruments that yield concrete data pertaining to myriad facets of their daily routines [14].

Li's stage-based model [15] is a renowned framework in personal informatics, delineating 5 psychological stages integral to engaging with digital self-tracking. The initial phase, termed "preparation," encompasses individuals' motivations to accumulate personal data, their decision-making process in choosing pertinent data, and their strategies for its documentation. Subsequently, in the "collection" phase, individuals amass self-related data. "Integration," the ensuing phase, prepares, amalgamates, or modifies the collected data to ease reflection. In the final "action" stage, individuals make informed decisions based on their improved self-awareness. Li et al [15] underscore a noteworthy observation that individuals frequently concentrate on a specific phase, such as logging the number of steps taken or hours slept, while neglecting the comprehensive process and anticipated health outcomes of self-tracking, thereby stressing the need for professional guidance and continued support. Additionally, Li et al [15] highlight the potential role of computers in streamlining self-tracking citing progress in sensor technologies, the ubiquity of internet-enabled information, and the advent of user-friendly systems and interfaces. Subsequently, Epstein et al [16] proposed an updated version of Li's stage-based model, termed the "lived informatics model." This refreshed framework introduces additional stages—"deciding," "selecting," "tracking and acting," and "lapsing." The integration of these phases offers an expansive insight into how individuals use self-tracking tools, uncovers motivational strategies, and complements the original stage-based model in tracing behavioral changes.

The management of personal health data plays a crucial role in the broader health care landscape. As delineated by the "illness work and personal information management" framework [17], patients undertake a range of complex self-care activities. These tasks span several responsibilities including, but not limited to, adhering to medication regimens, refilling prescriptions, shopping for groceries and preparing meals, exercising, or undergoing physical therapy, navigating medical challenges, identifying health care providers, scheduling medical appointments, and maintaining medical records. Consequently, patients contending with multiple chronic conditions often encounter additional challenges and feelings of being overwhelmed when tasked with managing their health-related information. Early on, Corbin and Strauss [18] emphasized the importance of "articulation work" within the scope of "illness work," particularly stressing its role in the use of technologies.

Prior research illustrates several advantages offered by using mHealth technologies to monitor daily activities, especially concerning the automatic assembly and aggregation of data [19]. For instance, the variety of mHealth applications available assists both patients and health care providers in selecting the application best suited for their needs. In terms of function, there are diagnostic applications that assist in identifying illnesses, health behavior change applications aimed at fostering healthier habits, symptom checkers that guide users based on their current symptoms, and specialized apps for managing chronic conditions such as diabetes or asthma. Depending on the characteristics of health data, passive applications automatically collect data using sensors, while active applications require individuals to manually input data, like diary entries. Based on the responsibilities and central roles in self-care, the roles of patients in using mHealth technologies can vary [1]. For example, when reshaping healthy lifestyles,

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patients bear greater responsibilities. Conversely, in acute care and serious illnesses, the responsibilities predominantly fall on health care professionals [1]. The Good Practice Guidelines on Health Apps and Smart Devices [20] offer recommendations for the design, deployment, and adoption of mHealth technologies aiming to enhance their use in health care environments and improve health outcomes.

A Digitized Self-Care Model

Overview

Existing self-care models need some updates to adequately address the influence of personal informatics and personal health tracking in the context of nursing. For instance, while the middle-range theory of self-care for chronic illness [4] comprehensively addresses the self-care process in patients with chronic conditions, it does not encompass the recently developed field of personal health informatics [21]. The vital interaction between personal health tracking and self-care is notably missing element, hindering the understanding of factors influencing self-care in the digital age. To bridge this gap, this paper scrutinizes published papers on patients' health-tracking behaviors to comprehend how personal informatics is reflected in their self-care practices and desired health outcomes. In light of these findings, the author proposes a digitized self-care model and recommends its application for future mHealth-based nursing interventions.

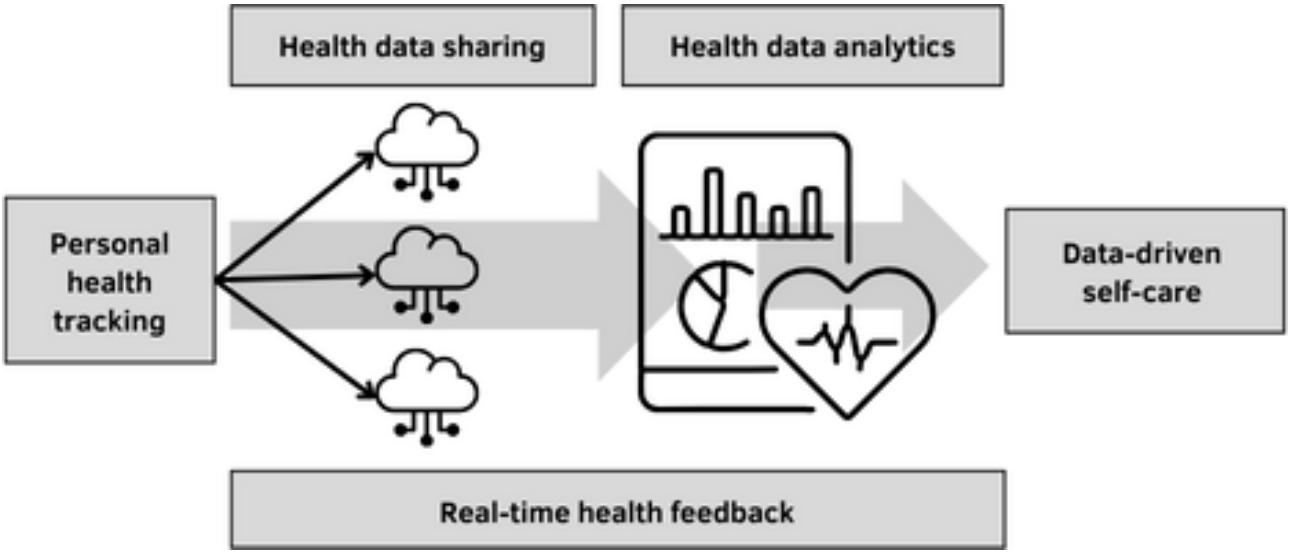
Personal Health Tracking

In this paper, the term "personal health tracking" is favored over "self-tracking" by the author. This preference is intended to more accurately represent self-monitoring behaviors within the scope of self-care, specifically using mHealth technologies and quantified health metrics. Essentially, in the context of this study, "personal health tracking" denotes the practice of individuals leveraging mHealth technologies to collect personal health data with the intention of addressing abnormal health issues or enhancing their overall health.

Personal health data cover a range of health-related metrics that individuals can autonomously monitor in their daily lives, such as heart rate, body temperature, blood oxygen saturation, sleep patterns, physical activity or exercise, food consumption, and mood states [22]. The practice of observing and collecting these data using digital technologies and tools is typically termed "self-tracking" [23]. Historically, patients relied on traditional pen-and-paper methods to document their symptoms and perceived status. The modern approach, however, involves wearing devices that capture diverse health metrics, considerably alleviating the workload associated with data collection. For example, individuals can now wear fitness trackers that automatically record heart rate, sleep patterns, step count, and daily calorie burn. These devices collect data in real time, eliminating the need for manual logging. Beyond capturing health metrics and behaviors, there is a growing emphasis on patient-reported outcomes—direct reports from patients regarding their health status [24]. Health care providers are increasingly valuing these patient-reported outcomes, recognizing that the patient's voice is vital for patient-centered care [24]. While a segment of the older population continues to use manual methods [25], this unobtrusive capture of health data mitigates the traditional tracking burden, offering users a more convenient and accurate means to oversee their health and behaviors.

The digitized self-care model (Figure 1) highlights the intersection between the concept of self-care monitoring [5] and personal health tracking. As defined in the self-care model, self-care monitoring involves the practice of self-observation for alterations in signs, symptoms, or regular bodily monitoring [4]. They emphasize that self-care monitoring incorporates vital elements such as detectable health conditions, dependable methods for identifying bodily changes, and the capacity for appropriate response [5]. While individuals may detect physical alterations through various means, quantified measures are deemed reliable health data for health care providers in evaluating and responding to these changes. Nonetheless, the lack of contextual information in personal health tracking has drawn criticism from health scientists [26]. Therefore, the synthesis of contextual information and health data is crucial in comprehending individuals' health conditions and related behaviors [27].

Figure 1. The digitized self-care model.



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In the digitized self-care model, personal health tracking can be conducted either short-term or long-term, depending on the person's intent and determination. "Selective personal health tracking" refers to the temporary collection of personal health data to reflect diagnosis and management. Meanwhile, "prolonged personal health tracking" denotes the ongoing monitoring of physical changes, health indicators, and disease conditions. Selective personal health tracking, which involves a relatively small volume of personal health data, primarily monitors current illness progress, gauges treatment effectiveness, and aims to achieve desired health outcomes in a brief period. This approach is less about discerning meaningful health-related patterns from accumulated health data for predictive purposes. In contrast, prolonged personal health tracking does not focus on attaining immediate health status changes, but primarily aims to continuously monitor physical changes for health promotion and to maintain health status within a distinct adjunct to care. Therefore, the duration of personal health tracking is determined by individuals based on their health and health care needs.

eHealth Literacy, Technology Literacy, and Data Literacy

eHealth literacy, technology literacy, and data literacy are important skills in the digital age. eHealth literacy centers on the capability to seek, retrieve, comprehend, and evaluate health information from electronic sources [28]. Technology literacy pertains to proficiency in interacting with technology [29], and data literacy encompasses the aptitude to comprehend, analyze, and interpret data [30]. These competencies are crucial for individuals to make informed decisions, especially in the health care sector. The digitized self-care model starts with the premise that patients have the basic literacy expected in the digital age, coupled with individuals' motivation necessary for basic self-care practices. This pertains not just to a fundamental comprehension of one's technology usage and health data interpretation, but also its application in subsequent self-care behaviors. The extent of an individual's education, their inclination toward health care knowledge, and their comprehension of it serve as crucial components for successful personal health data-driven self-care. Furthermore, it is important to assess individuals' access to technologies and financial constraints, as these factors can pose challenges to their engagement with mHealth-based self-care.

In clinical practice, the adoption of mHealth technologies for personal health tracking is influenced by factors such as health care needs, attitudes toward mHealth technology, as well as the literacy levels of individuals [31]. Health care providers should be aware of the patient's capabilities and preferences to recommend appropriate mHealth tools. Assessing the patient's context and clinical care information is essential in determining the most effective approach to their self-care. In the realm of digital health, nurses will have a critical role in evaluating patients' information and selecting the most suitable mHealth tools to support their self-care activities. Additionally, it is crucial to educate patients who may have difficulties in understanding their health data, as this is vital for successful digitized self-care. Furthermore, efforts to enhance patients' self-efficacy in acquiring new technological skills and interpreting health data should be an integral part of this process.

As we embrace the evolution of mHealth technology in health care, we also risk widening health disparities across diverse populations. This is partly due to the fact that the intellectual gap among individuals capable of leveraging these technologies is not being adequately addressed. It is paramount that when introducing mHealth technologies to patients, their foundational literacy skills are evaluated to ascertain their capacity to use these technologies in self-care practice. Only when individuals can independently use mHealth technologies and make sense of the personal health data collected, can they fully comprehend their personalized care plans and take responsibility for their self-care. Moving forward, incorporating assessments and education regarding patients' eHealth literacy, technology literacy, and data literacy will become an essential component of clinical practice.

Personal Health Data-Driven Self-Care

The essence of the digitized self-care model involves collecting and analyzing personal health data over varying periods, thereby enabling constructive self-care. Self-care maintenance, self-care monitoring, and self-care management [5] are founded on the quantified health metrics derived from the collection and analysis of personal health data. While intuition and self-care insights from past experiences can influence self-care planning and practice, it is the interpretation of personal health data that has a more profound impact. Health data collected during an individual's daily routine are shared with health care providers and caregivers. With the appropriate patient consent, personal health data stored in the cloud can be accessed by third parties. This facilitates person-centered care through a process commonly known as health data sharing [32]. The accumulated personal health data can be harnessed to deliver predictive care plans to patients and caregivers. This is made possible by using data mining techniques that are powered by big data.

Thanks to real-time access and analysis capabilities in mHealth systems, patients can receive immediate personalized feedback and medical alerts [33]. Such real-time data analytics technology is gaining momentum in the health care sector, empowering patients with proactive self-care tools. Personal health data–driven self-care increases the likelihood of achieving expected health outcomes, and prediction of health conditions may aid in the early detection and prevention of diseases [34]. Consequently, self-care effectiveness and efficiency can be maximized by analyzing personal health data, rather than relying solely on the existing medical knowledge and professional experience of health care providers. This real-time health feedback feature, which encompasses health data sharing and health data analytics, shares characteristics commonly found in consumer health informatics [35]. Consumer health informatics integrates remote monitoring systems, patient medical records, decision support systems, and web-based health communities to facilitate individual self-care [36]. This is realized through the amalgamation of daily routines, concurrently focusing on patients, family members, associated daily activities, and the surrounding context. In contrast to the consumer health informatics applications, the digitized self-care model places more emphasis on the ability of persons to collect their own health information and use it as a means to improve their health and well-being.

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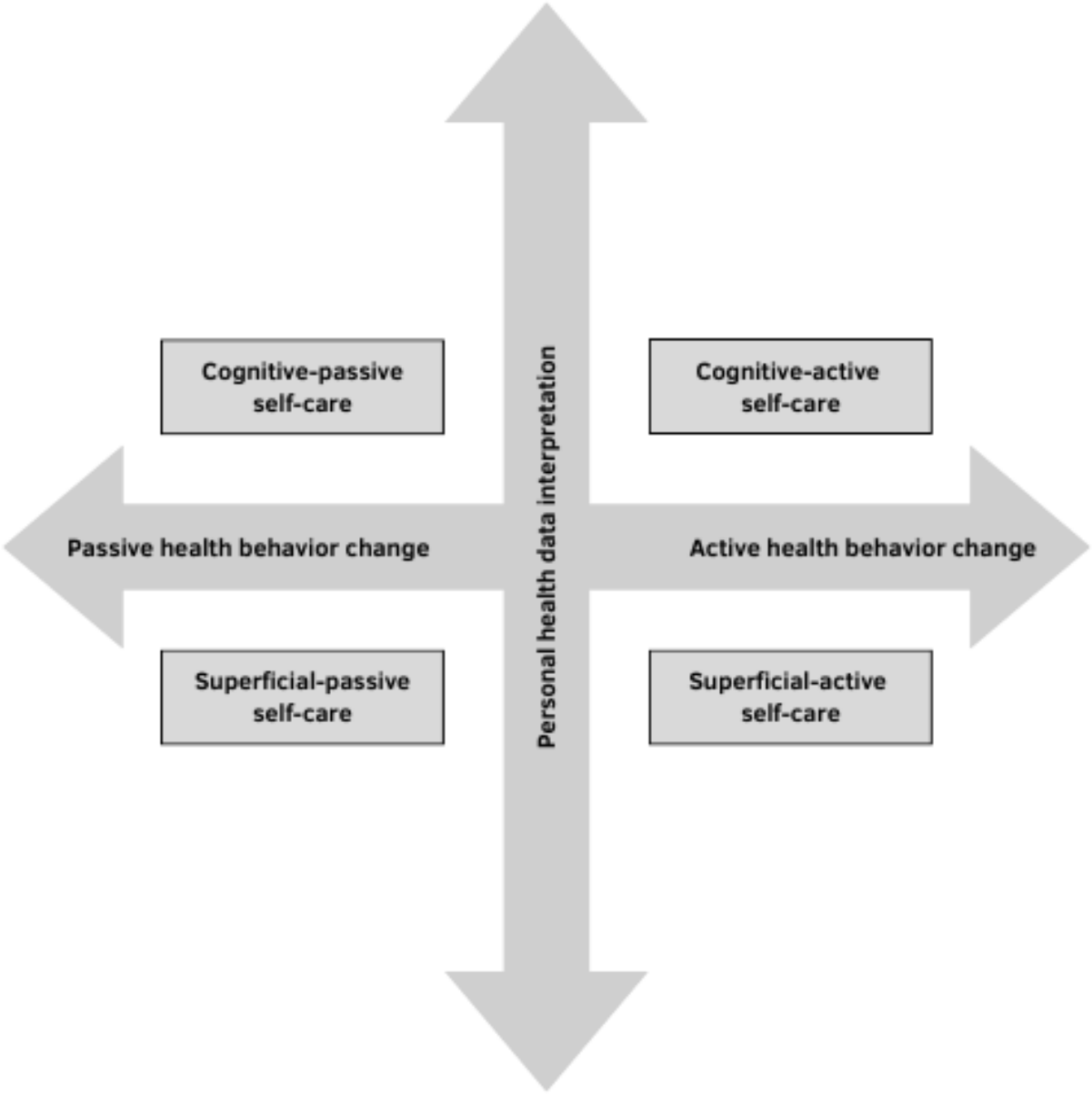
As previously noted, the digitized self-care model's fundamental objective is to guide researchers to incorporate the concept of personal health tracking in the design of mHealth-based self-care interventions. Previous mHealth studies have not primarily focused on patient access to, and comprehension of, personal health data. Instead, the collected health data have predominantly been used by health care providers and researchers for evaluating patients' health status or measuring intervention effectiveness. In the majority of prior studies, patients have not been active governors of their health data. This novel model, however, underscores the significance of patients becoming active participants in mHealth technologies. It advocates for patients to voluntarily monitor their health data, stay attuned to changes in their bodies, and take an active role in the self-care process.

The health data-driven self-care can be classified into four primary categories based on the extent of an individual's engagement in interpreting health data and implementing health behavioral changes (Figure 2): (1) cognitive-active self-care, where an individual grasps the underlying meaning of their health data and translates it into subsequent health behavior changes (eg, patients modifying their dietary intake in response to blood glucose readings); (2) superficial-active self-care, which involves a superficial understanding of one's health data, followed by implementing health behavior changes as mainly guided by health care feedback (eg, patients who respond to messages from an app recommending 30 minutes of walking); (3) cognitive-passive self-care, in which an individual deeply comprehends the significance of their health data but does not initiate any health behavior change (eg, patients understanding a consistent weight gain trend from the health chart but do not show any behavioral modifications); and (4) superficial-passive self-care, where an individual merely glosses over their health data without instigating any health behavior change (eg, patients who use wearables without demonstrating enhanced health literacy or behavioral modifications).

Figure 2. Types of data-driven self-care.



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As per the self-experimentation framework in personalized health [36], individuals who are cognitive and active go beyond simple self-tracking. They endeavor to comprehend their present or potential health issues and possibly take effective measures to optimize health outcomes. These individuals generate hypotheses to address their health-related queries and use their own bodies to ascertain the causes of health problems. This advanced level of self-care requires individuals to possess a superior understanding of medical knowledge and logical thinking skills to conduct "self-experiments." In fact, individuals capable of practicing this advanced level of self-care are rare. Laypersons are often confronted with misleading medical information and struggle with assessing and navigating the surfeit of medical misconception [37]. As a result, patient's self-care activities must be supplemented with the guidance of health care professionals, assisting them in correctly interpreting their health data and devise actions to enhance their health and well-being. It is crucial to acknowledge that misuse of data and information can promote detrimental health behaviors and result in unforeseen negative health outcomes. Additional educational opportunities and counseling should be provided to patients and caregivers to ensure that digitized self-care outside of the health care setting—be it at home or in the community, in realms beyond the influence of health care professionals—is executed appropriately.

Clinical and Research Implications

Without a doubt, not all individuals possess the ability to engage in digitized self-care. Currently, various marginalized groups in our society, including the older populations, people with disabilities, and low-income individuals face challenges in using new digital technologies and frequently updated software. Hindered by lower education levels and financial constraints, they are often unable to adopt innovative technologies. Health care systems and health insurance plans must persist in providing financial support and assistance to these marginalized groups, thus enabling greater access to innovative technologies that can facilitate self-care and health improvement. Moreover, encouraging patients to monitor their personal health data can be challenging for various reasons. A primary obstacle can be the skepticism patients might have toward mHealth technologies' accuracy and reliability for tracking health metrics and behaviors. This skepticism can demotivate them from collecting and sharing their health data with health care professionals. Further research is required to determine how to encourage patients to use mHealth technologies for self-care. Nonetheless, all individuals in the digital age should have equal opportunities to use cutting-edge technologies, such as mHealth, to enhance their quality of life.

The adoption of mHealth technology for patients' self-care in clinical and community settings can pose several challenges for nurses. These challenges include infrastructure constrains, technological disparities, privacy issues, and patient-related factors. Significantly, there is scant research regarding nurses' comprehension of mHealth technologies and their proficiency in effectively using these tools within self-care routines. Within the domain of nursing education, it is imperative to emphasize the importance of systematic training to address the technological divide, equipping nurses with the confidence to adeptly use these tools in patient care. Additionally, as mHealth platforms are integrated into health care, the transmission of health data introduces potential ethical concerns. It remains crucial for nursing educators to underscore the importance of maintaining data privacy and confidentiality to secure patient trust and align with professional ethical standards.

Collaborating with diverse experts is crucial to address the needs of data security, data governance, and interoperability in the adoption of mHealth technologies in patient care. Data security is pivotal in mHealth technologies due to the handling of sensitive patient information. Collaboration with cybersecurity and data privacy experts is essential for preparing strong protective measures. Clear protocols for data handling are essential for preserving its integrity, privacy, and confidentiality. Experts in data governance and ethics can guide on aspects like ownership, consent, and compliance with regulations, including the Health Insurance Portability and Accountability Act. Finally, interoperability can be a challenge in mHealth due to varying data formats across systems and devices. Collaborating with health informatics experts can help create standardized data exchange protocols and the designs of systems that allow data sharing across diverse health care platforms.

Conclusions

In conclusion, amidst the deluge of mHealth technologies available to the public, this paper presents a digitized self-care model for the contemporary era. This updated self-care model merges the established self-care model with the concept of personal health tracking, with an aim to enhance self-care practices for both patients and health care providers. This model eliminates extraneous research concepts, providing researchers or practitioners with flexibility when crafting nursing interventions. It can further be used by incorporating significant external factors affecting self-care as valued by health care scientists. The core of personalized care is diminished when patients forgo their agency. However, by empowering patients to actively collect, understand, and use their health data to modify problematic self-care activities, they can maintain optimal health outcomes. As we progress in the digital age, marked by unpredictable advancements in artificial intelligence and internet of things, existing nursing models will need frequent updates to remain relevant and effective.

Conflicts of Interest

None declared.

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Abbreviations

mHealth: mobile health
QST: quantified self technologies

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Review

Information and Communication Technologies to Support the Provision of Respite Care Services: Scoping Review

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Abstract

Background: Respite care is one of the most frequently requested support services by family caregivers. Yet, too often, respite care services are inaccessible, due in part to families' lack of knowledge regarding available services and a lack of service flexibility. Information and communication technologies (ICTs) may help to improve the flexibility of services available and families' knowledge of such services. However, an understanding of the use of ICTs and research in this area is lacking.

Objective: The objective of this study was to provide a comprehensive overview of the academic literature on ICTs for supporting the provision of respite care services.

Methods: A scoping review study was conducted. Six library databases were systematically searched for relevant literature. Key data were extracted into a summary chart. Text and quantitative data were coded using descriptive qualitative content analysis techniques, and the results were collated and summarized into a comprehensive narrative.

Results: A total of 23 papers describing 15 unique ICT programs exploring the potential of ICTs to support respite care services met the inclusion criteria. ICTs supported the provision of respite care by facilitating information-sharing with families and providers, recruiting and training respite care providers, and coordinating services. Key design considerations for developing respite care ICTs were trustworthiness and participatory design methods. Implementation considerations included designing for complementarity with existing services, assessing the appropriate timing for introducing the ICT-based services, and ensuring adequate promotion strategies to raise awareness about the services.

Conclusions: There is limited but promising research on the potential of ICTs to support the provision of respite care services. Further research should be conducted to advance the results of this review, ultimately aiming to build ICTs that can improve the quality of, and access to, respite care services.

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KEYWORDS

caregivers; eHealth; health services accessibility; home care services; mHealth; respite care; short break care

Introduction

Respite care is one of the most frequently requested support services by family caregivers and is typically provided in person by a home care nurse or health care aide [1-3]. Respite care services are meant to help provide caregivers with short breaks from their caregiving responsibilities, so they may sustain their caregiving roles [2]. These breaks also offer patient and care receivers opportunities to socialize with new people and to access additional health care services through new care providers in their homes [2].

Unfortunately, respite care services are often underused, largely due to a lack of service flexibility and accessibility among respite care services capable of addressing different families' unique needs [1,4,5]. Families may also lack information regarding the resources available to support them [6,7]. Family caregivers suggest that easier, more flexible access to respite care services would help support their caregiving work and alleviate feelings of burden [1,3].

Information and communication technologies (ICTs) have unique capabilities for supporting the flexible and efficient provision of community and home care services like respite care [8]. ICTs are tools that can be used to coordinate activities immediately over a distance and to facilitate the provision of flexible services [8]. Different forms of ICTs exist, such as personal computers, smartphones, and telephone systems [9]. The unique capabilities of ICTs could be used to make respite care services more flexible and accessible, by making it easier to coordinate care, share information about local respite care services, and provide continuing education to train more respite care providers [10-12].

A review of existing literature on technologies for supporting respite care services could be used to guide future research on developing ICTs to facilitate the provision of respite care services. Furthermore, a review can be particularly helpful for providing an overview of recommendations and trends from across multiple smaller research projects on ICTs for supporting respite care, when such recommendations and trends are not obvious in any single one of the smaller, context-specific studies. To our knowledge, no review has been conducted on respite care ICTs. Therefore, the aim of this scoping review was to provide a comprehensive overview of academic literature on ICTs for supporting the provision of respite care services.

Methods

Overview

A scoping review study was appropriate for our purposes, as this method allows researchers "to assess and understand the extent of the knowledge in an emerging field" (p. 2121) [13]. This study was conducted by adhering to the following key procedural steps for scoping review studies, as per the most recent JBI Manual for Evidence Synthesis [14].

Defining and Aligning the Objective and Question

The primary research question was the following: what uses of ICTs have been studied in the academic literature for supporting the provision of in-person respite care services?

As per the JBI scoping review methodology, this question includes the following PCC (participant, context, concept) elements of a scoping review question: participant (stakeholders of respite care services, including family caregivers, patients, managers, and software designers), context (respite care services), and concept (ICTs) [14].

Related subquestions that we identified after iterative analyses were as follows: (1) what design factors should research teams consider when developing ICTs for respite care? (2) What implementation factors should research teams consider when developing ICTs for respite care, to support the uptake of ICTs?

Developing and Aligning the Inclusion Criteria With the Question

The above research questions and PCC elements were used to identify our final inclusion criteria, as listed in Table 1.

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Table 1. The inclusion and exclusion screening criteria.

Screening and inclusion criteria	Exclusion criteria
Concept and phenomenon of interest	
ICTs[a] that primarily support the provision of in-person respite care	Respite care that was not an in-person service (eg, if a robot or a video game were to be used to monitor or distract the care receiver temporarily) ICTs were primarily used for different purposes than respite care support (eg, telemedicine appointments with general practitioners, and general social media networks for caregivers to share their experiences)
Participants and target end users of the ICTs	
All participants and target end users of the ICTs where care receivers had a medical or an aging concern	General parenting support services (eg, babysitting coordination) Respite as a service for people experiencing homelessness
Context	
ICTs were being used to support the provision of respite care services located in the community (eg, in-home care, adult day-care centers, or short-term stays in long-term care institutions) Respite care had to be "in-person"; that is, another person would be physically present to provide care, allowing the caregiver to safely remove themselves from the care receiver's environment	Remote presence (eg, in-home robotic tele-monitoring) Hospital-based care
Research design	
All literature retrieved from academic library databases: empirical studies, editorials, commentaries, letters, abstracts, dissertations, perspectives, reviews, and study protocols	Full text was unavailable Study protocols without preliminary data were excluded
Languages included	
English, French, and Chinese	Papers written in other languages would have been excluded However, no papers were excluded due to language because all retrieved sources were written in one of these three languages

[a]ICT: information and communication technology.

Describing the Planned Approach

We did not submit a protocol for this scoping review for publication [14]. However, Multimedia Appendix 1 displays our Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for Scoping Reviews checklist [15], summarizing our commitments to the scoping review methodology [13,14].

Searching for the Evidence

A preliminary search strategy was conducted as follows: (1) reviewed by a research librarian [13,14]; (2) applied to MEDLINE (through OVID) and CINAHL Plus (through Ebscohost); and (3) refined and applied to MEDLINE and CINAHL, in addition to another 4 library databases: Embase Classic (1947-Present) (through OVID), APA PsycINFO (1987-Present) (through OVID), Scopus (through Elsevier), and Web of Science Core Collection (through Clarivate). A search strategy example for MEDLINE is outlined in Multimedia Appendix 2. The final comprehensive search was conducted in January 2022.

The reference lists of included publications and excluded ineligible literature reviews on respite care or technology for caregivers were also screened. Included publications were entered into Google Scholar to screen their "cited by" connections for inclusion. The Research Gate and Google Scholar profiles of the first and last authors were screened for references relevant to the research questions. The authors of respite care ICT programs established since 2010 were emailed seeking further information or updates on the projects that might not have been published yet [13].

Selecting the Evidence

EndNote software was used to manage the search and remove duplicate entries [16]. Rayyan literature management software was used to independently screen all titles and abstracts, followed by reviewing the full texts of selected papers by 2 authors based on the inclusion criteria [14]. The screening process was iterative and at least 2 reviewers (AC and LOB or AP) discussed any challenges they encountered, refining the selection strategy as needed with input from coauthors.

Data Extraction

One reviewer (AC) was responsible for charting data into an Excel (Microsoft Corp) workbook. Data items included year of publication, author, manuscript type, stated objectives, country, participant data, health condition necessitating caregiving, setting details, ICTs discussed (ie, intervention type), and other key results specific to our research questions [14]. Another reviewer (QC) independently extracted data from five manuscripts to verify the preliminary extraction process [14].

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Analysis of the Evidence

Descriptive qualitative content analysis techniques were used to code and relabel data into categories that addressed the research questions [13,14]. The full-text data from each manuscript (ie, introductions, methods, results, discussions, and any commentary data) were copied into Excel. Each row of data was open-coded to offer a brief summary of the main ideas for each data cell and to gain familiarity with the data. By rereading, comparing, and contrasting these open codes, we were able to generate a list of initial codes relevant to ICT uses, design, and implementation. The data were then relabeled in a new Excel column according to these initial codes. Using the "sort" function in Excel, similar ideas were grouped and regrouped in an iterative process as the codebook was refined to build new categories that we identified in the grouped data.

Presentation of the Results and Summarizing the Evidence

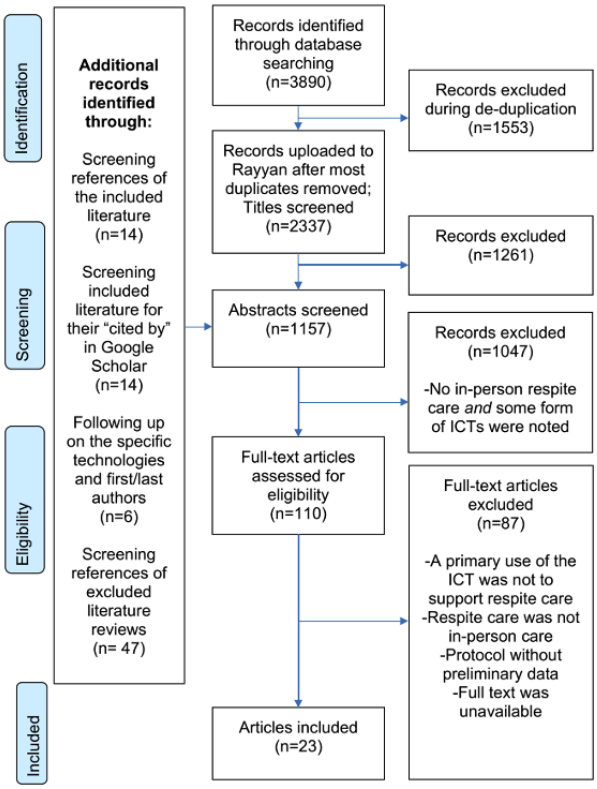
We have presented the results using both, a table summarizing the extracted data and key results (Multimedia Appendix 3), and a text-based narrative of our results addressing the primary and secondary research questions in "a descriptive format that aligns with the objective/s and scope of the review" (p. 422) [14]. Multimedia Appendix 4 provides examples of raw data extracted from the publications that exemplify the key ideas addressing our research questions.

Results

Search Results

Figure 1 shows the results of the screening process. Of the 3890 records screened, 23 met the inclusion criteria. All papers were published in English between 1990 and 2021.

Figure 1. This flowchart outlines the results of the screening process. ICT: Information and communication technology.



Study and Sample Characteristics

A total of 15 unique ICT research programs for exploring the uses of ICTs to support the provision of respite care services were described across the 23 papers (Multimedia Appendix 3). A total of 16 of the papers were empirical studies, including 6 qualitative [12,17-21], 6 quantitative [6,11,22-25], and 4 mixed methods [26-29] studies. Seven other papers provided project commentaries and overviews, or brief literature reviews [30-36].

Collectively, the 16 empirical studies included 2698 participants, although 74% (n=2000) of the total participants were derived from one survey study [23]. Participant types were typically family caregivers, health care providers, or health care stakeholders. Gender was only indicated in 6 studies, with women representing 76% (128/168) of these studies' total participants. Age was indicated in 7 studies, with a range of 21-92 years of age, although most participants were middle-aged or older.

Additional details specific to program location, caregiving conditions necessitating respite care, and respite care settings discussed, are listed in Table 2.

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Table 2. List of geographic locations, caregiving conditions, and respite care settings of the 15 programs.

Detailed criteria	Programs
Geographic locations	
North America (United States only) programs (n=5)	• Program 1 [33,34] • Program 2 [11] • Program 3 [24] • Program 9 [35] • Program 14 [19,21]
Europe programs (n=7)	• Program 4 [12,28] • Program 5 [27] • Program 6 [30] • Program 7 [31,36] • Program 10 [20] • Program 11 [22,23] • Program 15 [25]
South America (Chile only) program (n=1)	• Program 12 [17,18]
Australia program (n=1)	• Program 13 [6]
Asia (Taiwan only) program (n=1)	• Program 8 [26,29,32]
Caregiving populations	
Older adults with chronic illnesses programs (n=8)	• Program 1 [33,34] • Program 3 [24] • Program 4 [12,28] • Program 7 [31,36] • Program 12 [17,18] • Program 13 [6] • Program 14 [19,21] • Program 15 [25]
General chronic conditions, age unspecified program (n=1)	• Program 11 [22,23]
Children living with developmental disabilities programs (n=6)	• Program 2 [11] • Program 5 [27] • Program 6 [30] • Program 8 [26,29,32] • Program 9 [35] • Program 10 [20]
Respite care setting	
In-home respite care programs (n=10)	• Program 1 [33,34] • Program 3 [24] • Program 4 [12,28] • Program 5 [27] • Program 9 [35] • Program 10 [20] • Program 11 [22,23] • Program 12 [17,18] • Program 13 [6] • Program 14 [19,21]
Respite day care access programs (n=7)	• Program 1 [33,34] • Program 4 [12,28] • Program 5 [27] • Program 9 [35] • Program 10 [20] • Program 13 [6] • Program 15 [25]

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Detailed criteria	Programs
Short-term stay planning programs (n=4)	• Program 9 [35] • Program 10 [20] • Program 11 [22,23] • Program 13 [6]

Uses of Respite Care ICTs: Information-Sharing, Recruiting and Training, and Coordinating Care

ICTs were explored for the following uses in respite care services: (1) facilitating information-sharing with families and care providers, (2) offering recruitment and training resources for respite care providers, and (3) coordinating respite care services. Most programs focused on 1 of these 3 uses of ICTs for respite care, although one publication explored ICTs for both information-sharing and coordination [20]. Multimedia Appendix 3 describes key findings for these ICT uses in more detail.

ICTs for Sharing Information About Respite Care Services

In 4 of the programs (5/23 publications), the use of text and video information about local respite care services was explored for supporting information-sharing with families and respite care providers [6,12,20,28,35]. ICTs for information-sharing included using televisions and remote controls to share modules about "Getting a Break" [12,28]; and using websites [6,20,35], social media [35], or telephone helplines [6] to learn more about local respite care services. However, 2 papers noted that for information on respite care services, families often relied on recommendations from their friends or clinicians, more than they relied on ICTs like the internet [6,20].

ICTs for Recruiting and Training Respite Care Providers

Three programs (4/23 publications) used ICTs to support respite care provider recruitment and training [11,30,31,36]. One commentary briefly described the value of DVD materials for recruiting providers to serve ethnically diverse families [30]. Another research program studied the effectiveness of using a video-based training program to teach respite care skills to volunteers [11]. This program reported a mean improvement in the percentage of total correct responses on respite care skills questions after videotape training as between 35.5% and 47.6%, depending on the size of the training group [11]. Two publications described the creation of a CD and DVD training program to teach respite care students and staff how to provide high quality respite care services [31,36].

ICTs for Coordinating Respite Care Services

Nine programs (15/23 publications) studied the uses of ICTs for facilitating respite coordination [17-27,29,32-34]. Authors noted that mobile devices with features, such as texting, location-based tracking, and mobile payment options, could improve the accessibility and flexibility of services by making communication and scheduling between families, respite care managers, and respite care providers easier [19-21,26,29,32,35]. Other programs explored the potential for ICTs to make service planning more efficient. For instance, information-sharing through interagency databases could improve service efficiency by ensuring that agencies have up-to-date information on service usage, to efficiently allocate their agencies' resources [24,33,34]. Furthermore, several publications argued that ICTs, such as computerized databases, geographic information systems (GIS), and machine learning techniques, are often better at synthesizing large amounts of data than humans are. Authors suggested that these big data syntheses could be used for epidemiological studies and to predict and plan for community health initiatives, such as planning for different communities' respite care needs [22,23,25,27,34].

Design Considerations: Designing for Trust by Using Participatory Design Methods

Two key design considerations were noted across the research programs: the importance of designing for trust in the respite care services and their ICT platforms and the importance of using participatory design methods for developing these ICTs.

Designing for Trust in the Providers, Services, and ICT Platforms

These ICT programs emphasized that for a respite care ICT to be useful, end users had to trust in (1) the providers delivering the respite care, (2) the service being facilitated by the platform, and (3) the ICT platform itself.

Trust in the Competencies of the Providers

End users had to believe that respite care providers being coordinated through a respite care ICT platform were competent and safe. Trust in the providers could be facilitated by sharing providers' training experiences or institutional affiliations through the coordination platform [17,18].

The authors also emphasized that the ICTs should provide basic background information about the respite care service provider and the family receiving care, such as their care preferences and routines [17-19,21,26,29]. Easier communication with respite care agencies and providers using mobile devices and texting could further increase trust in the reliability and safety of respite care providers [17,19,21,26,29]. One program accomplished this through a quick check-in communication feature to facilitate communication between the family caregiver and respite care provider [19]. This program also recommended using elements of social matching (based on families' and providers' skills, preferences, and demographic features) to match the family with a suitable respite care provider [21]. Another program used the geo-location capabilities of ICTs to facilitate matching local and available respite care volunteers with families nearby in need of immediate respite care [32,37]. Other recommended features to engender trust in the programs' respite care providers included background checks of respite care providers, training

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in community care ethics, and training in the fundamental skills of providing personal care [17,18,24,26,32].

Trust in the Reliability of the Service

End users needed to trust that suitable respite care services could be scheduled easily and reliably through the ICT platforms [6,17,19,31]. ICT features to support such scheduling included embedding the following features within the ICT platforms: scheduling assistants, respite care to-do lists (with task prioritization highlighted), lists of care receivers' personal habits and family requirements for respite care services, and medical case files [19,26,29,32]. Features to enable calendar sharing, easy scheduling, and estimated arrival times also supported trust by helping to enhance the reliability of the service [19,32]. Additionally, a few programs recommended embedding a log feature to record respite care visit details and any additional notes or concerns for the family or future care providers to be aware of, to facilitate continuity of care [21,32].

Trust in the Data Privacy Standards and Usability of the Platform

Finally, end users had to trust in the data privacy standards and usability of the platform. End users needed to trust that their employees' or families' data recorded through the platform would remain protected and confidential [17,19,26,27,29,32,34]. Features to engender trust in ICT platforms included login modules that tracked where the sign-in occurred, and information exchange portals monitored by program administrators [21,26,29,32]. Two research programs suggested that for synthesizing large data sets of clients to plan services across respite care agencies, the patient or family data must first be deidentified [27,34]. End users also needed to trust that the platform would be useful and easy to use. For instance, 1 program added the option to leave voice recording notes as feedback, which was perceived as an easier input method than expecting users to type in notes [37]. To facilitate ease of use, the included programs particularly advocated the use of participatory design methods to build platforms that end users would trust.

Using Participatory Design Methods to Build Usable and Trusted Platforms

The importance of designing ICTs with and for the end users (ie, family caregivers, patients or care receivers, or health care managers) was either stated explicitly in the papers or implicitly in the methods of including end users from the study onset [12,17,19,27,29,31-34,36]. A user-centered approach was explicitly used in 2 of the research programs [12,19,28]. Iterative testing with end users was implemented by at least 2 programs, to ensure that ICT platforms met end users' needs [12,28,33,34].

A participatory approach was also evident in the designers' consideration of the users' comfort and ease with the technologies. Familiarity with the technology corresponded with end users' willingness to use a new ICT for supporting respite care services [17,20,28]. One program suggested that older adults and family caregivers would be willing to use ICTs that they perceive to be helpful to them, such as television sets, remote controls, and telephone technologies to provide information and support on local respite care services [28]. Similarly, Foley [27] concluded that for GIS to be beneficial to health care planners, the planners must have a basic knowledge of GIS capabilities. The authors suggested that if ICTs are developed using tools that are less familiar to the end users, then developers should expect to spend additional time and resources to appropriately and efficiently train these service users [27,33,34].

However, while user-centered design and partnerships were emphasized, only 1 of the publications discussed participation by patients [28]; most of the 15 ICT programs focused on family caregivers, respite care providers, and respite care managers as the end users.

Implementation Considerations for Respite Care ICTs

In addition to offering ICT design considerations, the 15 programs also offered considerations for successfully implementing the ICT platforms once they were developed. Specifically, the programs highlighted the importance of complementarity, timing, and promotion of respite care ICTs, to support ICT uptake.

Considering Complementarity of the ICTs With Existing Services

Authors and participants noted that the ICTs being implemented should be designed to complement existing in-person respite care services, rather than to replace these services [6,11,12,17,20,21,27]. Several publications suggest that ICTs should facilitate, not replace, in-person contact with health care providers [6,17,20]. Similarly, Abarca et al [17] and Campos-Romero et al [18] noted that initial face-to-face meetings between volunteer respite care providers and families might be needed before these end users would be comfortable using the ICT to further coordinate respite care.

Considering Timing and Family Readiness for Implementing the ICTs

Timing was an important factor in family caregivers' willingness to use ICTs for respite care information and services [6,20,28]. McSwiggan et al [20] and Hanson et al [28] highlighted that the success of ICTs for accessing respite care depended on the caregiver's stage of caregiving. For instance, at the early crisis stage of accepting the need for respite care, most caregivers relied on their social networks; they did not typically use ICTs or the Internet to find respite care information [20]. As they became more settled into their roles, caregivers also became more open to using ICTs [20]. Therefore, ICT developers must not only create the tool, but also assess when end users, such as respite care managers or families themselves, are most likely to be amenable to adopting the ICTs into their routines.

Considering Promotion Strategies to Raise Awareness for Respite Care and the ICTs

Efficient promotion of novel services was also essential for addressing families' needs for respite care and diminishing the burden of navigating ICT-based services [6,20]. The authors shared that when accessing respite care, caregivers often felt guilty or conflicted about needing these services, causing them to delay their search until a crisis occurred [6,20,21,28,31,36]. Once caregivers finally sought respite care, some found that

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adequate, flexible assistance was often difficult to find or unavailable [20,31]. Phillipson et al [6] concluded that launching a new ICT service was insufficient for supporting family caregivers and care receivers; frequent promotional strategies by the respite care services and primary health care providers are necessary when new ICTs are developed, to raise awareness of these respite care ICTs among families and care providers [6]. Such promotional strategies should include developers sharing the ICT links or platforms with families and health care providers; clinicians reminding families at regular primary care checkups that respite care services are available in their region; and clinicians reminding families that respite care services can improve both caregiver and patient well-being [6,20]. These strategies for promoting novel respite care services should be implemented as early in the caregiving journey as possible, so that families are made aware of resources before a crisis occurs [6,21].

Discussion

Overview

This scoping review analyzed 23 papers exploring how ICTs can support the provision of respite care services, providing a foundational map of the literature on respite care ICTs. The following discussion will compare our results to findings in related literature on ICTs for supporting other community health services. We will also discuss implications for future health care strategies and research on respite care ICTs.

ICT Uses in Related Caregiving Services

Our scoping review found that ICTs can be used to support information-sharing about local respite care services with families and care providers, helping to raise awareness of existing services. Similarly, a cross-sectional questionnaire study of ICT-mediated support for family caregivers in the paid workforce found that 76.8% (86/129) of caregivers reported that access to information through the Internet about family caregiving support services was very valuable to them [38]. Another scoping review on ICT and non-ICT support for employed family caregivers also found that ICTs can be used to support information-sharing on caregiver supports like respite [39]. Therefore, our results add to the growing body of knowledge that ICTs may be particularly beneficial for supporting family caregivers by making information on respite care services more accessible.

ICTs can also support the building of caregiving skills, by offering more flexible and remote training structures than in-person training allows for. For example, ICTs, such as e-learning platforms and SMS text messaging have been found to be useful modalities for offering health care provider training in palliative care skills and supporting knowledge retention [40]. Thus, our results show that ICTs can be used for respite care skills training aligned with previous work in this area.

Finally, our review found that a common use of ICTs was for facilitating respite care coordination. Other researchers have also argued that ICTs can be used to support family caregiving by facilitating the coordination of caregiving support services [39,41]. Coordination support for home care nursing include easy SMS text messaging or calling members of the care team, as well as storing information on the care receiver's health care status and caregiving support needs. This information could then be accessed digitally by new health care providers using secure ICT platforms [39]. Spann et al [39] did not mention the coordination of respite care directly in this context, but their results are likely transferred to the coordination of respite care services, which are a specific type of home care service. Furthermore, Andersson et al's [38] study of ICT- and non–ICT-mediated caregiver supports found that family caregivers valued having assistance with planning and care coordination; yet, 79.4% of respondents did not receive such support from their care teams. Combined, our review and these other studies highlight the potential benefits of using ICTs to share information, provide training, and coordinate services to better support family caregiving.

Design and Implementation Considerations for Related ICTs and Services

Design considerations for respite care ICTs identified in this study emphasized the need for trust, as well as the need for participatory design methods. Without trust in the respite care services, providers, and ICT platforms, family caregivers will not use the available resources [4,41,42]. In a recent scoping review on the challenges of using ICTs to support family caregiving, Hassan [43] concluded that facilitating trust in ICT was an important factor for successful ICT deployment. Trust in an ICT platform could be facilitated in a variety of ways, such as by working with end users and medical experts to co-design the ICTs, by teaching these end users how to assess the quality of health care ICTs, and by integrating the ICTs with complementary nondigital interactions (eg, face-to-face meetings) [43]. Furthermore, without participatory design methods, ICTs may be designed that do not actually meet the needs of family caregivers, health care workers, and care receivers; or that are not easy and efficient for these end users to use [8,43]. Thus, the conclusions of our scoping review on the importance of designing for trust with end users, and of using participatory design methods when designing respite care ICTs, are corroborated by external literature on ICTs for supporting caregiving.

Our review also found that if ICT developers did not plan for successful implementation within the existing health care context, well-designed ICTs might also not be taken up. Authors warned that ICT implementation was likely to fail for three reasons: (1) the ICT did not complement existing services, (2) it was not introduced to families at the appropriate times, and (3) it was inadequately promoted to existing services and families. Three other reviews on ICTs to support family caregiving also concluded that ICTs should complement, not replace, face-to-face services because families often feel that they uniquely benefit from face-to-face interactions with caregiving peers and health care teams [8,39,43]. Furthermore, respite care support, including ICT-based respite care tools, must be frequently promoted to family caregivers for early uptake, so that families have respite care resources in place before caregiving crises [1,39]. For ICTs to support these health care services, they must also be implemented with strategies to

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raise awareness of these programs among clinicians, families, and other stakeholders [43].

These design and implementation findings also speak to the importance of clinical-academic partnerships in ICT development for respite care [44]. Clinicians know that family caregivers and patients need more flexible and efficient respite care services [1,3]. Nurse clinicians can inform the design of complementary and useful ICT supports, which these clinicians can then promote with families and colleagues in their practices [43,44]. Furthermore, clinicians are best placed to assess timing and promotion of services that might help families. Clinicians should regularly update their knowledge of existing respite ICTs for families, frequently assess families' readiness for such services, and regularly promote these services [2,39].

Future Research Opportunities for Respite Care ICTs

There is limited but promising research on ICTs in respite care, as evidenced by the inclusion of only 23 papers despite our expansive search. Several of the papers touched on the same ICT respite care programs as other papers, with only 15 unique programs discussed. The studies often had small sample sizes and no control groups, as they were focused on ICT design and brainstorming with participants, rather than on conducting rigorous evaluations of the effects of ICT programs on respite care service outcomes. Such outcomes could include effects on caregiver and patient quality of life, service efficiency, or cost-effectiveness. Future research should not only describe the potential of ICTs to support respite care services but also evaluate the effectiveness of these programs in doing so.

Furthermore, ICTs have the potential to synthesize massive amounts of data. Yet, little work has been done to date to explore the potential of computerized data science tools (eg, GIS, machine learning) to facilitate the accessibility and delivery of respite care services using large health care data sets. Other technology evidence gaps in the academic literature include limited discussions of the potential of social media to support respite care information-sharing, training, and coordination; and little discussion of the use of ICTs for remote notification reminders of existing services. Given the importance that family caregivers placed on learning about respite care services from their peers and clinicians identified in our review [6,20], social media platforms may be important sources of peer-to-peer learning about caregiving support services [40]. Additionally, there was no discussion of ICT use for reminding families of available respite care services, such as using app notifications to remind families about the importance of beginning respite care services early in the caregiving role or to notify families of new respite services in their regions. Future research should build on these works to rigorously design and test the feasibility of smartphone apps for improving direct respite care coordination.

Finally, the participant demographics were relatively homogenous—the average age of included participants was often over 50 years and mostly focused on ICT support services to caregivers of aging adults. ICTs should be explored for their potential to support other specialized forms of respite care services, such as supporting families coping with cancer diagnoses, or families of younger adults with severe mental health challenges. Future research should consider the different perspectives of younger caregivers and care receivers and who will be using ICT-facilitated caregiving support services for many years to come [18,45,46]. Furthermore, only 1 program discussed care receivers as the participants or end users. For respite care ICT research to be truly user-centered in the designs and implementations, the perspectives of patients and care receivers should be included, as well [41,43,47,48].

Strengths and Limitations

This review adhered to the most recent JBI scoping review methodology [14], and it was conducted across 6 library databases, allowing for a broad search and inclusion of relevant papers. Due to time and resource constraints, and several iterations of the protocol, we did not submit a protocol for this scoping review for publication [14]. However, we did submit a PRISMA checklist to support the rigor of our methods (Multimedia Appendix 1).

The original search was conducted in October 2019, and fully updated across the 6 databases in January 2022, making the comprehensive search for this review just over 1 year. The January 2022 search only returned 1 new manuscript. In February 2023, an abbreviated search was conducted across MEDLINE (through OVID), and limited to publications since January 1, 2022, using the following subject headings and search terms: (exp respite care/OR respite.tw,kf) AND (exp technology/OR (info* and communication* technolog*).tw,kf OR digital health.tw,kf). In MEDLINE, this search retrieved 4 references, none of which met the inclusion criteria. We conducted a similar search across CINAHL, and none of the retrieved references were eligible. Given these results and the limited resources of our team, we decided it would not be beneficial to reupdate the entire search.

The focus of this review on the academic literature means that the results of the included papers are evidence-based, reducing some of the risks of translating the conclusions of this review to clinical settings. However, by only searching academic databases, we may have missed uncatalogued but relevant gray literature (such as policy documents, or existing respite care smartphone apps). A forthcoming app store search study by our research team will help to address the latter limitation [49]. Finally, by keeping the search focused on the concept of "respite," we may have missed literature that included respite but that was categorized under broader concepts, such as "palliative care" or "home care." However, other systematic reviews on ICTs for palliative care [40,50] and ICTs for home care [8,51] have previously been conducted, offering complementary knowledge syntheses to this scoping review.

Conclusions

This scoping review study adds to the bodies of academic literature on respite care services and ICTs by being the first study to offer an overview of the intersection of these 2 areas. This review establishes that there is limited but promising research on the potential uses of ICTs to support the provision of in-person respite care, by facilitating information-sharing, coordination, and training. However, for such ICTs to be successfully launched, they must be co-designed to engender

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trust, and they should be implemented with consideration for contextual concerns like complementarity, timing, and promotion. Additional research should be conducted to advance these conclusions and build ICTs for services that are designed with and for families needing respite care services, alongside the respite care organizations that serve these families. Patients and family caregivers want more flexible, trusted, and efficient respite care services; further research in this area should develop respite care ICTs to fulfill these needs.

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Authors' Contributions

ARC, LOB, AQ-V, AA, and AT designed the study. ARC, LOB, QC, and AP collected the data. ARC, LOB, AA, and AP analyzed the data. All authors contributed to writing the manuscript, finalizing the discussion points, and approving the final submission.

Conflicts of Interest

None declared.

Multimedia Appendix 1
PRISMA-ScR checklist for scoping reviews.
[DOCX File , 61 KB - nursing_v6i1e44750_app1.docx]

Multimedia Appendix 2
Search strategy for library database, MEDLINE.
[DOCX File , 48 KB - nursing_v6i1e44750_app2.docx]

Multimedia Appendix 3
Summary of 15 programs described in the 23 publications.
[DOCX File , 98 KB - nursing_v6i1e44750_app3.docx]

Multimedia Appendix 4
Examples of raw data coded into categories addressing the research questions.
[DOCX File , 59 KB - nursing_v6i1e44750_app4.docx]

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Abbreviations

GIS: geographic information system
ICT: information and communication technology
PCC: participant, context, concept
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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Review

Nurses' Roles in mHealth App Development: Scoping Review

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Abstract

Background: Although mobile health (mHealth) apps for both health consumers and health care providers are increasingly common, their implementation is frequently unsuccessful when there is a misalignment between the needs of the user and the app's functionality. Nurses are well positioned to help address this challenge. However, nurses' engagement in mHealth app development remains unclear.

Objective: This scoping review aims to determine the extent of the evidence of the role of nurses in app development, delineate developmental phases in which nurses are involved, and to characterize the type of mHealth apps nurses are involved in developing.

Methods: We conducted a scoping review following the 6-stage methodology. We searched 14 databases to identify publications on the role of nurses in mHealth app development and hand searched the reference lists of relevant publications. Two independent researchers performed all screening and data extraction, and a third reviewer resolved any discrepancies. Data were synthesized and grouped by the Software Development Life Cycle phase, and the app functionality was described using the IMS Institute for Healthcare Informatics functionality scoring system.

Results: The screening process resulted in 157 publications being included in our analysis. Nurses were involved in mHealth app development across all stages of the Software Development Life Cycle but most frequently participated in design and prototyping, requirements gathering, and testing. Nurses most often played the role of evaluators, followed by subject matter experts. Nurses infrequently participated in software development or planning, and participation as patient advocates, research experts, or nurse informaticists was rare.

Conclusions: Although nurses were represented throughout the preimplementation development process, nurses' involvement was concentrated in specific phases and roles.

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KEYWORDS

mobile health; mHealth; mobile app; product development; software design; scoping; search strategy; nursing; health app; mobile app; nurse; nursing; allied health; development; design; software; scoping literature review; scoping review; app; sensor; wearable; software development; mobile phone

Introduction

Background

More than 350,000 mobile health (mHealth) apps are available in major app stores worldwide, including medical, health care, and fitness apps [1]. Although there is no standardized definition of mHealth, it broadly refers to health care supported by mobile and wireless devices to deliver, educate, and exchange health care information and monitor and promote health conditions or behaviors [2-4]. Many of these apps are focused on condition management, such as mental and behavioral health disorders, diabetes, and heart and circulatory system conditions [1]. One survey of American adults who had used an mHealth app found that approximately 70% of them had used it to keep track of their health, 39% to obtain health information, and 25% to share health information with their providers [5]. A Pew Research Center study reported that 62% of smartphone users used their devices to gather health-related information [6], and 90% of physicians used smartphones at work to access electronic health records, communicate with their team, reference information, or manage their schedule [7]. Similar to physicians, many nurses use apps for professional purposes [8].

Despite the ubiquity of mHealth apps for health care consumers and providers, health information technology implementation is frequently unsuccessful [9]. Previous research has found that apps may not align with end-user behavior and organizational needs, essentially showing a mismatch between how the app is designed to function and how the intended end user expects it to work [10-12].

Nurses are uniquely positioned to help address the challenge of this mismatch. The American Nurses Association Code of Ethics for Nurses includes multiple provisions emphasizing the centrality of the patient in health care, stating that "[t]he nurse's primary commitment is to the patient" and that "[t]he nurse promotes, advocates for, and protects the rights, health, and safety of the patient" [13]. Integrating nurses as product development team members brings this patient-centered perspective to the development process. It has the potential to create apps that contain validated, current evidence-based health-related content that is meaningful to end users. Nurse informaticists, in particular, can ensure that the usability and features of the app are relevant for all end users and are incorporated into clinical workflows, leveraging interoperability standards [14].

Despite this potential, the extent to which nurses are involved in all aspects of the development process remains unclear. A thorough understanding of the role of nurses in mHealth app development is critical for several reasons. The first and most essential is that nursing professionals represent the largest segment of the health care workforce, spend the most time with patients, and coordinate all aspects of patient care [15]. Previous research has found that physicians in the intensive care unit spend 15% to 18% of their time with patients, whereas nurses in the same study spent 33% of their time in patient rooms and an additional 11% to 12% of their time directly outside patient rooms [16]. A longitudinal study of hospital nurses found that nurses spend 37% of their time with patients, and that direct care, indirect care, medication management, and communicating with other health professionals consumed >76% of the nurses' time [17]. Therefore, nurses have a holistic view of health care processes and are keenly aware of what problems need to be solved.

Objectives

To better understand nurses' role in mHealth app development, this scoping review aims to determine the extent of the evidence regarding the role of nurses in app development and describe the apps nurses are involved in developing by answering the following research questions: (1) what role or roles do nurses perform in mHealth app development? (2) in what phases are nurses involved in mHealth app development? and (3) what type of apps are nurses involved in developing?

Methods

Overview

A scoping review was selected as the appropriate methodology, as the objectives of the project were to determine the extent of the evidence and to identify gaps in the existing literature, both of which were identified by Arksey and O'Malley [18] as the rationale for a scoping review [18]. This review followed the 6-stage methodology proposed by Levac et al [19]: (1) identifying the research question, (2) identifying all relevant publications, (3) selecting studies using inclusion and exclusion criteria, (4) charting the data to be extracted from each study, (5) synthesizing the data, and (6) reporting results. As the research questions of interest are described in the *Objectives* section, the *Methods* section will outline stages 2 to 5. The protocol for this scoping review was registered in Open Science Framework [20].

Identifying Relevant Publications

We conducted an extensive search combining natural language and controlled vocabulary searching to capture the concepts of mHealth, app development, and nurses. We defined an mHealth app as a portable device that must interface with a patient or consumer and facilitate the information and data collection and delivery. It may interface with sensors, wearables, or cameras and may be connected to the internet. It includes health-related data and may assist with clinical decision-making. We defined app development as 1 of the first 5 phases of the Software Development Life Cycle (SDLC): planning, gathering requirements, design and prototyping, software development, and testing [21]. Planning includes allocating resources, scheduling the project, and determining costs. Requirements gathering engages subject matter experts (SMEs), technology

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specialists, and others to understand the necessary elements of the tool. Design and prototyping involve rapid preliminary prototyping to identify possible technical solutions. Software development advances the app from prototype to functional software. Finally, testing before deployment ensures that the app is fully operational and ready to be implemented in production. We chose to focus on these preimplementation phases of development, as nurses' roles in implementation and adoption have been more fully explored in previous systematic reviews [22-24]. Health care providers included all licensed nurses, those in training to become nurses, subject matter nurse experts and health information technology nurse experts.

A librarian conducted the search across 14 databases: CINAHL via EBSCO, Cochrane via Wiley, Compendex via Engineering Village, Education Source via EBSCO, Embase via Ovid, ERIC via EBSCO, Global Index Medicus, Google Scholar, IEEE Xplore, MEDLINE via Ovid, PsycINFO via Ovid, PubMed, Scopus, and Web of Science Core Collection. The selected databases were chosen to represent an array of subject areas, including nursing, medicine, psychology, psychiatry, education, computer science, and engineering. Broad, multidisciplinary databases, such as Clarivate's Web of Science Core Collection, Elsevier's Scopus, and Google Scholar, were selected because of their coverage of nonarticle research outputs, such as conference papers and abstracts. A complete search strategy is presented in Multimedia Appendix 1. No restrictions were placed on the language, geography, or study design. The search was restricted to items published since 2016 to focus on the most recent developments in this field. The search was conducted in April 2021 and was updated in April 2023. To ensure that no potentially relevant studies were overlooked, we also hand searched the reference lists of the included publications. The results were compiled and deduplicated in EndNote (Clarivate).

Selecting Studies

Items were first reviewed as titles and abstracts, followed by a full-text screening phase. A total of 2 independent researchers reviewed every item using Rayyan, a web-based tool that facilitates screening [25]. During the initial piloting phase, discrepancies were discussed as a group to establish a shared understanding of criteria and aims. Following this initial phase, a third researcher resolved discrepancies. We excluded publications that did not include an mHealth app, did not reference nurse involvement, did not include one of the relevant SDLC phases, or were published before 2016. We excluded review papers, including systematic reviews, and papers describing or reviewing previously developed apps. These exclusion criteria were used during the project's title-abstract screening and full-text screening phases. Items retrieved through hand searching followed the same screening process and used the same inclusion and exclusion criteria. During the full-text screening phase, reasons for exclusion were recorded and reported in a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram.

Charting the Data

A total of 2 reviewers extracted data from each article into REDCap (Research Electronic Data Capture; Vanderbilt University), a secure web-based data capture and management platform [26]. We used this platform to gather the following data: the SDLC phase or phases included in the publication, the role of the nurse in any of the phases, details regarding the app, and bibliographic details of the publication. Details regarding the app included the primary and secondary users, meaning the intended audience and other individuals who could engage with the app such as for data entry; the functionality of the app; the version of the app; and the condition or purpose of the app. The app's functionality was identified using the IMS Institute for Healthcare Informatics functionality scoring system [27], a well-established scale for functionality assessment [28-30]. The IMS Institute for Healthcare Informatics functionality scoring system consists of 7 main categories and 4 subcategories, and the overall functionality score, between 0 and 11, is calculated by summing the scores across individual items, where 1 indicates presence and 0 indicates absence. Where the publication was in a language not spoken by the research team members, Google Translate was used to create an English-language translation, as Google Translate had been previously found to have a high level of accuracy when used to facilitate data extraction in evidence synthesis [31].

Synthesizing the Data

After data extraction was completed, the findings were summarized according to the 3 research questions. Descriptive statistics were used to assess the frequency of roles, phases according to the SDLC, and the co-occurrence of specific roles and phases. The summary of the description of the apps included the IMS functionality, the condition of interest or purpose of the app, the primary and secondary users, the version of the app, and whether technical or content standards were used during the development of mHealth apps.

Results

Overview

We retrieved 5483 items through database searching, 2492 (45.45%) of which were duplicates, resulting in 2991 (55.55%) items being screened at the title-abstract level. Following the title-abstract screening, 11.03% (330/2991) of the items were reviewed in full text, leading to 4.88% (146/2991) of publications that met the inclusion criteria [32-176]. Hand searching of reference lists identified additional 8.5% (11/130) of publications [177-187], resulting in 2.8% (157/5613) of included publications. There were 0.4% (22/5483) of items in the title-abstract screening phase that could not be retrieved for full-text screening through the resources available via any of the institutions or via interlibrary loans. Reasons for exclusion are presented in Figure 1.

The characteristics of the included studies are summarized in Table 1. Of the 157 included publications, 132 (84.1%) either described usability testing or were original research papers [32-49,51,52,55,56,58-65,67-75,77-81,83,85-87,89-107,110,112-117,119-124,126,129,130,132-134,136,138,140-145,147-160,162-169,171-173,175-187].

Of the 157 publications, 8 (5.1%) were conference abstracts [76,82,125,137,161,170,174,188], 7 (4.5%) were case reports [84,108,111,118,127,128,146], and 3 (1.9%) were commentaries

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or editorials [66,88,135]. The remaining publications (7/157, 4.5%) were protocols or descriptions of theoretical frameworks [50,53,54,57,109,130,139]. A total of 34 countries were represented in the publications, most frequently Brazil (29/157, 18.5%) [36,37,40,45,48,60,61,65,70,83,87,114,115,117,120,134,136,138,142,143,152-154,157,163,165,177,182,183], the United States (26/157, 16.6%) [33,38,41,42,44,47,54,57,66,68,69,71,76,81,89,97,102,103,107,113,121,132,160,164,170,181], South Korea (10/157, 6.4%) [56,58,101,105,118,133,149,156,180,184], and China (9/157, 5.7%) [90,95,110,127,167,172,173,176,186].

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

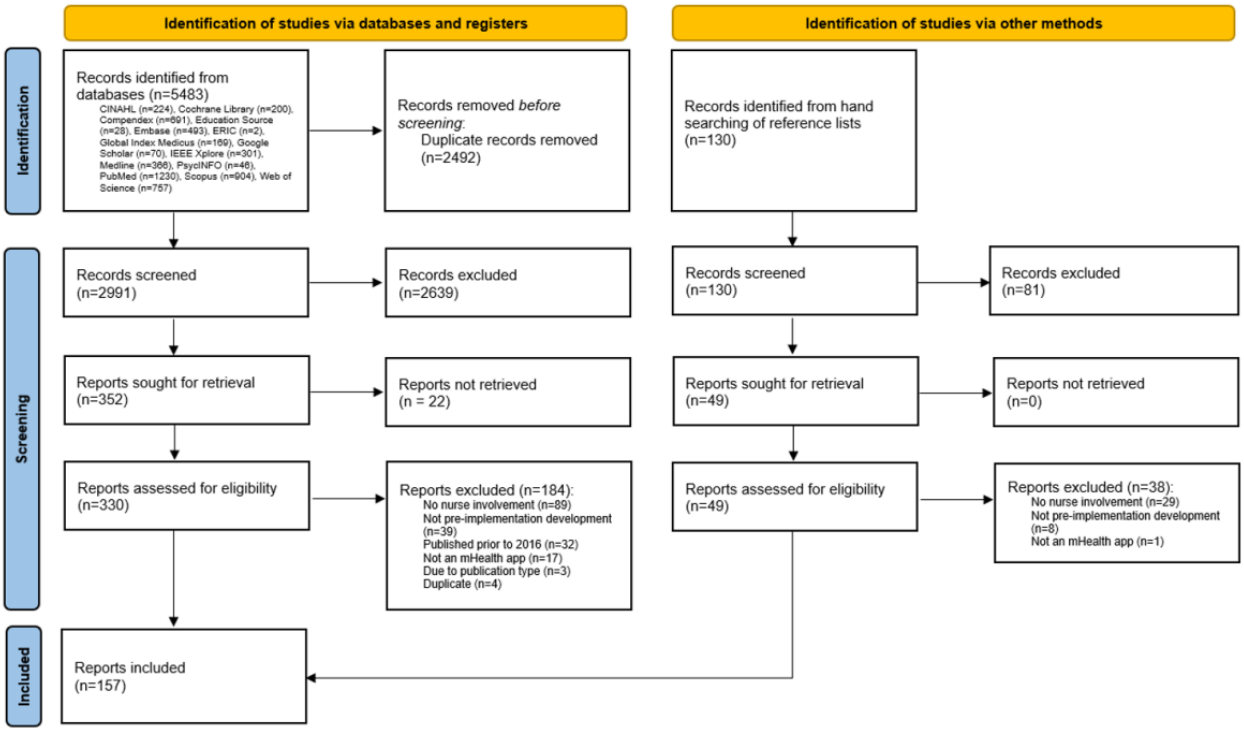

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Table 1. Characteristics of the included studies.

Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Abbasi et al [32], 2023	Usability testing (Iran)	Medication dosage or ICU[a] (nurse)	Requirements and design and prototyping	Evaluator and informant or SME[b]	1
Achury Saldaña et al [145], 2021	Research (Colombia)	Heart failure (client or patient)	Design and prototyping and testing	Evaluator	5
Adib et al [33], 2022	Usability testing (United States)	Pediatric transplantation (caregiver)	Planning, requirements, design and prototyping, software development, and testing	Evaluator and informant or SME	7
Alexandrou et al [34], 2021	Research (Sweden)	Childhood obesity prevention (caregiver)	Requirements and design and prototyping	Evaluator and informant or SME	5
Alhodaib et al [35], 2020	Usability testing (United Kingdom)	Diabetes or chronic kidney disease (nurse and nonnurse provider)	Requirements, design and prototyping, and testing	Evaluator and informant or SME	7
Alves et al [36], 2021	Usability testing (Brazil)	Sexual violence care (nurse and nonnurse provider)	Requirements and design and prototyping	Evaluator and informant or SME	3
Alves et al [37], 2022	Usability testing (Brazil)	COVID-19 (nurse)	Requirements, design and prototyping, and testing	Evaluator and informant or SME	2
Anderson et al [38], 2021	Usability testing (United States)	Oncology (patient)	Testing	Research expert, patient advocate, and distributor	7
Andrades-González and Molina-Mula [39], 2022	Research (Spain)	Stroke (caregiver)	Requirements and design and prototyping	Evaluator, informant or SME, and research expert	2
Araujo et al [40], 2019	Usability testing (Brazil)	Neonatal care or NICU[c] (nurse)	Requirements and testing	Evaluator and informant or SME	5
Aronson et al [41], 2021	Usability testing (United States)	Neonatal care (caregiver)	Requirements, design and prototyping, software development, and testing	Evaluator and informant or SME	5
Athilingam et al [42], 2016	Research or usability testing (United States)	Heart failure (client or patient)	Design and prototyping and software development	Content developer, designer or creator, evaluator, and research expert	2
Austin et al [43], 2022	Usability testing (Netherlands)	Oncology (client or patient)	Requirements, design and prototyping, and testing	Informant or SME, patient advocate, and evaluator	8
Awan et al [44], 2018	Usability testing (United States)	EHR[d] documentation (nurse)	Testing	Evaluator	5
Barbosa de Lira et al [45], 2020	Research or usability testing (Brazil)	Older adults' care (caregiver)	Design and prototyping and testing	Content developer, designer or creator, and evaluator	2
Barros et al [177], 2019	Research (Brazil)	Consciousness level assessment (student nurse)	Design and prototyping and testing	Evaluator and informant or SME	1
Benda et al [46], 2022	Usability testing (Myanmar)	Population health surveillance (nurse)	Requirements and design and prototyping	Evaluator and informant or SME	3
Berg et al [47], 2021	Research (United States)	Medication errors (nurse)	Testing	Research expert and evaluator	4
Bonifácio et al [48], 2021	Research (Brazil)	COVID-19 (client or patient)	Requirements	Evaluator	1

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Bootsman et al [49], 2019	Usability testing (Netherlands)	Lower back posture (nurse and nonnurse provider)	Requirements, design and prototyping, software development, and testing	Evaluator and informant or SME	5
Børøsund et al [178], 2018	Research (Norway)	Mental health or oncology (client or patient)	Requirements, software development, and testing	Evaluator and informant or SME	7
Borycki et al [50], 2016	Theoretical framework (Canada, Australia, and Finland)	Nursing education (nurse, nonnurse provider, and student nurse)	Planning and requirements	Informant or SME	NR[e]
Broderick et al [188], 2016	Abstract (Ireland)	Pediatric hematology or oncology (caregiver and nurse)	Requirements, design and prototyping, software development, and testing	Content developer and informant or SME	2
Buinhas et al [51], 2019	Usability testing (Portugal)	Type 2 diabetes (client or patient)	Design and prototyping, software development, and testing	Evaluator and patient advocate	7
Calvillo-Arbizu et al [52], 2019	Usability testing (Spain)	Chronic kidney disease (caregiver, client or patient, nurse, and nonnurse provider)	Requirements, design and prototyping, software development, and testing	Evaluator and informant or SME	9
Castro et al [53], 2022	Protocol (Canada)	Palliative care or oncology (caregiver)	Requirements and design and prototyping	Evaluator and informant or SME	NR
Chalela et al [54], 2021	Protocol (United States)	Breast cancer (client or patient)	Requirements	Informant or SME	NR
Chávez et al [55], 2019	Usability testing (Mexico)	Alzheimer disease and dementia (nurse, nonnurse provider, and other)	Requirements, design and prototyping, and testing	Evaluator and informant or SME	4
Cho and Lee [56], 2017	Research or usability testing (South Korea)	Surgical safety (client or patient)	Requirements, design and prototyping, software development, and testing	Content developer, designer or creator, evaluator, informant or SME, distributor, and research expert	2
Choi et al [57], 2018	Theoretical model (United States)	Breast cancer or pain (client or patient)	Design and prototyping and testing	Content developer and designer or creator	4
Choi et al [58], 2021	Usability testing (South Korea)	Coronary artery disease (client or patient)	Requirements and design and prototyping	Content developer, evaluator, and informant or SME	6
Costa et al [59], 2021	Usability testing (Portugal)	Nursing home care (nurse and nonnurse provider)	Requirements	Informant or SME	7
Cruz et al [60], 2021	Usability testing (Brazil)	Breast cancer (client or patient)	Design and prototyping	Evaluator and informant or SME	5
da Silva et al [61], 2021	Usability testing (Brazil)	Blood donation (client or patient)	Requirements	Evaluator and informant or SME	4
de Dicastillo et al [62], 2019	Research or usability testing (Spain)	Surgery (client or patient and nurse)	Testing	Evaluator	5
de Dios et al [63], 2022	Usability testing (Spain)	HIV (client or patient)	Requirements and design and prototyping	Evaluator and informant or SME	7
de Jong et al [64], 2017	Research or usability testing (Netherlands)	Inflammatory bowel disease (client or patient, nurse, and nonnurse provider)	Requirements, design and prototyping, and testing	Evaluator and informant or SME	9
de Sousa et al [65], 2022	Usability testing (Brazil)	Heart failure (client or patient)	Design and prototyping	Evaluator	2

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
DeLemos [66], 2017	Briefs, commentaries, and editorials (United States)	Brain and nervous system diseases (nurse)	Software development	Not specified	3
Derksen et al [67], 2021	Usability testing (Netherlands)	Smoking cessation or pregnancy (client or patient)	Requirements and design and prototyping	Evaluator and informant or SME	5
Dodson and Layman [68], 2022	Usability testing (United States)	Pharmacogenomics or oncology (nurse)	Design and prototyping	Evaluator	4
Dodson and Layman [69], 2023	Usability testing (United States)	Pharmacogenetics (nurse)	Design and prototyping	Informant or SME	4
Duarte and Mandetta [70], 2022	Usability testing (Brazil)	Pediatric oncology or stem cell transplantation (caregiver and client or patient)	Design and prototyping	Evaluator	2
Durham et al [71], 2023	Research (United States)	Bladder exstrophy-epispadias-cloacal exstrophy complex (caregiver and client or patient)	Requirements	Research expert	2
Dürr et al [72], 2020	Usability testing (Germany)	Patient transfer safety (nurse)	Planning, requirements, and testing	Designer or creator, informant or SME, and evaluator	6
Ehrler et al [73], 2019	Research or usability testing (Switzerland)	Bedside care (nurse)	Requirements, design and prototyping, and testing	Evaluator and informant or SME	4
Ehrler et al [74], 2021	Research and usability testing (Switzerland)	Emergency department patient management (nurse and nonnurse provider)	Requirements and design and prototyping	Evaluator and informant or SME	3
Ekstedt et al [75], 2021	Usability testing (Sweden)	Chronic disease or older adults' care (client or patient)	Requirements and design and prototyping	Evaluator and informant or SME	7
El-Jawahri et al [76], 2018	Abstract (United States)	Acute myeloid leukemia (client or patient)	Requirements and design and prototyping	Not specified	2
Elsayed Rashed et al [77], 2022	Research (Egypt)	EHR (student nurse)	Planning, requirements and design and prototyping	Evaluator and informant or SME	3
Elsbernd et al [78], 2018	Usability testing (Denmark)	Pediatric oncology (client or patient)	Planning, requirements and design and prototyping	Content developer and designer or creator	7
Escalada-Hernández [79], 2019	Usability testing (Spain)	Medical devices (nurse and nonnurse provider)	Requirements, design and prototyping, and software development	Evaluator and informant or SME	2
Esteves et al [80], 2019	Usability testing (Portugal)	Nursing home care (nurse and nonnurse provider)	Planning, requirements, and testing	Evaluator and informant or SME	5
Feldman et al [81], 2022	Usability testing (United States)	Immunizations or pediatric transplantation (caregiver and client or patient)	Planning, requirements, and design and prototyping	Informant or SME	6
Fernandez-Ortega et al [82], 2018	Abstract (Spain)	Chemotherapy-induced nausea and vomiting (client or patient and nurse)	Testing	Evaluator	NR
Ferreira et al [83], 2021	Usability testing (Brazil)	Nursing education (nurse)	Planning, requirements, and testing	Evaluator and informant or SME	2
Ferrua et al [84], 2020	Case report (France)	Oral cancer (client or patient and nurse)	Planning, requirements, and design and prototyping	Evaluator and informant or SME	9
Firdaus et al [85], 2022	Research and usability testing (Malaysia)	Diabetes (client or patient)	Planning and design and prototyping	Evaluator and informant or SME	2

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Flohr et al [86], 2018	Usability testing (Canada)	Patient safety or ICU (nurse and nonnurse provider)	Planning, requirements, and design and prototyping	Evaluator and informant or SME	9
Franco et al [87], 2022	Research and usability testing (Brazil)	Pediatric oncology or medication management (client or patient)	Design and prototyping and testing	Evaluator	4
Fraser [88], 2018	Briefs, commentaries, and editorials (New Zealand)	Pediatric mental health (client or patient, nurse, and nonnurse provider)	Design and prototyping	Content developer, designer or creator, and evaluator	5
Gallimore et al [89], 2022	Usability testing (United States)	Urinary tract infections or COVID-19 (nurse)	Requirements	Informant or SME and research expert	6
Gao et al [90], 2020	Research or usability testing (China)	Pediatric mental health or pediatric oncology (caregiver, client or patient, nurse, and nonnurse provider)	Requirements, design and prototyping, and testing	Evaluator and informant or SME	5
Garne Holm et al [91], 2017	Usability testing (Denmark)	Neonatal care (caregiver, nurse, and nonnurse provider)	Requirements, design and prototyping, and testing	Evaluator and informant or SME	10
Given [92], 2017	Usability testing (Ireland)	Blood transfusion (nurse)	Planning, requirements, and design and prototyping	Content developer, designer or creator, and evaluator	6
Görtz et al [93], 2023	Usability testing (Germany)	Surgery (client or patient)	Design and prototyping	Evaluator and informant or SME	3
Grover et al [94], 2020	Usability testing (Botswana)	Oncology (nurse and nonnurse provider)	Testing	Evaluator	6
Guo et al [95], 2022	Research and usability testing (China)	Nutrition or macular degeneration (client or patient)	Requirements	Informant or SME	NR
Gutiérrez-Puertas et al [96], 2021	Research or usability testing (Spain)	Basic and advanced life support (student nurse)	Design and prototyping and testing	Evaluator	1
Harte et al [179], 2017	Research (Ireland)	Fall risk or older adults' care (client or patient)	Testing	Evaluator	4
Herbert et al [97], 2021	Research (United States)	Heart failure (student nurse)	Testing	Evaluator	2
Hjorth-Johansen et al [98], 2022	Usability testing (Norway)	Severe cardiac disease or pediatrics (caregiver)	Requirements and testing	Evaluator and informant or SME	7
Hochstenbach et al [99], 2017	Usability testing (Netherlands)	Oncology or pain (client or patient and nurse)	Planning, requirements, and design and prototyping	Evaluator and informant or SME	11
Iyengar et al [100], 2021	Usability testing (Fiji)	Mental health (client or patient and nurse)	Design and prototyping and testing	Evaluator	3
Jeon et al [101], 2016	Research or usability testing (South Korea)	Metabolic syndrome (client or patient)	Requirements, design and prototyping, and testing	Content developer, designer or creator, and evaluator	10
Jones et al [102], 2017	Usability testing (United States)	Urinary tract infections (nurse and nonnurse provider)	Planning, requirements, design and prototyping, and testing	Evaluator and informant or SME	6
Keegan et al [103], 2016	Research (United States)	Neonatal care (student nurse)	Testing	Evaluator	2
Kho et al [104], 2019	Usability testing (Singapore)	Type 2 diabetes (client or patient)	Planning, requirements, design and prototyping, software development, and testing	Content developer, evaluator, and informant or SME	6

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Kim et al [105], 2022	Usability testing (South Korea)	Peripheral artery disease (client or patient)	Requirements and testing	Evaluator and distributor	8
Kovach and Pollonini [107], 2022	Research (United States)	Pressure injuries (nurse)	Requirements and design and prototyping	Evaluator and informant or SME	6
Kurscheidt et al [108], 2022	Case report (Ireland)	Cystic fibrosis (client or patient)	Requirements	Informant or SME	8
Laranjeira et al [109], 2022	Protocol (Portugal)	Palliative care (caregiver and client or patient)	Requirements	Informant or SME	3
Lee and Kim [180], 2018	Research (South Korea)	Neonatal care or breastfeeding (client or patient)	Design and prototyping and testing	Evaluator	4
Lefco et al [181], 2017	Usability testing (United States)	Asthma (caregiver)	Requirements	Informant or SME	7
Liu et al [110], 2017	Usability testing (China)	Breast cancer (client or patient)	Planning, requirements, and design and prototyping	Content developer, designer or creator, evaluator, and informant or SME	1
Mallet et al [111], 2021	Case report (Canada)	Influenza (client or patient and nurse)	Design and prototyping	Evaluator	NR
Marino et al [112], 2022	Research (United Kingdom)	Nutrition or pediatrics (nurse and nonnurse provider)	Design and prototyping	Evaluator	6
Markossian et al [113], 2021	Usability testing (United States)	Chronic kidney disease (client or patient)	Design and prototyping	Evaluator and informant or SME	7
Melo et al [115], 2020	Usability testing (Brazil)	Nursing history and diagnosis (nurse and student nurse)	Design and prototyping	Evaluator	4
Miller et al [116], 2020	Usability testing (United Kingdom)	Colorectal cancer surgery (client or patient, nurse, and nonnurse provider)	Requirements and design and prototyping	Evaluator and informant or SME	10
Miranda and Salomé [117], 2022	Research (Brazil)	Pressure injuries (nurse and nonnurse provider)	Design and prototyping	Evaluator	6
Mohseni Moallem Kolaei et al [106], 2021	Usability testing (Iran)	Burns or delirium (nurse and nonnurse provider)	Planning, requirements, and design and prototyping	Evaluator and informant or SME	8
Moon et al [118], 2022	Case report (South Korea)	Delirium (nurse)	Requirements and design and prototyping	Evaluator	5
Morse et al [119], 2021	Usability testing (Tanzania)	Palliative care (client or patient, nurse, and nonnurse provider)	Requirements and testing	Evaluator and informant or SME	7
Motta et al [120], 2022	Usability testing (Brazil)	Cardio-respiratory arrest (student nurse)	Testing	Evaluator	2
Mueller et al [121], 2022	Usability testing (United States)	Pediatric oncology (caregiver)	Design and prototyping	Evaluator and informant or SME	5
Müller et al [122], 2021	Usability testing (Denmark)	Cardiopulmonary resuscitation (nurse and nonnurse provider)	Design and prototyping and testing	Evaluator	8
Muscat et al [123], 2021	Usability testing (Australia)	Chronic kidney disease (client or patient)	Planning, requirements, and design and prototyping	Content developer, designer or creator, evaluator, and informant or SME	3
Nes et al [124], 2023	Research (Norway)	Nursing education (nurse and student nurse)	Planning, requirements, and design and prototyping	Informant or SME	5

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Neubeck et al [126], 2016	Usability testing (Australia)	Cardiovascular disease (client or patient)	Planning, requirements, and design and prototyping	Content developer, designer or creator, informant or SME, and informaticist	11
Neubeck et al [125], 2016	Abstract (Australia)	Cardiovascular disease (client or patient)	Planning, requirements, and design and prototyping	Content developer, designer or creator, informant or SME, and research expert	3
Ni et al [127], 2022	Case report (China)	Lung cancer (client or patient)	Design and prototyping	Evaluator and informant or SME	5
Noergaard et al [128], 2017	Case report (Denmark)	Heart disease (client or patient)	Design and prototyping, software development, and testing	Evaluator	9
Noori et al [129], 2016	Usability testing (Malaysia)	Mental health (caregiver and client or patient)	Requirements, design and prototyping, and testing	Content developer, evaluator and informant or SME	2
O'Connor and Andrews [130], 2016	Protocol (United Kingdom or Ireland)	Nursing education (student nurse)	Requirements and testing	Evaluator	4
O'Connor and Andrews [131], 2016	Usability testing (United Kingdom or Ireland)	Nursing education (student nurse)	Design and prototyping and testing	Designer or creator and evaluator	1
Odom and Christenbery [132], 2016	Usability testing (United States)	Asthma (client or patient)	Requirements, design and prototyping, and testing	Content developer, informant or SME, patient advocate, distributor, and research expert	3
Park and Cho [133], 2022	Research (South Korea)	Neonatal care (caregiver)	Design and prototyping and testing	Evaluator and informant or SME	4
Paschoal et al [134], 2022	Research (Brazil)	Diagnostic reasoning (nurse)	Planning, requirements, and design and prototyping	Designer or creator, evaluator, and informant or SME	2
Patel et al [135], 2019	Briefs, commentaries, and editorials (United Kingdom)	Wound care (nurse and non-nurse provider)	Requirements, design and prototyping, and testing	Content developer, designer or creator, evaluator, and distributor	7
Pereira et al [136], 2016	Usability testing (Brazil)	Vital Signs (student nurse)	Planning, requirements, design and prototyping, and software development	Content developer, designer or creator, and informant or SME	2
Pereira et al [182], 2019	Usability testing (Brazil)	Surgery (student nurse)	Design and prototyping	Evaluator	2
Pérez-Sádaba et al [137], 2022	Abstract (Spain)	Frailty (client or patient)	Requirements	Informant or SME	3
Pontes et al [138], 2021	Research (Brazil)	Clinical assessment of patients who are hospitalized (nurse)	Requirements and design and prototyping	Evaluator and informant or SME	4
Putri et al [139], 2022	Protocol (Indonesia)	Type 2 diabetes (client or patient)	Planning, design and prototyping, and testing	Evaluator, informant or SME, and research expert	NR
Ramli et al [140], 2022	Research (Malaysia)	Clinical management (client or patient)	Testing	Evaluator	6
Rathnayake et al [141], 2021	Research (Australia)	Dementia (caregiver)	Design and prototyping	Evaluator, informant or SME, and research expert	5

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Rezende et al [142], 2016	Research or usability testing (Brazil)	NICU care (nurse)	Planning, design and prototyping, and testing	Evaluator and informaticist	4
Rutz et al [144], 2019	Research or usability testing (Germany)	Dementia (caregiver)	Planning and design and prototyping	Not specified	NR
Salomé et al [183], 2022	Usability testing (Brazil)	Upper airway aspiration (nurse and nonnurse provider)	Testing	Evaluator	5
Saparamadu et al [146], 2021	Case report (Singapore)	Delivery of lab information (nurse and other)	Requirements, design and prototyping, and testing	Designer or creator, evaluator, and informant or SME	3
Schmidt et al [147], 2021	Research (Germany)	Chewing efficiency (nurse)	Testing	Evaluator	8
Schweers et al [148], 2016	Usability testing (India)	Complications in childbirth (nurse and other)	Requirements and design and prototyping	Evaluator and informant or SME	6
Seo et al [184], 2021	Research (South Korea)	Postpartum depression (client or patient)	Requirements, design and prototyping, and testing	Content developer, evaluator, and informant or SME	8
Seok and Suh [149], 2022	Research and usability testing (South Korea)	Oncology (student nurse)	Design and prototyping and testing	Evaluator and informant or SME	6
Shahmoradi et al [150], 2021	Research and usability testing (Iran)	Urinary tract infections (client or patient)	Requirements and testing	Evaluator and informant or SME	7
Shahmoradi et al [151], 2021	Research (Iran)	Pain management (student nurse)	Requirements, design and prototyping, and testing	Content developer, designer or creator, evaluator, and informant or SME	5
da Silva Lima Roque et al [143], 2021	Usability testing (Brazil)	Wound care (nurse and nonnurse provider)	Software development and testing	Evaluator	5
da Silva Melo et al [114], 2020	Usability testing (Brazil)	Diabetes (client or patient and nurse)	Requirements, design and prototyping, software development, and testing	Content developer, evaluator, and informant or SME	9
Silva et al [153], 2021	Usability testing (Brazil)	Domestic violence against children (nurse)	Planning, requirements, and design and prototyping	Content developer, designer or creator, and informant or SME	5
Silva et al [152], 2022	Research (Brazil)	Pregnancy and postnatal care (client or patient)	Planning, design and prototyping, and testing	Designer or creator, evaluator, and informant or SME	4
Sobrinho et al [154], 2018	Research or usability testing (Brazil)	Chronic kidney disease (client or patient)	Requirements	Informant or SME	9
Soilemezi et al [155], 2021	Research (Greece)	Hemodialysis patient handoff (nurse)	Planning, requirements, design and prototyping, software development, and testing	Evaluator and informant or SME	5
Song and An [156], 2021	Usability testing (South Korea)	Chronic myeloid leukemia (client or patient)	Testing	Informant or SME	6
Souza et al [157], 2022	Research (Brazil)	Prenatal care (client or patient)	Design and prototyping and testing	Evaluator and informant or SME	7
Strandell-Laine et al [158], 2019	Research (Finland)	Nursing education (nurse and student nurse)	Requirements, design and prototyping, software development, and testing	Content developer, evaluator, and informant or SME	4
Sun et al [159], 2021	Research (United Kingdom)	Esophageal cancer (caregiver and client or patient)	Requirements and testing	Evaluator and informant or SME	6

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Sundaram et al [160], 2023	Research (United States)	Spinal cord injury (client or patient)	Planning, requirements, design and prototyping, and testing	Evaluator and informant or SME	6
Tamamoto et al [161], 2017	Abstract (Japan)	Chronic obstructive pulmonary disease (client or patient)	Design and prototyping	Not specified	3
Tan et al [162], 2023	Research (Singapore)	COVID-19 (client or patient)	Requirements, design and prototyping, and testing	Designer or creator, evaluator, and informant or SME	7
Torrente et al [163], 2021	Research (Brazil)	Emergency services (client or patient)	Requirements, design and prototyping, and software development	Designer or creator and informant or SME	5
Vamos et al [164], 2019	Research or usability testing (United States)	Oral Health or pregnancy (nurse)	Requirements, design and prototyping, and testing	Designer or creator, evaluator, and informant or SME	6
Vêscovi et al [165], 2017	Usability testing (Brazil)	Diabetes or foot care (nurse)	Requirements, design and prototyping, and testing	Content developer, designer or creator, evaluator, and informant or SME	4
Vilarinho et al [185], 2017	Research (Norway)	Cystic fibrosis (client or patient)	Requirements, and design and prototyping	Evaluator and informant or SME	5
Wan et al [166], 2021	Research (Singapore)	Colorectal cancer (caregiver, client, or patient)	Requirements	Designer or creator and informant or SME	3
Wang et al [167], 2017	Usability testing (China)	Pediatrics (caregiver, client or patient, and nurse)	Planning, requirements, design and prototyping, and testing	Evaluator and informant or SME	4
Wang [168], 2017	Research (Singapore)	Type 2 diabetes (client or patient)	Requirements and testing	Content developer, evaluator, informant or SME, and research expert	7
Wang et al [186], 2021	Research (China)	Lung cancer (client or patient)	Requirements and design and prototyping	Evaluator and informant or SME	6
Wannheden and Revenäs [169], 2020	Usability testing (Sweden)	Parkinson disease (client or patient, nurse, and nonnurse provider)	Planning, requirements, design and prototyping, and testing	Designer or creator, evaluator, and informant or SME	9
Wirawan and Arsa [187], 2020	Research (Indonesia)	Basic life support or cardiac arrest (nurse and nonnurse provider)	Requirements	Informant or SME	2
Woo et al [170], 2016	Abstract (United States)	Medication management (client or patient and nonnurse provider)	Planning and requirements	Informant or SME	3
Woods et al [171], 2018	Usability testing (Australia)	Heart failure (caregiver and client or patient)	Requirements and design and prototyping	Designer or creator, evaluator, and informant or SME	NR
Yang et al [172], 2016	Research or usability testing (China)	Delirium or ICU (nurse)	Software development and testing	Evaluator	5
Yang et al [173], 2022	Research (China)	Chronic disease (client or patient)	Requirements and design and prototyping	Content developer, designer or creator, informant or SME, and research expert	5
Yerlett et al [174], 2021	Abstract (United Kingdom)	Epidermolysis bullosa (client or patient)	Design and prototyping	Designer or creator and informant or SME	3

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Study, year	Publication type or study design (country)	Condition or purpose of app (primary user group or groups)	Development phase or phases described	Nurse's role or roles during development	IMS Institute for Healthcare Informatics functionality score (0-11)
Ying et al [175], 2022	Research (Singapore)	Care coordination (nurse and nonnurse provider)	Design and prototyping and testing	Designer or creator, evaluator, and informant or SME	5
Zhang et al [176], 2021	Research (China)	Wound care (nurse)	Design and prototyping and testing	Evaluator	7

[a]ICU: intensive care unit.

[b]SME: subject matter expert.

[c]NICU: neonatal intensive care unit.

[d]EHR: electronic health record.

[e]NR: not reported.

Nurse Involvement

Nurses played a role in all the stages of development. Nurses were most represented in the design and prototyping phase (112/157, 71.3%) [32-37,39,41-43,45,46,49,51-53,55-58,60,63-65,67-70,73-79,81,84-88,90-93,96,99-102,104,106,107,110-118,121-129,131-136,138,139,141,142,144-146,148,149,151-153,155,157,158,160-165,167,169,171,173-177,180,182,184-186,188], followed by the requirements gathering phase (98/157, 62.4%) [32-37,39-41,43,46,48-50,52-54,56,58,59,61,63,64,67,71-81,83,84,86,89-92,95,98,99,101,102,104-110,114,116,118,119,123-126,129,130,132,134-138,146,148,150,151,153-155,158-160,162-171,173,178,181,184-188] and the testing phase (80/157, 51%) [33,35,37,38,40,41,43-45,47,49,51,52,55-57,62,64,72,73,80,82,83,87,90,91,94,96-98,100-105,114,119,120,122,128-133,135,139,140,142,143,145-147,149-152,155-160,162,164,165,167-169,172,175-180,183,184,188]. Nurses were infrequently involved in the software development phase (20/157, 12.7%) [33,41,42,49,51,52,56,66,79,104,114,128,136,143,155,158,163,172,178,188] and the planning phase (33/157, 21%) [33,50,72,77,78,80,81,83-86,92,99,102,104,106,110,123-126,134,136,139,142,144,152,153,155,160,167,169,170].

Nurses most frequently assumed the role of evaluator, with 123 (78.3%) of 157 publications indicating that nurses took on this role in at least 1 phase [32-37,39-49,51-53,55,56,58,60-65,67,68,70,72-75,77,79,80,82-88,90-94,96-107,110-123,127-131,133-135,138-143,145-152,155,157-160,162,164,165,167-169,171,172,175-180,182-186].

This was followed by the role of informant or SME (106/157, 67.5%) [32-37,39-41,43,46,49,50,52-56,58-61,63,64,67,69,72-75,77,79-81,83-86,89-91,93,95,98,99,102,104,106-110,113,114,116,119,121,123-127,129,132-134,137-139,141,146,148-160,162-171,173-175,177,178,181,182,184-188], designer or creator (31/157, 19.7%) [42,45,56,57,72,78,88,92,101,110,123,125,126,131,134-136,146,151-153,162-166,169,171,173-175], or content developer (27/157, 17.2%) [42,45,56-58,78,88,92,101,104,110,114,123,125,126,129,132,135,136,151,153,158,165,168,173,184,188].

Nurses served in different roles across different phases of development. The most common co-occurrence was a nurse acting as an informant or SME during the requirements gathering phase (88/157, 56.1%) [32-37,39-41,43,46,49,50,52-56,58,59,61,63,64,67,72-75,77,79-81,83,84,86,89-91,95,98,99,102,104,106-110,114,116,119,123-126,129,132,134,136-138,146,148,150,153-155,158-160,162-171,173,178,181,184-188], closely followed by acting as an evaluator during the design and prototyping phase (84/157, 53.5%) [32-34,36,37,39,41,43,45,46,49,51-53,55,56,58,60,63-65,67,68,70,73-75,77,79,84-88,90-93,96,99-102,104,106,107,111-118,121-123,127,129,131,133-135,138-142,146,148,149,151,157,158,164,165,167,169,171,180,182,184-186] or acting as an evaluator during the testing phase (71/157, 45.2%) [35,37,40,41,43-45,47,49,51,52,55,62,72,73,80,82,83,87,90,91,94,96-98,100-105,114,119,120,122,128-130,133,135,139,140,142,143,145-147,149-152,155,157-160,162,164,165,167-169,172,175-180,183,184].

Roles were not mutually exclusive in the various development phases. The authors indicated that nurses took on between 1 and 4 roles within a development phase and more frequently took on a greater number of roles during earlier development phases. In total, 36% (12/33) of the publications describing the planning phase indicated nurses taking on >1 role [85,92,102,104,110,123,125,126,134,136,139,152]. Nurses taking on >1 role grew to 42 (43%) out of 98 publications in the requirements gathering phase [36,37,39,52,55,56,58,61,78,83,84,86,89,92, 99,101,104,110,114,116,123,125,126,129,132,134,136,139,146,151,153,158,164-169,171,173,184,188] and 50 (44.6%) out of 112 publications in the design and prototyping phase [34,36,37,39,42,43,45,46,51,56-58,60,75,78,88,92,93,101,104,110,113,114,121,123,125-127,131-136,138,141,142,146,151,157,158,162-164,169,171,173-175,184]. None of the nurses took on >1 role during the software development phase, whereas 12 (15%) out of 80 publications noted nurses taking >1 role during the testing phase [38,43,47,51,56,132,135,139,149,151,152,160].

Characteristics of the Apps

Nurses were equally involved in developing apps for care providers and apps for health care consumers. Care providers were most frequently nurses (69/157, 43.9%) [32,35-37,40,44,46,47,49,50,52,55,59,62,64,66,68,69,72-74,79,80,82-84,86,88-92,94,99,100,102,106,107,111,112,114-119,122,124,134,135,138,142,143,146-148,153,155,158,164,165,167,169,172,175,176,183,187,188],

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followed by nonnurse providers (30/157, 19.1%) [35,36,49,50,52,55,59,64,74,79,80,86,88,90,91,94,102,106,112,116,117,119,122,135,143,169,170,175,183,187], and student nurses (16/157, 10.2%) [50,77,96,97,103,115,120,124,130,131,136,149,151,158,177,182]. In 49.7% (78/157) of the publications, clients or patients were included as primary end users [38,42,43,48,51,52,54,56-58,60-65,67,70,71,75,76,78,81,82,84,85,87,88,90,93,95,99-101,104,105,108-111,113,116,119,123,125-129,132,137,139,140,145,150,152,154,156,157,159-163,166-171,173,174,178-180,184-186]; in 15.9% (25/157) of the studies, caregivers were considered primary end users [33,34,39,41,45,52,53,70,71,81,90,91,98,109,121,129,133,141,144,159,166,167,171,181,188]. This pattern continued when considering secondary end users, which we defined as individuals interacting with the app to enter data but who may not be the intended market for the app. Although care providers were more prominent than health care consumers as secondary end users, both were represented. Nurses were secondary end users in 57.3% (90/157) of the publications [32-35,38,40,41,44,49,52-55,61-64,66,67,71-75,79-84,86-88,90-92,94,98-100,102,104-109,111,113-116,119-122,128,129,132,135,137,139-142,145,146,148,150,152-154,157,158,160,162-170,172,173,176,179,184,185], whereas nonnurse providers were noted as secondary end users in 42.7% (67/157) of the publications [35,38,41,46,49,52-55,61,63,64,68,69,71,72,74,79-81,86-88,90,91,94,98,102,105,106,108,109,113,116,118-123,128,129,132,135,137,139-141,145,147,150,152,154,157,160,162,163,166,167,169,170,172,173,175,179,184,185], and clients or patients were noted as secondary end users in 26.8% (42/157) of the publications [42,49,51,52,56-58,60,62,64,76,78,82,84,85,88,90,93,95,99,101,104,106,110,111,114,116,119,123,125,126,128,129,132,143,154,161,167-171].

In general, the apps focused on specific conditions, most frequently cancer (27/157, 17.2%) [38,43,53,54,57,60,68,70,76,78,82,84,87,90,94,99,110,116,127,149,156,159,166,178,186,188, 189], cardiovascular disease (12/157, 7.6%) [42,58,65,97,98,120,125,126,128,145,171,187], pregnancy or neonatal care (11/157, 7%) [40,41,67,91,103,133,152,157,164,180,184], and diabetes (8/157, 5.1%) [35,51,85,104,114,139,165,168]. These apps were often in the early stages of development, although 26.1% (41/157) of the publications described multiple versions of the app [33,34,41-43,57,58,63,71,73,77,78,83,86,92, 95,99,102,104,116,119,122,123,126,128,129,135,136,145,146,148,153,158-160,171,172,175,177,178,184]. Most commonly, the apps were the alpha or prototype versions (117/157, 74.5%) [32,33,35,37,39-43,45,46,49,51,52,55-58,60,61,63,65,67,68,71,73-75,77-80,83-88,90-93,95,98-107,110-119,121-126,128,129,131,132,134-136,138,140-143,146-167,169-181,184], followed by the storyboard or wireframe (32/157, 20.4%) [33,41,43,48,57,59,70,71,76,78,81,83,86,92,102,108,116,122,123,126,128,129,136,146,148,153,158,171,177,178,185,186], beta (29/157, 18.5%) [33,34,36,38,42,43,47,58,63,69,71-73,77,89,95,97,99,104,119,133,135,145,159,160,168,172,175,184], and release (10/157, 6.4%) [33,34,62,66,71,94,120,135,145,188] versions. In total, 10.2% (16/157) of the publications did not report the version of the app or described apps that had not yet been created [44,50,53,54,64,82,96,109,127,130,137,139,144,182,183,187].

The median number of functions based on the IMS Institute for Healthcare Informatics Functionality was 5 (range 1-11). A total of 2 apps scored 11, the maximum possible score on the IMS Institute for Healthcare Informatics Functionality score [99,126]. Most publications (142/157, 90.4%) described multifunctional apps, with only 15 (9.6%) out of 157 publications describing an app with only a single function. The most frequently reported functionalities were to inform (101/157, 64.3%) [34-37,39,41-43,45,48,49,56,57,59-61,63-67,70-72,75,76,78,79,81,83-88,90,91,93,97-99,101,103-110,113-116,120,122,123,125-130,132-136,138,140,141,146,147,149-151,153,154,157,159-166,168,173,174,176-178,180-184,186-188], collect data (100/157, 63.7%) [33,35,38,43,44,46,47,49,51,52,55,57-64,67-69,72,73,75,77,78,80,81,84,86-92,94,98-102,104-106,108,112-114,116-119,121,122,124,126-128,130,132,133,135,137,138,140-143,145,147-150,152-159,162-164,167-169,172,173,175,176,178,179,181,183-186], or instruct (80/157, 51%) [33-37,39,40,42,43,45,56,57,60,64-67,70-72,75,76,78,79,85,91,93,97-99,101-104,106-109,114,115,120,122,123,125-131,134-136,141,143,146,147,149-151,154,157,160,161,164-166,168,170,173,174,178,180-184,186-188]. The least frequently reported functionalities were to intervene (29/157, 18.5%) [33,38,40,49,51,52,59,68,84,86,89,92,99,101,107,116-118,122,126,128,147,148,153,154,156,169,178,181], remind or alert (41/157, 26.1%) [33,38, 43,44,52,59,60,63,72,75,81,84,87,91,94,99,101,105,107-109,113,116,126,140,145,146,148,150,157,159,160,162,166,168,169, 179,180,184,185,189], and evaluate data (48/157, 30.6%) [35,43,44,47,51,52,55,58,62,64,80,84,86,89,91,92,94,98,99,101,102,106,112-114,116-119,122,126,128,135,142,143,147,148,151,153,154,165,167,169,170,172,176,184,186]. Some of the apps integrated with other tools, with a majority integrating with some form of communication (39/157, 24.8%) [34,38,44,51,54,58,60,64,67,71,74,75,81,83,84,86,88,91,94,99,106,119,126,128,133,138,143,145,148,152,154,157-160,169,180,184,186], external resources (30/157, 19.1%) [32,34,36-39,43,48,54,58,60,61,71,75,81,83,84,89,105,111,118,123,126,128,133,135,145,146,159,184], or electronic health record (21/157, 13.4%) [38,44,47,58,59,73,77,81,84,88,91,126,132,135,145,152,159,164,167,169,175]. Apps less frequently integrated with portals (15/157, 9.6%) [38,52,59-63,84,86,99,105,118,119, 126,145], sensors or add-ons (8/157, 5.1%) [38,49,62,72,86,105,160,179], or other tools (ie, cloud-based servers and storage or databases; 5/157, 3.2%) [33,103,141,172,176]. Many apps (85/157, 54.1%) did not report integration with other devices.

The use of technical standards and standards for guiding content was also variable. In total, 26.8% (42/157) of the publications used ≥1 standard. In total, 8.9% (14/157) of the publications included content standards [41,96,97,102,127,153,164,167,177,181,182,184,186,187], such as clinical practice guidelines or recommendations for patient care, whereas 14% (22/157) included technical standards that informed the app's development [37,40,52,59,60,67,75,88,104,108,114,115,117,123,134,151,159,165,172,173,178,179], and 3.8% (6/157) of the publications included both technical and content standards [36,68,69,145,154,158]. Most

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of the manuscripts (115/157, 73.2%) did not indicate using a standard when developing their app.

Discussion

Principal Findings

This scoping review illuminated the various roles of nurses in mHealth app development. However, considering the number of published materials, few publications describe the development process of mHealth apps. This review reinforces previous findings that the levels of overall provider representation in app development are low, despite the recognition that provider involvement is key to creating effective apps [190-193]. Although nurses were represented throughout the development process in this review, the level of involvement was concentrated in specific phases and roles. Nurses were most frequently involved in the requirements gathering, designing and prototyping, and testing phases of development. Despite established recommendations for co-design and participatory design in mHealth, which reinforce the importance of involving clinicians and patients early and throughout the process [194,195], we found more limited involvement of nurses in the planning and software development phases. This parallels the findings of a recent rapid review on co-design practices in mHealth, which found that both patients and health care providers were most frequently engaged in needs identification, prototype design, and feedback and testing [196].

We found that the most common role for a nurse was an SME during the requirements gathering phase, followed by an evaluator during the testing phase. However, the roles for nurses as research experts, patient advocates, or informaticists were rare. This concentration in specific phases and roles reinforces the previous findings. A systematic review of clinician involvement in developing predictive clinical decision support tools found that clinicians most frequently served as informants (specifically, identifiers of system needs and requirements and developing clinically relevant content) but were less involved in evaluation [197]. Another systematic review of pain management apps found that most apps included in their study indicated that a health care professional was involved in the development, which was limited to content development or the role of a SME [198]. Although our study found that nurses were involved in content development and served as SMEs, involvement in testing and evaluation was prominent. The role of patient advocate may be implicit given the patient-centered focus of nurses; however, the role was rarely named as such. Although not named as patient advocates, nurses were frequently involved in the development of apps that included patients or caregivers as primary end users. This may be in recognition of the nurses' understanding of patient needs concerning their health, diagnoses, and treatment options, given that nurses spend time and interact with patients more than any other health care provider. Patients are most likely to adopt an mHealth app when they believe that the information and services provided are trustworthy [199,200], and previous systematic reviews have found a strong, positive relationship between a patient's perception of the opinions of those important to them and the intention to use mHealth apps [199,201]. In 1 study of older adults, 64% either agreed or strongly agreed that they would use an mHealth app if their health care provider recommended it [202]. A systematic review of barriers and facilitators in mHealth in oncology noted that "[n]urses seemed to the stakeholders with the greatest potential to push mHealth uptake" [203].

In the case of patient-facing solutions, nurses often have a unique perspective as patient advocates. For example, nurses can routinely answer questions from patients and families related to the use of apps or their health data [189,204]. Leveraging first-hand accounts of these experiences can provide important insights into how an app may be best designed for optimal patient engagement and ease of use [205]. Nurse-led and nurse-supported mHealth interventions have been associated with increased patient compliance, more complete self-reporting, and healthier lifestyle choices [206,207]. We believe that nurses should play an integral role in developing apps intended for patient or caregiver use and that their role as patient advocates should be integrated throughout the development process.

Nurses frequently assumed the role of evaluator throughout the development process. Although nurses responded to information, decisions, or app functionality, they were less frequently tasked with developing the app or designing its content. Nurses are more frequently evaluating or informing, rather than designing and developing, which may reflect previous findings that nurses have had limited involvement in mHealth app development [204]. The apps described in this scoping review lack robust functionality such as facilitating communication between systems and health care teams and evaluating data entered by the end user. These findings are not surprising because apps are relatively new to health care systems [208]. Our results partially parallel the IMS Institute's findings, in which the authors assessed 23,682 apps to determine their functionality according to the IMS Institute for Healthcare Informatics Functionality. They found that the most widely available individual functionality was to inform, followed by instruct, and noted that most apps supported only a single functionality rather than being multifunctional. The authors noted that "most of the healthcare apps available today are only simple in design and do little more than provide information" [27]. Most apps included in our study were multifunctional, unlike those evaluated by the IMS Institute. However, the most frequent functionalities were focused on providing information to users. Although some more advanced functionalities were available in the apps included in our study, such as facilitating bidirectional communication with health care providers or providing reminders or alerts to patients, this was less common.

Previous systematic reviews have noted that apps have limited clinical utility and do not facilitate intervention or adjustment of care plans; instead, they focus on collecting patient data or providing basic information [191]. As apps become more sophisticated with sensor technology and interoperable with clinical decision support systems, adopting mHealth standards to support more advanced functions and features will be essential. Standards for mHealth app development exist but are rarely described in the literature, with the vast majority of publications lacking a description of technical standards or content standards. The lack of documentation describing the

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evidence base underlying these apps is a glaring omission and, unfortunately, is consistent with the findings of previous research [192,209,210]. Equally important to content standards are app development standards to ensure interoperability with other systems, usability, effective data capture and transfer, and the protection of patient information.

Further complicating the disorganized approach to mHealth development is an absent organizing body to establish and manage standards, ways to update and maintain systems, an overarching interoperable plan in health care, and the enterprising nature of technology. Those who develop technologies, including technologies for health care, are business oriented with a budget and prioritize profits over collaboration. Instead, businesses prefer to have more clients and purchasers than to become interoperable with competing systems.

To overcome some of these barriers, nurses have a role in planning and developing mHealth apps. Interoperable systems that support data sharing and transfer strengthen the provision of quality care to patients, who are now more involved in their care and decision-making. Creating these systems requires individuals with a knowledge base of institutional systems and health care as well as working knowledge of the fundamental needs of patients. These characteristics define a nurse informaticist. A nurse informaticist offers a clinical perspective combined with expertise in the technological systems and structures underlying patient care. Nurse informaticists are uniquely qualified because they have expertise in the health care environment and technology, functioning as liaisons between the clinical team, patients, and developers. The nurse informaticist transforms data into information and knowledge to be leveraged by technologies within a given environment to improve health, health care equity, safety, quality, and outcomes [211].

It is not surprising that apps focusing on cancer were the most prevalent in publications included in our review. Oncology has been recognized as a key space for nurse informaticists because of the complexity of coordinating care across multiple specialties and settings and the subsequent range of eHealth tools that have emerged as a result of this complexity [212-214]. Although cancer was the most predominant condition, many of the apps included in this review focused on complex, chronic conditions, such as cardiovascular diseases, diabetes, chronic kidney disease, and mental health. Chronic conditions have been previously identified as an opportunity for mHealth, given that the management of chronic conditions requires frequent data collection and transfer better suited to mHealth interventions than conventional office visits [215,216]. Patient engagement is key to the success of mHealth interventions for managing of chronic conditions. As previously noted, nurses can have a pivotal role in both motivating patients to start using the app and providing ongoing support and guidance for its continued use.

mHealth apps are still in their infancy, as is the nurses' role in these apps. Nurses have a depth and breadth of knowledge in the health care environment, disease management, organizational infrastructure, quality, safety, patient education, and evidence-based practice. As McGonigle and Mastrian [217] note, "nursing is an information-intensive profession," and "[a]t the heart of all of these [patient care] skills lies the management of data and information." The accuracy of the information and the guidance an app may offer cannot be validated without due diligence by the health care professionals and patients. One way to ensure that health-related content is valid, based on evidence, and meets the needs of the end user is to incorporate nurses into the early stages of app creation [204]. Interventions fail most frequently because of misalignment between the app and existing workflows and clinical processes, leading to increased workloads or cumbersome workflows [218]. The technological burden for clinicians is at an all-time high. This technological stress contributes to clinician burnout, resulting in clinicians leaving the workforce [219,220]. Including nurses in the development of technologies can provide a sense of value while simultaneously increasing the likelihood of successful implementation by addressing workflow and clinical misalignment issues during the design process.

Limitations and Future Work

The full spectrum of app development efforts might not be fully documented or reported in the published literature. Although this review included conference presentations, abstracts, and protocol papers to capture ongoing projects and projects communicated outside of research articles, there may be previous or ongoing development efforts in which nurses are involved that are described only in internal documents or materials restricted owing to intellectual property considerations. Although we developed a search strategy in accordance with best practices and attempted to be as comprehensive as possible, our search terms may not include relevant terminology in every discipline. Despite this, we believe that we have captured all publications meeting our inclusion criteria.

Our decision to include protocol papers means that some description of nurse involvement and the phase of involvement is anticipated rather than having been completed. Although it is possible that projects ultimately deviate from their published protocols, we believe that these descriptions of planned involvement, nevertheless, contribute to addressing our overall research questions.

Our review is limited to examining the reported role of nurses in mHealth app development and does not account for the postimplementation involvement of nurses. Our analysis is also limited to what is described in the publication. It is possible that the nurses took on additional roles or were engaged in other phases that were not described in the publication. Future research should consider additional research methods, such as surveys, to understand the role and experience of nurses in mHealth app development beyond what is documented in the literature. Similarly, it is possible that technical and content standards were used more broadly, but their use was not described in publication. More complete reporting of standards would more effectively communicate which standards are most broadly implemented and subsequently promote further awareness and adoption.

This scoping review did not examine the efficacy of mHealth apps or their impact on clinically relevant outcomes. As more randomized controlled trials become available, future research

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may consider quantifying the impact of nurse involvement in mHealth app development on clinical outcomes.

Although we did not assess the risk of bias in the included studies, as this is not a component of scoping reviews, there is a lack of clarity regarding funding sources. Depending on the funding models for app development, there may be a conflict of interest on the part of the authors describing the app development process or its outcomes. This lack of information makes it difficult to assess whether any conflict of interest existed. Although the potential conflict of interest may not directly affect our findings, clear reporting of funding sources and any conflicts of interest enables a more thorough examination of the quality of the research.

Conclusions

Regardless of the type of health system, nurses must work toward nurse representation on all technology-specific committees and task forces influencing health care services. Currently, the role of nurses in mHealth app development is limited, although the potential benefit of incorporating this expertise throughout the development process would be to patients, providers, and care systems. Advocacy for nurse involvement in planning, development, implementation, and evaluation is a vital role for nursing leadership in all care systems, and widespread communication and dissemination of these roles can serve as an example for those developing mHealth apps.

Conflicts of Interest

CJB is a subject matter expert for the American Gastroenterological Association and Lead Information Specialist for the Cochrane Collaboration Urology Group.

Multimedia Appendix 1
Search strategies.
[PDF File (Adobe PDF File), 285 KB - nursing_v6i1e46058_app1.pdf]

Multimedia Appendix 2
PRISMA-ScR checklist.
[PDF File (Adobe PDF File), 165 KB - nursing_v6i1e46058_app2.pdf]

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Abbreviations

mHealth: mobile health
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
REDCap: Research Electronic Data Capture
SDLC: Software Development Life Cycle
SME: subject matter expert

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Corrigenda and Addenda

Correction: 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

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In "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" (JMIR Nursing 2022;5(1):e33586) the authors noted one correction.

In the published manuscript, the Acknowledgments read as follows:

> *The authors would like to extend their acknowledgments to the Performance Analytics team at Canada Health Infoway for reviewing this manuscript before submission.*
>
> *The publication costs for this article have been covered by Canada Health Infoway Inc, a non-profit corporation funded by the Government of Canada.*

They have now been changed to:

> *The authors would like to extend their acknowledgments to the Performance Analytics team at Canada Health Infoway for reviewing this manuscript before submission.*
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>
> *The publication costs for this article have been covered by Canada Health Infoway Inc, a non-profit corporation funded by the Government of Canada.*

The correction will appear in the online version of the paper on the JMIR Publications website on October 13, 2023 together with the publication of this correction notice. Because this was made after submission to PubMed, PubMed Central, and other full-text repositories, the corrected article has also been resubmitted to those repositories.

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Corrigenda and Addenda

Addendum to the Acknowledgements: Experiences of Complex Patients with Telemonitoring in a Nurse-Led Model of Care: Multi-Method Feasibility Study

Kayleigh Gordon[1,2], RN, MN; Katie N Dainty[1,3], PhD; Carolyn Steele Gray[1,4], PhD; Jane DeLacy[5], MHSC; Amika Shah[1,2], MScCH; Myles Resnick[2], MSc; Emily Seto[1,2], PEng, PhD

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Corrigenda and Addenda

Correction: Exploring an Innovative Care Model and Telemonitoring for the Management of Patients with Complex Chronic Needs: Qualitative Description Study

Kayleigh Gordon[1,2], BNSc, MN; Carolyn Steele Gray[1,3], PhD; Katie N Dainty[1,4], PhD; Jane DeLacy[5], MHSc; Patrick Ware[2], PhD; Emily Seto[1,2], PEng, PhD

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Corrigenda and Addenda

Correction: 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 DeLacy[5], MHSc; Amika Shah[1,2], MScCH; Emily Seto[1,2], PhD, PEng

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In "Normalizing Telemonitoring in Nurse-Led Care Models for Complex Chronic Patient Populations" (JMIR Nursing 2022;5(1):e36346) the authors made two additions.

In the original publication, one author was missed and the existing authors were incorrectly arranged. The authorship list was originally published as:

Kayleigh Gordon, Emily Seto, Katie N Dainty, Carolyn Steele Gray, Jane DeLacy

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Additionally, an Acknowledgments section has been added as follows:

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Review

The Use and Structure of Emergency Nurses' Triage Narrative Data: Scoping Review

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Abstract

Background: Emergency departments use triage to ensure that patients with the highest level of acuity receive care quickly and safely. Triage is typically a nursing process that is documented as structured and unstructured (free text) data. Free-text triage narratives have been studied for specific conditions but never reviewed in a comprehensive manner.

Objective: The objective of this paper was to identify and map the academic literature that examines triage narratives. The paper described the types of research conducted, identified gaps in the research, and determined where additional review may be warranted.

Methods: We conducted a scoping review of unstructured triage narratives. We mapped the literature, described the use of triage narrative data, examined the information available on the form and structure of narratives, highlighted similarities among publications, and identified opportunities for future research.

Results: We screened 18,074 studies published between 1990 and 2022 in CINAHL, MEDLINE, Embase, Cochrane, and ProQuest Central. We identified 0.53% (96/18,074) of studies that directly examined the use of triage nurses' narratives. More than 12 million visits were made to 2438 emergency departments included in the review. In total, 82% (79/96) of these studies were conducted in the United States (43/96, 45%), Australia (31/96, 32%), or Canada (5/96, 5%). Triage narratives were used for research and case identification, as input variables for predictive modeling, and for quality improvement. Overall, 31% (30/96) of the studies offered a description of the triage narrative, including a list of the keywords used (27/96, 28%) or more fulsome descriptions (such as word counts, character counts, abbreviation, etc; 7/96, 7%). We found limited use of reporting guidelines (8/96, 8%).

Conclusions: The breadth of the identified studies suggests that there is widespread routine collection and research use of triage narrative data. Despite the use of triage narratives as a source of data in studies, the narratives and nurses who generate them are poorly described in the literature, and data reporting is inconsistent. Additional research is needed to describe the structure of triage narratives, determine the best use of triage narratives, and improve the consistent use of triage-specific data reporting guidelines.

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KEYWORDS

nursing; artificial intelligence; machine learning; triage; review; narrative

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Introduction

Overview

There are an estimated 46.6 emergency department (ED) visits per 100 people in the United States or 142 million annual visits to Canadian and American EDs combined [1,2]. EDs sort and prioritize patients using triage to ensure that patients with the highest level of acuity are provided care quickly and safely. Modern electronic health records allow for the large-scale collection of triage data, such as time stamps, vital signs, screening assessments, and free-text descriptions [3,4]. These data can be used to track ED volumes and guide local and national policy decisions [5]. Machine learning (ML) and artificial intelligence have allowed the data to be examined for a range of purposes [5,6]. Despite the ubiquity of triage and triage-related data collection, the potential research impact of using triage narrative data remains largely unrealized [7,8].

Background

Triage is the process of sorting patients. It originated during the Napoleonic wars [9] and was introduced into civilian practice in the 1960s [10]. Triage was formalized using validated tools in the 1980s [11] and was first implemented in Australia as a national system in 1994 [12]. Most countries use a formal triage system [13] associated with improved patient safety and service efficiency outcomes [14]. Triage is typically performed by experienced ED nurses [15] who are specially trained to use formally validated triage assessment tools to prioritize patient care [13]. Triage assessment typically consists of a brief history and physical assessment of the patient, followed by the assignment of a visit category and triage priority level by the nurse [15].

Several countries have standardized the mandatory collection of ED data. Canadian [16,17] and Australian [18] EDs report a triage minimum data set of structured complaint code fields. In addition to these nationally coordinated triage data collection efforts, there are regional databases for the local monitoring of injuries or syndromic surveillance (eg, toxic drug supplies and infectious disease outbreaks) [19]. The triage data collected between systems will vary, but the data types can be grouped into either structured or unstructured data, with each data type having its own strengths and weaknesses.

Structured data force the triage nurse to select from one of several preformatted options and restrict the types of data that can be entered into any given data field. Examples of structured triage data include arrival time, vital signs, demographic information (ie, age and sex), insurance status, categorical chief complaints, and numerical triage acuity score. Structured data are the most frequently reported data generated during triage [4,5]. Structured data are readily available (owing to their routine collection) and simple to analyze and report compared with unstructured data; however, this convenience comes at a loss of contextual detail that is available from unstructured narratives [5].

Unstructured clinical data include free-text written notes or “narrative” [20]. Narratives generated at triage vary in length and structure depending on the electronic health record and triage system used. The narrative typically includes the triage nurse’s assessment and the patient’s reported reason for visiting the ED. These data are unstructured and allow nurses to record the chief complaint in the patient’s own words, descriptions of events associated with the ED presentation, and their physical examination findings [21].

Two systematic reviews that focused on injuries examined whether unstructured clinical narratives, including those generated at triage, could be used for large-scale injury surveillance [22,23]. These reviews summarized how narrative data were used to gather injury information and highlighted how data fields were interrogated [22,23]. Cumulatively, the reviews examined 2831 studies published over 18 years and included 56 studies, 13 of which used ED triage data [22,23]. They reported that narrative data use has increased over time and that analyzing the data required automatic or manual extraction of keywords or ML techniques. The review authors were critical of data heterogeneity and called for improved data collection methods [22,23]. The heterogeneity noted in these studies may be partially explained by the wide range of administrative data set types interrogated. A more homogeneous data set (ie, triage narratives alone) may have offered alternative insights.

Two additional review studies published in 2013 focused their analyses on studies using triage narratives for syndromic surveillance systems (ie, programs that monitor for disease outbreaks) [19,24]. Syndromic classifiers use chief complaint narratives to group patient visits into categories to monitor for changes (eg, outbreaks) in disease presentations. The first systematic review screened 89 studies identified through a structured search limited to PubMed to examine syndromic classifiers for detecting influenza in ED triage data sets [24]. The authors included 38 studies that met their inclusion criteria: (1) examined clinical data, which was (2) generated in the ED, and (3) examined influenza. The most commonly used method to identify cases was chief complaint classification. The authors noted that ED triage narratives allowed for large-scale research and program evaluation, but no details on the structure of or methods for extracting chief complaint classification data were offered [24].

The second 2013 nonsystematic review also focused on syndromic surveillance. This review offered descriptive details on the structure of syndromic surveillance systems and their data [19]. The review included 17 studies drawn from an undisclosed initial sample and identified 15 chief complaint classifier systems of interest. The authors described the geographic location where each system was in use and the process used by each system to group visits into syndromes and detailed the relative strengths and weaknesses of each system. The review noted that all but 1 system (from Canada) was American and that the classifiers used differing degrees of computer text parsing to assign patients into groups (eg, ranged from 4 to 9 syndromes) and classified the approach of each system by keyword, statistical, or linguistic methods. The authors highlighted that statistical methods relied on large data volumes to be robust to the “noisy” inputs found in narrative text. By contrast, keyword and linguistic methods used keyword-based strategies and were described as disadvantageous

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because time-intensive adjustments were needed to accommodate variations in triage vocabulary. The drawbacks of keyword-based methods were balanced by the transparency offered when compared with ML studies. The authors argued that triage narratives are of great utility for disease surveillance and were less critical of variations in the initial data quality, concluding that there is a need for common syndromic definitions to improve the utility of these data.

Despite the use of triage data for multiple purposes, there is a criticism of the methods used to classify triage narratives and a call for improved consistency and quality in their collection. There are documented efforts to create common data definitions for triage narratives [25] and to create national ED nursing data sets [26]; however, unstructured data are not as widely collected as structured data [7], and there is a paucity of literature examining what structures are common to triage narratives. This scoping review addresses these concerns and examines peer-reviewed literature to identify what ED triage narrative data have been used for, studies that may be sufficiently similar to compare, and the need for additional research. This scoping review systematically examines the evidence to determine what, if any, structures underlie these narrative data and describes what the data have been used for.

Objectives

The objectives of this review were as follows:

1. Describe the current literature on the use of ED nurses' triage narratives
2. Describe the objectives and findings of the included studies
3. Determine whether there are sufficient data to systematically review the structure or descriptions of triage narratives
4. Determine whether there is adequate consistency in the included studies to support further review of the outcomes.

Methods

Overview

In this review, we used the scoping framework proposed by Arksey and O'Malley [27,28]. The protocol was published previously [29]. The PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) framework was used to guide reporting [30]. To identify studies that examined unstructured narratives in the ED, we conducted a search using controlled terminology for the main topics of health record narratives, emergency, and triage. A medical librarian refined the search terms, and prespecified filters were used for ED [31-34]. To maximize the breadth of the retrieved studies, a comprehensive search was conducted in CINAHL, Ovid MEDLINE, Ovid Embase, Cochrane Library (via Wiley), and ProQuest Central. The search was limited to peer-reviewed literature published after 1990, four years before the first nationally implemented triage system [12]. The reference lists of select excluded studies, namely those that examined the free-text narratives of emergency physicians and review studies that included triage narratives, were hand searched for inclusion. There were no deviations from the published protocol [29].

Data were downloaded into Covidence (Veritas Health Innovation) for screening. The studies were screened independently by 2 authors (CP and MJD) in 2 stages (title plus abstract and then full text) using prepiloted screening forms. Any peer-reviewed studies that examined unstructured narratives [22,35] that were generated within an ED [36] by a nurse [37] were included. Studies that examined disaster triage systems, studies that did not have full text (ie, abstracts only), and non-English studies were excluded. Cohen κ was used to gauge agreement during screening, and all conflicts were settled by consensus. There were no deviations from the study protocol, which outlined the screening forms and operational definitions [29].

Data Extraction

The data were extracted into Microsoft Excel (version 2019, Microsoft Corp; by CP) using prepiloted forms. The results were independently confirmed by a second reviewer (MJD). Counts and proportions were used to describe categorical and numeric values. The extracted categorical values included study variables such as study design, country of origin, triage system used, and the use of ML. The extracted numerical data included the publication year, number of EDs from which the data were drawn, number of visits or patients included in the initial and final samples, and the number of nurses included in each study. For studies that reported data as minimum values (ie, "there were over three million of visits") [38-45], values were recorded as the minimum stated value (ie, 3 million). When studies reported using quality or reporting frameworks, we reported the tool by name. The main conceptual categories of each study (ie, the objectives, design, population, and results) were described [46]. We summarized the descriptions of the triage narratives and keywords when the narratives were reported in the study. When 5 or fewer keywords were used, they were recorded verbatim.

Data Analysis

Owing to the wide distribution of data, estimates of central measures were calculated using both median (with IQRs) and minimum and maximum counts. Statistical analyses were performed using SPSS (version 25, IBM Corp). Citation management was performed using Zotero (Corporation for Digital Scholarship). The study objectives were categorized dichotomously (ie, yes or no) based on whether ML was used in the study (defined as any form of artificial intelligence), and the y were grouped into exclusive categories according to the primary use of the triage narratives: case identification, predictor variable, or quality improvement.

Results

Overview of Studies

A total of 25,091 studies were identified in the initial search, and after deduplication, 18,074 (72.03%) studies underwent title and abstract screening. The proportionate agreement between reviewers (CP and MJD) during screening was 97.4% for the excluded studies and 98.1% for the included studies (Cohen κ=0.250). A full-text review was completed for 214 studies, and 131 (61.2%) studies were excluded at this stage,

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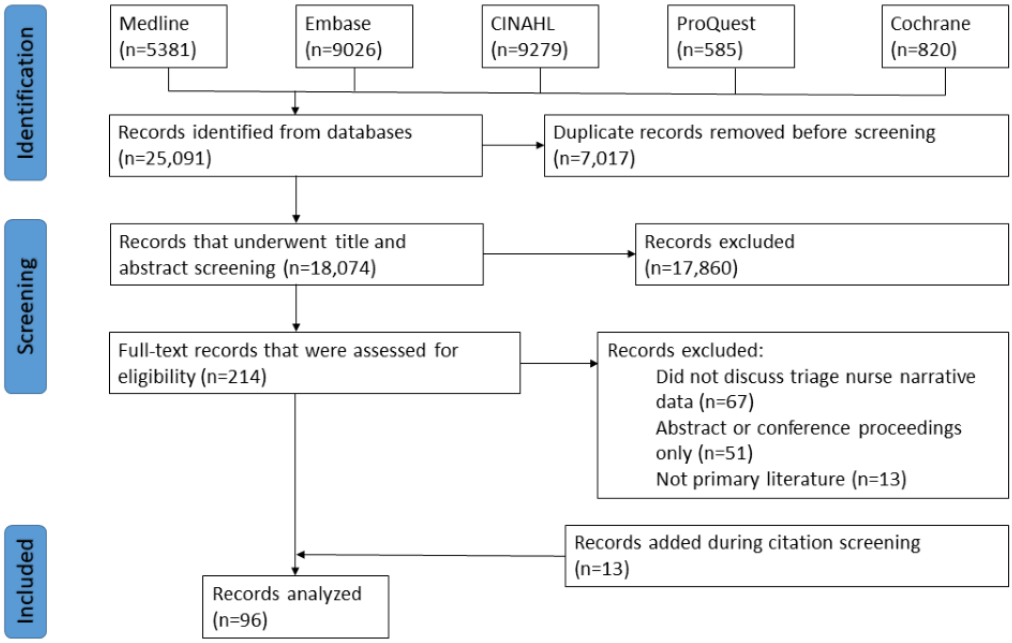
primarily for not specifying whether the narratives were generated by a nurse at triage (67/131, 51.1%). All review studies identified in the initial search that discussed narrative (although excluded) underwent citation screening in the primary search that discussed triage or ED narratives underwent citation screening. An additional 13 studies were included at this stage (Figure 1).

Figure 1. PRISMA diagram.



Study Designs

Retrospective design was the most common approach (80/96, 83%; Multimedia Appendix 1). Data were typically drawn (in part or entirely) from electronic databases, except in earlier studies, in which data were manually abstracted from paper charts [47-49]. The studies used data from hospitals (63/96, 66%) or regional databases (33/96, 34%). All studies reported on the unstructured narratives generated at triage; however, there was significant variation in the types and details of additional data reported. The most commonly collected non–triage-narrative data were patient demographic data, namely age (63/96, 66%), sex (60/96, 62%), and vital signs (29/96, 30%); visit details, namely chief complaint codes (57/96, 59%), discharge status (53/96, 55%), arrival date (35/96, 36%), and time (32/96, 33%); and ED data, namely triage system used (41/96, 43%; Multimedia Appendix 2 [22,36]). There was a weak relationship between the number of items collected and time, with 12% (R^2=0.122) of the variation being attributable to publication date (r_{94}=0.35; P<.001). The number of EDs included was reported in 92% (88/96) of studies. The initial data set size was reported in 81% (78/96) of studies. Of the 96 included cases, 76 (79%) reported the number of visits, and 28 (29%) reported the number of patients. The number of nurses who generated the narratives used in the study was reported in 9% (9/96) of studies [38,48-55].

The median study size included 12,103 (IQR 803-150,089) visits or 391 (IQR 391-76,069) patients from an initial sample of 60,231 (IQR 2943-461,435) visits from (IQR 1-12) 2 EDs (Table 1). There was a large variation in the numbers of visits and departments examined, with the included sample sizes ranging from fewer than 100 to >2 million visits. These visits were drawn from databases ranging from 100 to >14 million visits and reflected as few as 1 ED and as many as 496 EDs (Table 1). There was an increase in the number of studies performed and median sample size of studies in each 6-year period between 1998 and 2021, with 61% (59/96) of the studies published in the last 6 years, that is, after 2015. The median sample sizes increased after 2009 from 7951 (IQR 518-55,952) to 160,944 (IQR 19,418-501,758). There was a concurrent increase in the frequency of ML use as a primary tool, with 77% (30/39) of studies after 2017 using ML use as a primary tool (Table 1). We noted that ML was used more frequently in predictive studies (21/25, 84%) than in studies using narratives for case identification (17/58, 29%) or quality (1/13, 8%; Figure 2).

Geographically, the United States (43/96, 45%), Australia (31/96, 32%), and Canada (5/96, 5%) represented 82% (79/96) of the published papers; 1 study was reported each from South America and Africa (Table 2). The studies coming from countries with official languages other than English [51,54,56-59] were from countries that adopted or adapted the existing triage systems. Other countries with large English-speaking populations are either underrepresented (England and New Zealand) or not represented at all (South Africa, Wales, Ireland, and Scotland; Multimedia Appendix 1).

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Table 1. Study characteristics by publication year.

	Studies (n=96)	Included EDs[a]		Initial sample		Included visits		Included patients		Included nurses		Studies using ML[b] methods (n=39)
		Total[c] (n=2438)	Studies[d] (n=88)	Total[c] (n=63,413,919)	Studies[d] (n=78)	Total[c] (n=12,220,866)	Studies[d] (n=76)	Total[c] (n=1,804,813)	Studies[d] (n=28)	Total[c] (n=3844)	Studies[d] (n=9)	
Year, n (%)												
1998	1 (1.04)	1 (0.04)	1 (1.14)	104 (0.0001)	1 (1.28)	104 (0.0008)	1 (1.32)	104 (0.01)	1 (3.57)	0 (0)	0 (0)	0 (0)
1999	2 (2.08)	2 (0.08)	2 (2.27)	100 (0.001)	2 (2.56)	100 (0.0008)	2 (2.63)	100 (0.01)	2 (7.14)	24 (0.62)	2 (2.22)	0 (0)
2000	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2001	2 (2.08)	497 (20.39)	2 (2.27)	98,672 (0.16)	2 (2.56)	84,000 (0.69)	1 (1.32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2002	1 (1.04)	1 (0.04)	1 (1.14)	11,861 (0.02)	1 (1.28)	0 (0)	0 (0)	305 (0.02)	1 (3.57)	0 (0)	0 (0)	0 (0)
2003	2 (2.08)	5 (0.21)	2 (2.27)	43,078 (0.07)	1 (1.28)	17,413 (0.14)	2 (2.63)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.56)
2004	3 (3.12)	23 (0.94)	3 (3.41)	1,021,949 (1.61)	3 (3.85)	21,949 (0.18)	2 (2.63)	73,115 (4.05)	2 (7.14)	0 (0)	0 (0)	2 (5.13)
2005	4 (4.17)	14 (0.57)	3 (3.41)	579,032 (0.91)	3 (3.85)	1510 (0.01)	2 (2.63)	86,079 (4.77)	2 (7.14)	0 (0)	0 (0)	3 (7.69)
2006	1 (1.04)	1 (0.04)	1 (1.14)	46,602 (0.07)	1 (1.28)	45,329 (0.37)	1 (1.32)	0 (0)	0 (0)	50 (1.3)	1 (11.11)	0 (0)
2007	1 (1.04)	1 (0.04)	1 (1.14)	521 (0.0008)	1 (1.28)	419 (0.003)	1 (1.32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2008	2 (2.08)	95 (3.9)	2 (2.27)	119,479 (0.19)	2 (2.56)	5956 (0.05)	2 (2.63)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.56)
2009	2 (2.08)	14 (0.57)	2 (2.27)	3,556,352 (5.61)	2 (2.56)	1,089,984 (8.92)	1 (1.32)	389 (0.02)	1 (3.57)	0 (0)	0 (0)	0 (0)
2010	1 (1.04)	2 (0.08)	1 (1.14)	263,937 (0.42)	1 (1.28)	19,252 (0.16)	1 (1.32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2011	1 (1.04)	6 (0.25)	1 (1.14)	794 (0.001)	1 (1.28)	794 (0.001)	1 (1.32)	0 (0)	0 (0)	2 (0.05)	1 (11.11)	1 (2.56)
2012	5 (5.21)	182 (7.47)	5 (5.68)	12,810,122 (20.2)	3 (3.85)	71,427 (0.58)	4 (5.26)	519 (0.03)	1 (3.57)	27 (0.7)	2 (22.22)	1 (2.56)
2013	3 (3.12)	4 (0.16)	2 (2.27)	348,895 (0.55)	1 (1.28)	41,624 (0.34)	1 (1.32)	798 (0.04)	1 (3.57)	0 (0)	0 (0)	0 (0)
2014	3 (3.12)	282 (11.57)	3 (3.41)	16,074,953 (25.35)	3 (3.85)	43,114 (0.35)	2 (2.63)	38,479 (2.13)	1 (3.57)	3538 (92.04)	1 (11.11)	1 (2.56)
2015	3 (3.12)	74 (3.04)	3 (3.41)	13,051,141 (20.58)	2 (2.56)	310,353 (2.54)	3 (3.95)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.56)
2016	4 (4.17)	109 (4.47)	3 (3.41)	13,194 (0.02)	3 (3.85)	2972 (0.02)	2 (2.63)	369 (0.02)	1 (3.57)	0 (0)	0 (0)	0 (0)
2017	7 (7.29)	345 (14.15)	5 (5.68)	2,450,310 (3.86)	5 (6.41)	2,287,592 (18.72)	7 (9.21)	0 (0)	0 (0)	0 (0)	0 (0)	2 (5.13)
2018	9 (9.38)	18 (0.74)	8 (9.09)	195,014 (0.31)	8 (10.26)	59,801 (0.49)	8 (10.53)	183 (0.01)	2 (7.14)	10 (0.26)	1 (11.11)	3 (7.69)
2019	12 (12)	641 (26.29)	10 (11.36)	5,453,665 (8.6)	10 (12.82)	3,426,182 (28.04)	10 (13.16)	153,145 (8.49)	3 (10.71)	193 (5.02)	1 (11.11)	7 (17.95)

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	Studies (n=96)	Included EDs[a]		Initial sample		Included visits		Included patients		Included nurses		Studies using ML[b] methods (n=39)
		Total[c] (n=2438)	Studies[d] (n=88)	Total[c] (n=63,413,919)	Studies[d] (n=78)	Total[c] (n=12,220,866)	Studies[d] (n=76)	Total[c] (n=1,804,813)	Studies[d] (n=28)	Total[c] (n=3844)	Studies[d] (n=9)	
2020	14 (14.58)	29 (1.19)	14 (15.91)	4,183,453 (6.6)	12 (15.38)	3,372,239 (27.6)	10 (13.16)	1,029,147 (57.02)	7 (25)	0 (0)	0 (0)	10 (25.64)
2021	13 (13.54)	92 (3.77)	13 (14.77)	3,090,691 (4.87)	10 (12.82)	1,318,752 (10.79)	12 (15.79)	422,081 (23.39)	3 (10.71)	0 (0)	0 (0)	6 (15.38)
Value, median (IQR)[e]	2.5 (1-4.25)	2 (1-12)	N/A[f]	60,231 (2943-461,435)	N/A	12,103 (803-150, 089)	N/A	391 (240-76,069)	N/A	15 (10-50)	N/A	1 (0-2)
Value, range[e]	0-14	1-496	N/A	50-14,000,000	N/A	29-2,100,000	N/A	29-412,858	N/A	2-3538	N/A	0-10

[a]ED: emergency department.

[b]ML: machine learning.

[c]The totals represent pooled data from all studies generated in that particular year.

[d]The number of studies represents how many studies the total was distributed across.

[e]Median (IQR) and range values were calculated based on individual study sample sizes; results reported by year are pooled.

[f]N/A: not applicable.

Figure 2. Triage narrative uses.

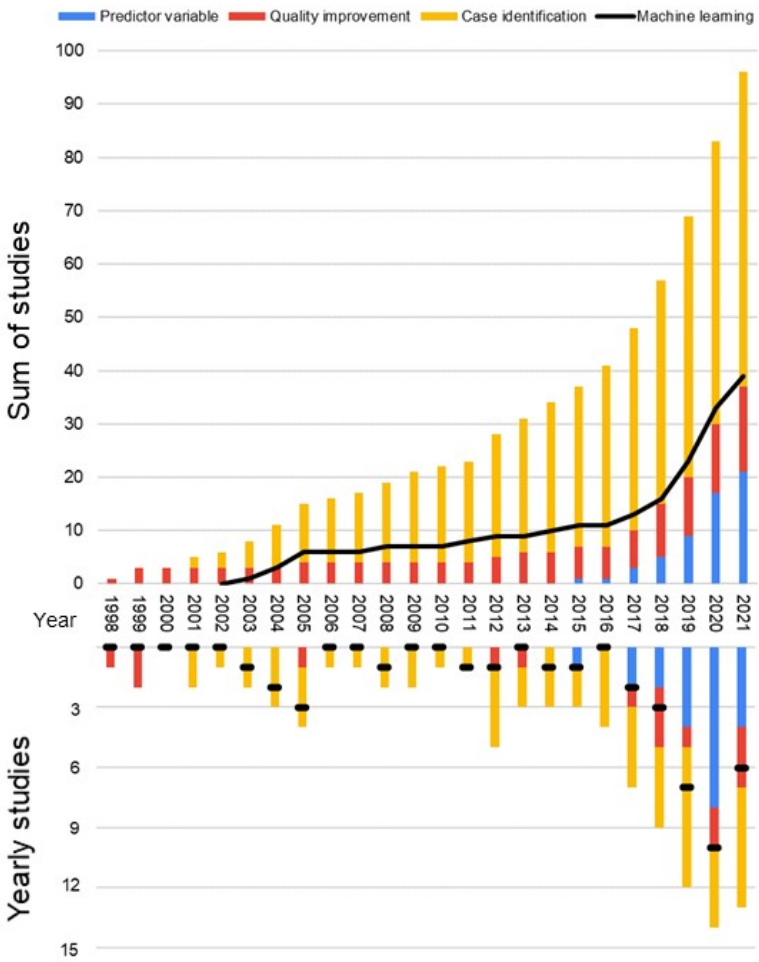

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Table 2. Study characteristics by country.

Country	Studies (n=96), n (%)	Included EDs[a]		Initial sample		Included patients		Included visits		Included nurses		Studies using ML[b] methods (n=39), n (%)
		Total (n=2438), n[c] (%)	Studies (n=88), n[d] (%)	Total (n=63,413,919), n[c] (%)	Studies (n=79), n[d] (%)	Total (n=1,804,813), n[c] (%)	Studies (n=28), n[d] (%)	Total (n=12,220,866), n[c] (%)	Studies (76), n[d] (%)	Total (n=3844), n[c] (%)	Studies (n=9), n[d] (%)	
United States	43 (44.79)	2008 (82.36)	39 (44.32)	36,528,693 (57.6)	35 (44.30)	916,955 (50.81)	12 (42.86)	4,986,560 (40.80)	34 (44.74)	3781 (98.36)	3 (33.33)	22 (56.41)
Australia	31 (32.29)	404 (16.57)	27 (30.68)	23,110,878 (36.44)	24 (30.38)	1996 (0.11)	5 (17.86)	4,784,753 (39.15)	24 (31.58)	2 (0.05)	1 (11.11)	10 (25.64)
Canada	5 (5.21)	7 (0.29)	5 (5.68)	6450 (0.01)	4 (5.06)	573 (0.03)	3 (10.71)	19,727 (0.16)	4 (5.26)	20 (0.52)	1 (11.11)	1 (2.56)
Israel	3 (3.12)	3 (0.12)	3 (3.41)	1,586,760 (2.50)	3 (3.8)	648,294 (35.92)	3 (10.71)	1,361,455 (11.14)	2 (2.63)	0 (0)	0 (0)	2 (5.13)
Great Britain	2 (2.08)	2 (0.08)	2 (2.27)	11,911 (0.02)	2 (2.53)	355 (0.02)	2 (7.14)	50 (0.0004)	1 (1.32)	4 (0.1)	1 (11.11)	0 (0)
Brazil	1 (1.04)	1 (0.04)	1 (1.14)	499,853 (0.79)	1 (1.27)	0 (0)	0 (0)	499,853 (4.09)	1 (1.32)	0 (0)	0 (0)	1 (2.56)
Switzerland	1 (1.04)	1 (0.04)	1 (1.14)	0 (0)	0 (0)	519 (0.03)	1 (3.57)	519 (0.004)	1 (1.32)	15 (0.39)	1 (11.11)	0 (0)
China	1 (1.04)	1 (0.04)	1 (1.14)	44,237 (0.07)	1 (1.27)	295 (0.02)	1 (3.57)	295 (0.002)	1 (1.32)	0 (0)	0 (0)	0 (0)
Spain	1 (1.04)	1 (0.04)	1 (1.14)	2080 (0.003)	1 (1.27)	0 (0)	0 (0)	1572 (0.01)	1 (1.32)	0 (0)	0 (0)	0 (0)
Finland	1 (1.04)	2 (0.08)	1 (1.14)	52,032 (0.08)	1 (1.27)	0 (0)	0 (0)	42,247 (0.35)	1 (1.32)	12 (0.31)	1 (11.11)	0 (0)
France	1 (1.04)	1 (0.04)	1 (1.14)	80,320 (0.13)	1 (1.27)	0 (0)	0 (0)	806 (0.01)	1 (1.32)	0 (0)	0 (0)	0 (0)
Iran	1 (1.04)	1 (0.04)	1 (1.14)	537 (0.0008)	1 (1.27)	0 (0)	0 (0)	537 (0.004)	1 (1.32)	10 (0.26)	1 (11.11)	1 (2.56)
South Korea	1 (1.04)	1 (0.04)	1 (1.14)	142,972 (0.23)	1 (1.27)	0 (0)	0 (0)	138,022 (1.13)	1 (1.32)	0 (0)	0 (0)	1 (2.56)
New Zealand	1 (1.04)	1 (0.04)	1 (1.14)	1000 (0.001)	1 (1.27)	0 (0)	0 (0)	1000 (0.01)	1 (1.32)	0 (0)	0 (0)	0 (0)
Portugal	1 (1.04)	1 (0.04)	1 (1.14)	599,276 (0.95)	1 (1.27)	235,826 (13.07)	1 (3.57)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.56)
Portugal and United States	1 (1.04)	2 (0.08)	1 (1.14)	719,925 (1.14)	1 (1.27)	0 (0)	0 (0)	356,475 (2.92)	1 (1.32)	0 (0)	0 (0)	0 (0)
Uganda	1 (1.04)	1 (0.04)	1 (1.14)	26,995 (0.04)	1 (1.27)	0 (0)	0 (0)	26,995 (0.22)	1 (1.32)	0 (0)	0 (0)	0 (0)

[a]ED: emergency department.

[b]ML: machine learning.

[c]The totals represent pooled data from all studies generated in that particular country.

[d]The number of studies represents how many studies the total was distributed across.

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Study Objectives

The most common objectives for studies using triage narratives were to perform case identification (59/96, 61%), to use narratives as a predictor variable in ML models (21/96, 22%), and to use narratives for quality improvement (16/96, 17%; Table 3). Studies categorized with case identification as their primary objective sought to describe incidence or prevalence estimates or populations of interest. Studies that used narratives as a predictor variable predicted patient acuity scores, resource use, or specific diagnoses.

Quality improvement studies used triage narratives to increase clinician or system safety and were subdivided as pertaining to reliability, accuracy, and validity or safety and efficiency. Reliability and validity studies examined interrater reliability and were used to assess whether the triage classification matched specific populations with specific categorical assignments or triage acuity scores. Safety and efficiency studies examined narratives to improve data quality or reduce errors and effort (Table 3).

ML consisted of several models, and we used an inclusive approach by combining all ML, natural language processing, and other artificial intelligence models. We noted the frequency of ML use to be increasing and that ML was more frequently used in predictive studies (21/25, 84%) than in studies using narratives for case identification (17/58, 29%) or quality (1/13, 8%; Figure 2).

Table 3. Summary of study objectives.

Study category and types of papers in the category	Explanation
Quality improvement	
Accuracy, validity, and reliability	Studies used triage narratives from previous ED[a] visits as a research instrument. These studies would have nurses or physicians rescore visits and compare the scores to calculate the reliability, validity, accuracy, or interrater agreement of providers for specific triage systems [48,49,51,54,60-62].
Safety and efficiency	These studies examined quality as the completeness of triage data [47], as how time-sensitive presentations were handled at triage [63,64], and to identify or improve errors in acuity or category assignment [51,54,62,65,66]. Other studies focused on improving triage and measured the amount of duplicate or redundant information within triage narratives [67] or the efficiency [42,54,55], accuracy [55], and completeness [55,58,68,69] of narratives.
Case identification	
Syndromic classification	These studies had a primary objective of developing, describing, or comparing syndromic surveillance systems. These systems attempt to group all patients from a single large cohort into one of several broadly defined groups to assign a reason for visit category [38,42-44,50,52,53,70-76].
Estimate incidence or describe a population	Triage narratives have been used as an alternate means of identifying general or specific presentations. General grouping included cases related to drugs or alcohol [39,40,77-86], sports [69,87-90], motor vehicle collisions [41,90-93], mental health–related presentations, [94-100], environmental injuries [45,101-103], infections [104,105], assaults [106,107], and animal bites [45,108,109]. Narratives seem to be particularly good at identifying rare cases [107,110-113]. Narratives have also been used to provide granular data about patients, such as temporal information [114], to complete missed vitals [115] and to provide contextual details such as events leading to an injury [39,78,87,89-91,116].
Prediction	
Acuity or resource use	Predictions using triage narratives attempted to forecast the resource uses by patients in general [117] or addressed specific aspects of care, including the need for admission [118-122], triage acuity [57,59,123-126], length of stay [119], critical illness [124], and mortality, [57,127,128].
Specific diagnoses	Triage narratives were used as a covariate for machine learning models that predicted specific resource or admission needs. Admission destinations and resources of interest included advanced diagnostic imaging use [56,129,130], mental health admission [131], ICU[b] admission [132], or neuro-intensive care unit admission [133].

[a]ED: emergency department.

[b]ICU: intensive care unit.

Descriptions of Triage Narratives

The quality and structure of the triage narratives used in each study were not clearly stated. Of the 96 studies included, only 30 (31%) described the narrative. The most common approach to describing narratives was a description of the triage narrative or of the keywords used to search within the narrative (Table 4).

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Table 4. Descriptions of the structure of triage narratives.

Study, year	Description of the triage narrative[a]	Keywords, n[b]	Keyword topics
Travers and Haas [75], 2003	There was a description of the characteristic components of the narrative chief complaints that were not matched by machine learning: punctuation, truncations, modifiers, and qualifiers were discussed	N/A[c]	N/A
Chapman et al [104], 2004	N/A	5	The following fever-related keywords were used: "fever(s)," "Febrile," "chill*," and "low grade temp*"
Day et al [43], 2004	The mean length of the triage narratives was 14.6 (SD 7.9) words in each database	6	Shortness of breath and difficulty in breathing were examined
Thompson et al [38], 2006	The maximum allowable space for triage narratives was 40 characters	>100	Keywords for chest pain, syncope, earache, and others
Indig et al [39], 2010	The average triage note was 35 words (including abbreviations) per presentation; there was a secondary text field that was not discussed	>160	Drug and alcohol keywords
Bregman and Slavinski [109], 2012	N/A	2	Mammal bite–related terms and their associated animals were examined using the search terms "bite" and "animal"
McKenzie et al [108],2010	N/A	50	Work, worker, and work-related keywords and truncations
Vallmuur et al [79], 2013	N/A	18	Alcohol-related keywords
Mitchell and Bambach [91], 2015	N/A	32	Alcohol- and vehicular collision–related keywords
Luther et al, [101], 2016	N/A	1	Presentations with the keyword "heat"
Rahme et al [95], 2016	N/A	16	Suicide-related keywords were identified in both English and French
Whitlam et al [81], 2016	N/A	12	Alcohol-related keywords
DeYoung et al [40], 2017	N/A	>150	Cannabis-related keywords
Kondis et al [107], 2017	N/A	2	"Crying" and "fussy" were the search keywords reported; however, variations in these terms were also included (although not specified by the authors)
Harduar Morano et al [102], 2017	N/A	11	Heat injury–related keywords
Zhang et al [118], 2017	N/A	25	A list of keywords predictive of patient admission
Chu et al [110], 2018	N/A	1	"Headache"
Gligorijevic et al [117], 2018	N/A	24	Mixed keywords for a variety of presentations
Goldman-Mellor et al [131], 2018	N/A	8	Mental health and substance use–related keywords
Hargrove and Waller [92], 2018	N/A	23	Vehicle collision–related keywords
Nagabhushan and Webley [111], 2018	N/A	2	Specific chest pain feature keywords "ripping" and "tearing"
Chen et al [89], 2019	N/A	2	"Tramp" and "bounce" were specified, but other terms may have been used
Eley et al [90], 2019	N/A	14	Bicycle-related keywords
Marx et al [83], 2019	N/A	8	Marijuana-related keywords

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Study, year	Description of the triage narrative[a]	Keywords, n[b]	Keyword topics
Trivedi et al [93], 2019	N/A	3	Electric scooter–related brand names “bird” and “lime” as well as “scooter” were the keywords
Sterling et al [126], 2020	The mean length of triage narrative was 143.17 (SD 77.8) characters (excluding spaces) or 64.3 (SD 35.2) words	N/A	N/A
Vernon et al [41], 2020	N/A	3	Electric scooter–related keywords and their variations were searched. “Scooter,” “e-scooter,” and “electric-scooter” were offered as specific terms
Ivanov et al [125], 2021	The average number of clinical features per text entry was 12.79. There was no discussion about character or word counts	N/A	N/A
Rahilly-Tierney et al [86], 2021	N/A	3	“Heroin” and “overdose” were specified as inclusion terms and “detoxification” as an exclusion term; although there may have been additional terms included, they were not specified
Rozova et al [99], 2021	The average triage note was 127 characters long (notes with <30 characters were excluded)	40	Suicide-related keywords

[a]Studies reporting only the process of cleaning and normalizing unstructured narratives were not included.

[b]Variations in spelling, abbreviations, bigram duplications, and negation terms were counted if specified.

[c]N/A: not applicable.

There were 7 studies that described triage narratives [38,39,43,75,99,125,126]. The descriptions included the counts of characters and words used in the typical triage narrative. The length of the triage narrative entries in these studies ranged from 40 [38] to 127 characters [99] and 14.6 [43] to 35 words (including abbreviations) [39] (Table 4). One study described the narratives in terms of “clinical features” [125]. “Clinical features” in this study were Unified Medical Language System clinical terms that the authors derived using a natural language processing algorithm (C-NLP), but it is unclear how much these differ from their input data or whether they can be compared with those in other studies.

There were 27 studies that reported on the specific keywords that were present within the narratives [38-41,43,79,81,83,86,89-93,95,99,101,102,104,107-111,117,118,125,126,131]. The number of keywords ranged from 1 [101] to >160 [39], with a median number of 11 (IQR 3-24.5) keywords reported (Table 4). However, 11% (3/27) of studies did not report the exact number of keywords used [38-40]. The authors reported the use of express keywords with correct spellings [86,93,101,107,109-111] as well as intentional variations such as misspellings, abbreviations, or truncations [39,40,81,92,108]. One of the studies searched for terms using keywords in 2 languages (English and French) [95].

In total, 9 studies reported the number of nurses who generated the narratives [38,48-55]. The total number of nurses whose documentation was assessed in these studies was 3844. The median sample size of nurses was 15 (IQR 10-50), and the sample size ranged from 2 [50] to 3538 [53]. These 9 studies represent only 3% of the total sample size (n=367,946). One of the studies reported on both the structure of triage narratives and the number of nurses included in the sample [38].

The most in-depth descriptions were provided by Travers and Haas [75], who explored triage narratives in depth by describing the structure of the narratives and regional variations. This 3-center retrospective cohort study used verbatim triage chief complaint narratives drawn from EDs in the United States. In a corpus of 13,494 unique chief complaint narratives drawn from 39,038 visits, they used manual and automated techniques to identify chief complaint concepts using the Unified Medical Language System data definitions. Concepts that were not readily classified using ML models were described in both form and function, and the authors detailed the function of the punctuation, acronyms and abbreviations, truncations, modifiers, and qualifier words used in triage narratives [75].

Although quality appraisal can be incorporated into scoping reviews [30], we did not opt to include one because our primary aim was to describe the literature rather than assess each study’s findings [27,28]. Consequently, we are limited to reporting that 8% (8/96) of the included studies used an Enhancing the Quality and Transparency of Health Research Network quality reporting guideline (Table 5). In total, 4% (4/96) of studies used reporting guidelines specifically for predictive models [62,99,124,129], and 1% (1/96) of studies reported using a quality framework to guide data cleaning and the protection of patient information [124].

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Table 5. Studies that used reporting guidelines and the types of guidelines used.

Study, year	Reporting guideline	Guideline body
Chu et al [110], 2018	The RECORD[a] statement	EQUATOR[b] Network
Jones et al [82], 2019	The STROBE[c] statement: guidelines for reporting observational studies	EQUATOR Network
Trivedi et al [93], 2019	The STROBE statement: guidelines for reporting observational studies	EQUATOR Network
Zhang et al [129], 2019	GRRAS[d]	EQUATOR Network
Joseph et al [124], 2020	(1) HIPAA[e] Safe Harbor method and (2) The TRIPOD[f] statement	(1) US Department of Health and Human Services and (2) EQUATOR Network
Cheung and Leung [62], 2021	GRRAS	EQUATOR Network
Lam et al [85], 2021	The RECORD statement	EQUATOR Network
Rozova et al [99], 2021	The TRIPOD statement	EQUATOR Network

[a]RECORD: Reporting of Studies Conducted Using Observational Routinely Collected Health Data.

[b]EQUATOR: Enhancing the Quality and Transparency of Health Research.

[c]STROBE: Strengthening the Reporting of Observational Studies in Epidemiology.

[d]GRRAS: Guidelines for Developing and Reporting Machine Learning Predictive Models in Biomedical Research.

[e]HIPAA: Health Insurance Portability and Accountability Act.

[f]TRIPOD: Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis.

Discussion

Principal Findings

We performed a scoping review to examine studies reporting on the structure and use of triage nurse narratives. Our search was systematic, used a prepublished protocol, and screened a significant number of studies published over a 32-year period. Our study protocol was registered and published and used standardized screening templates and data extraction forms [29]. Our search intentionally sacrificed specificity for sensitivity, including a substantial number of studies in keeping with the scoping review design. The volume of studies retrieved demonstrates that identifying triage narrative in academic literature is difficult and that straightforward ways of identifying pertinent studies are needed. Studies would be more readily identifiable if their keywords, titles, and abstracts were clear and consistent.

In addition to the triage narrative, we found that the most frequently reported data were patient age, sex, chief complaint category, discharge status, and triage acuity, similar to a 2020 systematic review of ML for clinical decision support in the ED [5]. Similar to other review studies, we found an increase in the number of studies conducted over time [3]. We found a sharp increase in the sample size of studies after 2008. Our findings also support that the studies using ML lag behind studies of health record data. However, we noted that this trend continued only until 2017, when ML became the most common approach reported in the literature. Wang et al [3] tabulated the top sources of electronic health record narratives and determined that the most common sources were discharge summaries (n=26, 45% of studies), progress notes (n=15, 26%), admission notes (n=9, 16%), operative notes (n=5, 9%), and primary care notes (n=3, 5%). We identified 5 studies [71,72,108,121,134] that used ML. ML studies were challenging to identify through structured searches. Similar to our review, Wang et al [3] determined that most studies were conducted in the United States. They identified fewer (3/263, 1%) studies from Australia. In comparison, our study identified that 56% (10/18) of the studies originated from Australia during the same period [50,108]. Our results differ in part because we did not restrict our search in the same manner as Wang et al [3], who explicitly examined ML, and rather focused on unstructured narratives as a primary search concept.

The previously discussed reviews and several other studies included in this review established that triage narratives can improve case identification when used in isolation or when added to diagnosis codes [22]. The use of narratives for these purposes was reported as a straightforward process in several studies that showed that their inclusion or exclusion can substantially impact the number of cases identified [72,78,79]. Refinement of these techniques may improve the sensitivity of searches and have significant impacts on disease prevalence estimates for diagnoses (eg, rare illnesses) that may not be well captured with administrative discharge codes, a common method for tracking population illnesses [113,135]. The methods used in keyword-based case identification studies are well positioned for implementation, given their clearly defined and reproducible methods and long history of being used for these purposes. Studies of disease prevalence were among the first to use narratives collected on a large scale [42,75]. The potential improvements to the sensitivity and specificity of case identification may justify the systematic review of the studies included in this review. In addition, future research could focus on clearly defining the improvements that narrative data analysis can offer to case identification studies.

There is a pressing need to collect nursing data [7], and triage has been identified as one of the most important areas for quality improvement [136]. Several studies have reviewed quality improvement efforts at triage [8] and called to include narratives in these efforts [137], but significant work is still needed. A

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renewal of early efforts to establish a minimum ED nurse data set [26] and efforts to create common definitions for narrative elements are needed [25], as is additional research to describe the structures of triage narratives in general. This work is required to determine whether there is a common structure in the data. Our results showed that even though 31% (30/96) of studies offered a description of narratives, only 1% (1/96) provided significant depth. A fulsome description is needed to ensure that triage nursing contextual data are not lost through text normalization (a typical early step in data cleaning for models), given that nurses use unique punctuation and abbreviations while recording triage narratives [75]. Finally, given the wide regional variations in the breadth and depth of information collected at triage, research is needed to identify the specific details that triage narratives should contain.

The Strengthening the Reporting of Observational Studies in Epidemiology and Reporting of Studies Conducted Using Observational Routinely Collected Data guidelines were published in 2007 [138] and 2015 [139], respectively. However, only 8% (8/96) of the studies reported using a reporting guideline, even though 86% (83/96) of these studies were reported after 2007. Recently published reporting guidelines such as the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis [140] may contribute to more consistent reporting guideline use, and 2021 saw the highest (3/13, 23%) proportion of studies using a reporting guideline. The use of reporting guidelines will help reduce the heterogeneity noted in reporting.

Limitations

In total, 3 concepts (emergency, triage, and narrative) were searched using an inclusive search approach, resulting in a substantial number of studies. The level of agreement during screening was fair, but it was likely reduced owing to the large number of studies reviewed and the need for full-text reading to determine whether the narrative was nurse generated. Future refinements to the search strategy may enable a less wide-reaching search, and more clearly defined methods to identify nurse-generated narratives may decrease the number of studies for screening. In addition, clear methods for identifying when narratives are generated by nurses may prevent researchers from pooling nurses' triage narratives with narratives generated by other clinicians such as physicians, which may result in more studies being positively identified as originating from triage nurses.

Conclusions

This review identified 96 studies that used triage narratives to achieve quality improvement, perform case identification, or make predictions about clinical outcomes. We have described how narrative use is changing to incorporate larger samples and more ML methods for interrogating the data. We have provided a strong argument that there is a considerable lack of research on the structure of triage narratives. Future research should not only focus on the outcomes of their study but also describe in detail the data sources used. Future researchers should strive to follow reporting guidelines to improve the quality of data reporting and increase the ability to pool and compare study findings. Emergency nursing scholars can encourage the national collection of triage data to allow comparison between regions if the common structures of data are better articulated.

Authors' Contributions

All the authors contributed to the design of this study. CP, MK, and MD initiated the project. The protocol was drafted by CP and refined by MK, HMO, CN, CM and MD. Screening was performed by CP and MD. Data extraction was performed by CP and confirmed by MD. CP performed the statistical analyses and was responsible for drafting the manuscript. MK supervised this study. All the authors have contributed to the manuscript read, refined, and approved the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Summary of the included studies.
[DOCX File , 74 KB - nursing_v6i1e41331_app1.docx]

Multimedia Appendix 2
Data items collected.
[DOCX File , 73 KB - nursing_v6i1e41331_app2.docx]

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Abbreviations

ED: emergency department
ML: machine learning
PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews

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Original Paper

Process Evaluation of a Wireless Wearable Continuous Vital Signs Monitoring Intervention in 2 General Hospital Wards: Mixed Methods Study

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Abstract

Background: Continuous monitoring of vital signs (CMVS) using wearable wireless sensors is increasingly available to patients in general wards and can improve outcomes and reduce nurse workload. To assess the potential impact of such systems, successful implementation is important. We developed a CMVS intervention and implementation strategy and evaluated its success in 2 general wards.

Objective: We aimed to assess and compare intervention fidelity in 2 wards (internal medicine and general surgery) of a large teaching hospital.

Methods: A mixed methods sequential explanatory design was used. After thorough training and preparation, CMVS was implemented—in parallel with the standard intermittent manual measurements—and executed for 6 months in each ward. Heart rate and respiratory rate were measured using a chest-worn wearable sensor, and vital sign trends were visualized on a digital platform. Trends were routinely assessed and reported each nursing shift without automated alarms. The primary outcome was intervention fidelity, defined as the proportion of written reports and related nurse activities in case of deviating trends comparing early (months 1-2), mid- (months 3-4), and late (months 5-6) implementation periods. Explanatory interviews with nurses were conducted.

Results: The implementation strategy was executed as planned. A total of 358 patients were included, resulting in 45,113 monitored hours during 6142 nurse shifts. In total, 10.3% (37/358) of the sensors were replaced prematurely because of technical failure. Mean intervention fidelity was 70.7% (SD 20.4%) and higher in the surgical ward (73.6%, SD 18.1% vs 64.1%, SD 23.7%; $P<.001$). Fidelity decreased over the implementation period in the internal medicine ward (76%, 57%, and 48% at early, mid-, and late implementation, respectively; $P<.001$) but not significantly in the surgical ward (76% at early implementation vs 74% at midimplementation [$P=.56$] vs 70.7% at late implementation [$P=.07$]). No nursing activities were needed based on vital sign trends for 68.7% (246/358) of the patients. In 174 reports of 31.3% (112/358) of the patients, observed deviating trends led to 101 additional bedside assessments of patients and 73 consultations by physicians. The main themes that emerged during interviews (n=21) included the relative priority of CMVS in nurse work, the importance of nursing assessment, the relatively limited perceived benefits for patient care, and experienced mediocre usability of the technology.

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Conclusions: We successfully implemented a system for CMVS at scale in 2 hospital wards, but our results show that intervention fidelity decreased over time, more in the internal medicine ward than in the surgical ward. This decrease appeared to depend on multiple ward-specific factors. Nurses' perceptions regarding the value and benefits of the intervention varied. Implications for optimal implementation of CMVS include engaging nurses early, seamless integration into electronic health records, and sophisticated decision support tools for vital sign trend interpretation.

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KEYWORDS

physiological monitoring; implementation science; clinical deterioration; continuous vital sign monitoring; wearable wireless devices; wearables; process evaluation; mixed methods; intervention fidelity

Introduction

Background

Most adverse events occurring in hospital wards are preceded by a considerable period of changes in vital signs, which are important indicators of clinical deterioration [1]. Monitoring vital signs allows for early detection and timely interventions that may improve outcomes [1-4]. In high-care units with patients who are critically ill, continuous monitoring of vital signs (CMVS) is the norm, whereas in general wards, vital signs are usually monitored intermittently, and interpretation is guided by Early Warning Scores (EWSs) [5-7]. Although the EWS system may facilitate early detection, there are still limitations owing to its intermittent nature and variable compliance [8-10]. Consequently, patients' condition may deteriorate unnoticed, which can lead to avoidable adverse events, adverse outcomes, and higher costs [11-13].

Given recent technological developments, CMVS using wearable wireless sensors has become available to patients in general wards. Previous studies have shown that these systems can accurately measure vital signs and detect deterioration [14-16]. However, evidence on the effects of these CMVS systems on patient outcomes is scarce [17,18]. This may be related to the fact that the implementation of CMVS at scale remains challenging and requires considerable upfront financial investment by hospital administrations [19,20].

Although many health care professionals acknowledge the potential benefits of CMVS for patient care, several studies have highlighted considerable challenges, such as difficult implementation into existing nursing workflows, poor integration with hospital electronic health record (EHR) systems, and primitive alarm management strategies [21-23]. In addition, monitoring vital sign trends may be challenging for most ward nurses because of a lack of experience with interpreting graphic representations of CMVS trends [15,24,25].

Objectives

Given these challenges, implementing CMVS in hospital wards is considered a "complex intervention" with many interacting components and the need for behavior change of health care professionals and affecting multiple patient outcomes [26,27]. Successfully scaled implementation in wards is necessary before any possible beneficial effects of CMVS on clinical outcomes can be expected [17,21,28]. Unfortunately, there is only scant knowledge on the facilitators and barriers to CMVS implementation [24,25,29]. We have previously conducted 2 feasibility studies [15,23] and 2 qualitative studies [24,30] that aided in developing and refining our CMVS intervention and an implementation strategy. For this study, an implementation-effectiveness hybrid design was used for the parallel evaluation of the implementation and effectiveness of the intervention [31]. This report focuses on the process evaluation of the implementation, with the primary aim of assessing and comparing intervention fidelity in 2 wards (internal medicine and general surgery). The secondary aims were to assess and compare implementation fidelity, technical fidelity, perceived appropriateness, acceptability, usability, adoption, and feasibility according to nurses. The effectiveness of the intervention will be analyzed and described in a separate paper.

Methods

Design

A mixed methods sequential explanatory design [32] was used for an 8-month period in a surgical ward and an internal medicine ward (September 2021-July 2022) of a 1245-bed tertiary teaching hospital in the Netherlands. The study was reported according to the Standards for Quality Improvement Reporting Excellence 2.0 checklist [33].

Context

The surgical ward consisted of 49 beds, in which patients of gastrointestinal and vascular surgery were admitted. A total of 57.4 full-time equivalent of nurses were employed at the ward. The nurse-to-patient ratio was 1:5 for the day shift, 1:6 for the evening shift, and 1:12 for the night shift. A nurse specialist or junior resident assessed the patients daily during morning rounds.

The internal medicine ward consisted of 48 beds and was divided into 2 teams of nurses based on subspecialties: general internal medicine and gastroenterology. The nurse-to-patient ratio was 1:4 for the day shift, 1:12 for the evening shift, and 1:12 for the night shift. A junior resident assessed the patients during morning rounds.

Patients admitted to the surgical and internal medicine wards were eligible to receive the CMVS intervention (Multimedia Appendix 1). Inclusion criteria were age of ≥18 years, no cognitive impairments, expected hospitalization time of ≥2 days, and ability to speak and read the Dutch language. The exclusion criterion was inability to wear the CMVS sensor because of an allergy. Nurses who were employed at the ward during the study

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period participated and were eligible for participation in the process evaluation if they had worked with the CMVS system for at least one month during the study period. Nurses temporarily employed from the flex pool were excluded from the study.

Intervention

In addition to standard care, patients included in the study were monitored using the Conformité Européene–marked Healthdot sensor (Philips Healthcare) and IntelliVue Guardian Solution (IGS) software platform (*Philips Healthcare*). Standard care consisted of intermittent monitoring (at least once daily) through manual measurements performed by the nurse and assessed using the Modified EWS (MEWS) according to the local hospital protocol [34].

The wireless wearable sensor was a water-resistant disposable patch worn on the patient's chest (Multimedia Appendix 2); it continuously records the heart rate (HR) in beats per minute and respiratory rate (ReR) in respirations per minute both using accelerometry. Previous studies have shown that this sensor is accurate [35,36]. The 2 vital sign measurements are transmitted wirelessly every 5 minutes through a long-range, low-power Internet of Things connection (LoRa; Semtech) to the IGS software. After connecting the sensor to the patient and to the software by scanning the QR code using a separate mobile phone, the software platform with trends was displayed on the computer on wheels and in a mobile app (Multimedia Appendix 3). The battery life of the patch was 14 days, and during the performance of an electrocardiogram, computer tomography, or magnetic resonance imaging, the sensor was temporarily removed.

Within the IGS software, individual vital sign trends were visualized, and complementary to the hospital MEWS protocol, a partial MEWS (D-EWS) was presented every hour to promote adequate detection. The D-EWS was based on the HR and ReR measurements and was in line with the MEWS thresholds and scores (Multimedia Appendix 4) on the preinstalled thresholds for HR and ReR. Patient numbers and names were automatically synchronized with the EHR using a Health Level 7 linkage, so manual entry was not required. As the device measures only 2 vital signs, routine manual measurements of other relevant vital signs (eg, temperature and blood oxygen saturation) by nurses were maintained throughout the study. Every 4 hours (ie, twice per shift), nurses routinely assessed vital sign trends and reported the D-EWS and any deviations and subsequent nursing activities in the EHR at the end of every shift. When the D-EWS was ≥3, additional checks and interventions could be performed as deemed appropriate by the nurse. No alarm strategy was applied in this study based on the substantial alarm fatigue experienced by nurses in our previous feasibility studies [15,23].

Implementation Strategy

Before the start of the study, the 2 wards were technically prepared for CMVS, and an e-learning module was developed (Textbox 1). This comprehensive 30-minute e-learning module (*Articulate 360; Articulate Global*) was developed by the project manager (JL) together with an educationalist. The e-learning module ended with a knowledge assessment that had to be successfully completed. The contents were pilot-tested by 4 nurses of the project team (Multimedia Appendix 5). This project team was formed per ward comprising the project manager, 4 nurses, the ward manager, and 1 consulting physician. First, information and goals about the project were presented in a regular team meeting 2 months before the start of the project. Subsequently, the e-learning module for nurses was made available on the web (Multimedia Appendix 5). It consisted of information about the purpose of the project, the rationale for CMVS, the protocol of the D-EWS, the work processes and policy, the practical use of the IGS system, and how to assess the vital sign trends. Afterward, there was a week of daily meetings with the project manager to provide ample opportunities to ask further questions. In addition, all relevant physicians were informed of the project and workflow in a team meeting.

During the first 4 weeks of the study, bedside training and coaching were provided by the project manager (Monday-Friday) 3 times daily. In addition, weekly status updates and feedback on the implementation were provided to the entire team via email. During the study period, the project manager coordinated the inclusion process (Monday-Friday). A small number of dedicated project team nurses acted as key users to provide support for all nurses.

To accurately monitor the implementation, the use of performance feedback was deemed essential. Each month of the study—as a structured evaluation moment—a dashboard with interim results of the inclusion rate and intervention fidelity was discussed in a project team meeting. In addition, a patient case study with deviating vital sign trends was presented, and CMVS experiences were discussed. Subsequently, actions were defined according to the Plan Do Check Act cycle [37], resulting in an iterative process of improvement of the implementation strategy. The results of the meeting, including the dashboard and related actions, were communicated to all team members via email. In addition, every 100th patient with CMVS was celebrated as an inclusion milestone in the team meeting.

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Textbox 1. Planning of the implementation process.

Preparation period

- Month –4
  - Technical preparation of the ward
  - Development of an e-learning module
- Month –3
  - Plenary team meeting
- Month –2
  - e-learning module on the web
  - Defining implementation measures with key users
- Month –1
  - Daily meetings for nurses
  - Education for physicians

Implementation period

- Month 1
  - Go live
  - Bedside coaching 3 times a day
  - Weekly feedback updates
  - Monthly evaluation and feedback
- Months 2 to 6
  - Monthly evaluation and feedback

Study Procedures

Admitted patients who met the inclusion criteria were approached and received information about the study. Patients of surgery were asked for informed consent during the preadmission call, and patients of internal medicine were asked when admitted to the ward. When the patients agreed to participate, the nurse started CMVS directly or immediately after the surgical procedure until discharge.

Sample Size

The study sample size was based on the primary aim of the project: evaluation of the implementation.

There is insufficient guidance in the literature regarding sample size calculations for this type of implementation evaluation studies. On the basis of historical data and the recruitment rate of our previous feasibility studies [15,23], we estimated that we would be able to include 350 patients across both wards over a period of 6 months.

Ethical Considerations and Informed Consent

The Medical Ethics Committee of the Isala Hospital reviewed the protocol (protocol 210414) and declared that the Medical Research Involving Human Subjects Act (also known by its Dutch abbreviation WMO) did not apply for this study. This study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients participating in the study. All patient data were registered in case report forms and stored securely.

Data Collection

Quantitative Data

On the basis of the outcome definitions by Proctor et al [38], a broad range of implementation outcomes was assessed—overall and per ward—to comprehend the full extent of the implementation. An overview of the measured constructs and timing is presented in Table 1.

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Table 1. Overview of study outcomes per ward.

Outcome	Month					
	1	2	3	4	5	6
Intervention fidelity	AD[a]	AD	AD	AD	AD	AD or I[b]
Implementation fidelity	AD	AD	AD	AD	AD	AD or I
Technical fidelity	AD	AD	AD	AD	AD	AD or I
Appropriateness	S[c]	N/A[d]	N/A	N/A	N/A	N/A
Acceptability	N/A	N/A	S	N/A	N/A	S/I
Usability	N/A	N/A	S	N/A	N/A	S/I
Adoption	N/A	N/A	S	N/A	N/A	N/A
Feasibility	N/A	N/A	S	N/A	N/A	S/I

[a]AD: administrative data from the patient record.

[b]I: interview.

[c]S: survey collected via email.

[d]N/A: not applicable.

The main outcome was the "intervention fidelity," defined as the proportion of written nurse EHR reports on the CMVS trend assessment per patient per nursing shift. A 100% score would be 3 reports per 24 hours per patient. We considered 70% of written reports per patient to be sufficient for implementation success based on our previous feasibility study [15]. In addition, any follow-up nursing activities in case of deviating trends were described.

The secondary outcomes were implementation fidelity; technical fidelity; and a survey of nurses on appropriateness, acceptability, usability, adoption, and feasibility. For implementation fidelity, the proportion of nurses who had completed the e-learning module, the proportion of monthly evaluations with the project team, and the implementation measures were documented and described. In addition, exposure (defined as the proportion of hospitalized patients receiving the intervention at the ward during implementation), recruitment (defined as the proportion of actual patients willing to participate), and retention rate (defined as retention of patients using CMVS during admission) were recorded. Moreover, regarding technical fidelity, the following data of the CMVS system were collected: number of measurements, proportion of data artifacts, D-EWSs, and premature replacement of the sensor because of technical failure. An artifact was defined as an invalid measurement as identified by the algorithm of the system and presented as -?-.

The surveys for nurses were sent via email and consisted of several questionnaires (Table 1). The 4-item Acceptability of Intervention Measure evaluated acceptability, the 4-item Intervention Appropriateness Measure evaluated appropriateness, and the 4-item Feasibility of Intervention Measure evaluated feasibility, all on a 5-point Likert scale (score 1-5). A median score of ≥3.5 was considered sufficient [39].

The 10-item System Usability Scale measured usability on a 5-point Likert scale, resulting in a score of 0 to 100. A usability score of ≤50 was considered unacceptable, 51 to 70 was considered marginal, and >70 was considered acceptable [40].

The 15-item Evidence-Based Practice Attitude Scale on a 5-point Likert scale measured adoption (score of 0-4) with the following subscales: requirements, appeal, openness, and divergence. Scores were reported as overall scores and per subscale. A higher score indicated better adoption. A median score of ≥2.5 was defined as sufficient adoption.

Finally, we collected data on patient characteristics (gender, age, BMI, American Society of Anesthesiologists classification, urgency of admission, Short Nutritional Assessment Questionnaire [41], smoking status, alcohol use, and comorbidities [Charlson Comorbidity Index score ranging from 0-12]) [42,43] and outcomes (length of stay, mortality, unplanned intensive care unit admissions, and rapid response teams) from administrative data from the EHR. Nurse demographics (gender, age, job position, working experience in years, and working hours per week) were collected from the hospital's personnel records.

Qualitative Data

In addition to the quantitative data, semistructured interviews were conducted with nurses (Table 1). The qualitative element of this study aimed to clarify the quantitative data. A pilot-tested topic list guided the interviews (Multimedia Appendix 6), which were conducted by 2 nursing students who were trained and supervised by the project manager (JL). The interviews were audio recorded and transcribed verbatim. No field notes were taken. Per ward, at least 10 semistructured interviews were conducted in a secluded room on the ward in the last month of the study.

Data Analysis

Quantitative Data

Data were analyzed using descriptive and inductive statistics with SPSS Statistics (version 26; IBM Corp) for Windows. Each continuous parameter was checked for normality using the Kolmogorov-Smirnov test and visually using a *Q-Q* plot and histogram. Normality-based reporting was performed using

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means with SDs or medians with IQRs. For categorical data, frequencies and percentages were reported.

To explore the differences between the wards, the unpaired *t* test, Mann-Whitney *U* test, and chi-square test of the Fisher exact test were performed based on normality and test assumptions. In addition, multiple linear regression was performed for explorative analysis of intervention fidelity of the nurses based on the reports. The independent variables were the Charlson Comorbidity Index [42], length of stay, number of D-EWSs of ≥3, amount of artifact data (in percentage), and the month of implementation. Implementation month was a dummy variable divided into early (months 1-2), mid- (months 3-4), and late (months 5-6) implementation. For all tests, $P<.05$ was considered statistically significant.

Qualitative Data

The interviews were analyzed using deductive thematic analysis with the qualitative data analysis software NVivo (version 12; *QSR International*). The raw data were analyzed using a 6-stage thematic analysis as outlined by Braun and Clarke [44]. The stages included (1) immersion, (2) generating initial codes, (3) searching for and identifying themes, (4) reviewing themes, (5) defining and naming themes, and (6) writing the report.

In total, 2 researchers (JL and HR) conducted stages 1 to 3 independently. During the first and second stages, JL and HR became familiar with the data by listening to the audio recordings, checking the transcriptions against the audio recording, reading, listening to sections again, and rereading the final transcripts. During the third stage, both researchers read the transcripts and codes for categorizing similar statements into first themes. In stages 4 to 6, all authors were responsible for reviewing, defining, and naming themes through discussion. During the sixth stage, the themes were brought to the nurses for member checking via email, which did not result in any changes to the themes.

Mixed Methods: Integration and Interpretation

Integration of the quantitative and qualitative elements of the study occurred through linking the methods of data collection and analysis. Linking of methods occurred through building: the data of the inclusion and intervention fidelity per month served as the start for the interview, and possible explanations based on the nurses' experiences were discussed. Interpretation and reporting occurred through the contiguous approach: presentation of qualitative and quantitative findings in consequent but different sections [45].

Results

Study Characteristics

A total of 384 patients were screened for participation, of whom 6 (1.6%) declined. Of the 378 patients included during the implementation period, 20 (5.3%) were excluded because of conversion to palliative surgery (n=5, 25%), known allergy (n=1, 5%), loss to follow-up (n=8, 40%), surgery cancellation (n=3, 15%), retraction (n=2, 10%), or postoperative admission to another ward (n=1, 5%). Finally, 358 patients were included in the analysis: 248 (69.3%) from the surgical ward and 110 (30.7%) from the internal medicine ward (Multimedia Appendix 7). The median length of stay at the surgical ward was 6.0 (IQR 3.5-10.5) days versus 8.8 (IQR 5.5-14.1) days at the internal medicine ward ($P<.001$). Nearly all patients of internal medicine (109/110, 99.1%) were emergency admissions in contrast to 7.3% (18/248) at the surgical ward ($P<.001$), and in-hospital mortality was considerably higher in the internal medicine ward (8/110, 7.3% vs 2/248, 0.8%; $P=.002$). For all the characteristics, see Table 2. In total, 148 nurses participated in the study: 71 (48%) from the surgical ward and 77 (52%) from the internal ward (Table 3). The median age of the nurses was 29 (IQR 24-42) years; they were predominantly female (136/148, 91.9%), and 37.2% (55/148) were senior nurses. The median work experience was 5 (IQR 2-16) years, with a median of 32 (IQR 24-32) working hours per week. There were no significant differences between the characteristics of the 2 wards (Table 3).

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Table 2. Study characteristics (n=358).

Characteristics	Surgery (n=248)	Internal medicine (n=110)	*P* value
Gender, n (%)			.01[a,b]
Man	138 (55.6)	77 (70)	
Woman	110 (44.4)	33 (30)	
Nonbinary	0 (0)	0 (0)	
Age (years), mean (SD)	67.8 (12.5)	71.2 (12.3)	.01[b,c]
BMI (kg/m^2), mean (SD)	26.4 (4.8)	28.5 (6.8)	.003[b,c]
Length of stay (days), median (IQR)	6.0 (3.5-10.5)	8.8 (5.5-14.1)	<.001[b,d]
Charlson Comorbidity Index, mean (SD)	5.0 (2.5)	4.0 (1.9)	<.001[a,b]
ASA[e], n (%)			<.001[a,b]
1-2	141 (56.9)	27 (24.5)	
3-4	107 (43.1)	55 (50)	
Unknown	0 (0)	28 (25.5)	
Urgency, n (%)			<.001[f]
Elective	230 (92.7)	1 (0.9)	
Urgent	18 (7.3)	109 (99.1)	
SNAQ[g] score, n (%)			.99[a]
0-2	214 (86.3)	95 (86.4)	
3-5	34 (13.7)	15 (13.6)	
Katz-ADL[h] score, n (%)			<.001[a]
0	214 (86.3)	72 (65.5)	
1-6	34 (13.7)	38 (34.5)	
Smoking, n (%)			.34[a]
Yes	39 (15.7)	18 (16.4)	
No	80 (32.3)	49 (44.5)	
Prior	129 (52)	43 (39.1)	
Alcohol (current use), n (%)	123 (49.6)	47 (42.7)	.23[a]
Mortality, n (%)	2 (0.8)	8 (7.3)	.002[b,f]
RRT[i] calls, n (%)	3 (1.2)	0 (0)	N/A[j]
Unplanned ICU[k] admissions, n (%)	5 (2)	5 (4.5)	.18[f]

[a]Chi-square test.
[b]Significant with *P*<.05.
[c]Unpaired *t* test.
[d]Mann-Whitney *U* test.
[e]ASA: American Society of Anesthesiologists.
[f]Fisher exact test.
[g]SNAQ: Short Nutritional Assessment Questionnaire.
[h]Katz-ADL: Katz Activities of Daily Living.
[i]RRT: rapid response team.
[j]N/A: not applicable.
[k]ICU: intensive care unit.

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Table 3. Characteristics of professionals (n=148).

Characteristics	Surgery (n=71)	Internal (n=77)	*P* value
Gender (man), n (%)	3 (4.2)	9 (11.7)	.10[a]
Age (years), median (IQR)	29 (25-44)	29 (24-41)	.99[b]
Job position, n (%)			.90[a]
Nurse	45 (63.4)	48 (62.3)	
Senior nurse	26 (36.6)	29 (37.7)	
Work experience (years), median (IQR)	5 (1-15)	5 (2-17.5)	.78[b]
Working hours per week, median (IQR)	32 (24-32)	32 (24-32)	.60[b]

[a]Chi-square test.
[b]Mann-Whitney *U* test.

Intervention Fidelity

Eventually, 6142 shifts were analyzed. The overall mean intervention fidelity for both wards was 70.7% (SD 20.4%); it was considered sufficient in the surgical ward but not in the internal medicine ward (73.6%, SD 18.1% vs 64.1%, SD 23.7%; *P*<.001). Multiple regression analysis showed that intervention fidelity remained stable over time in the surgical ward but decreased over time in the internal medicine ward (76.3% at early implementation vs 56.5% at midimplementation vs 48.2% at late implementation; *P*<.001; Figure 1 and Table 4). Changes in intervention fidelity could not be explained by other variables (Multimedia Appendix 8).

With respect to the documented nursing activities (n=174; range 1-9 per patient), for most patients (246/358, 68.7%), no nursing activities were needed based on the vital sign trend assessments. A total of 101 interventions were carried out by nurses individually; it mostly consisted of an extra bedside assessment of the patient followed by wait and see (n=73). In addition, 73 activities were performed after consultation with a physician (59/73, 81% of these were at the surgical ward; Table 5).

Figure 1. Intervention fidelity per ward over time. The dotted line represents the 70% threshold. Early: months 1 to 2; mid: months 3 to 4; late: months 5 to 6.

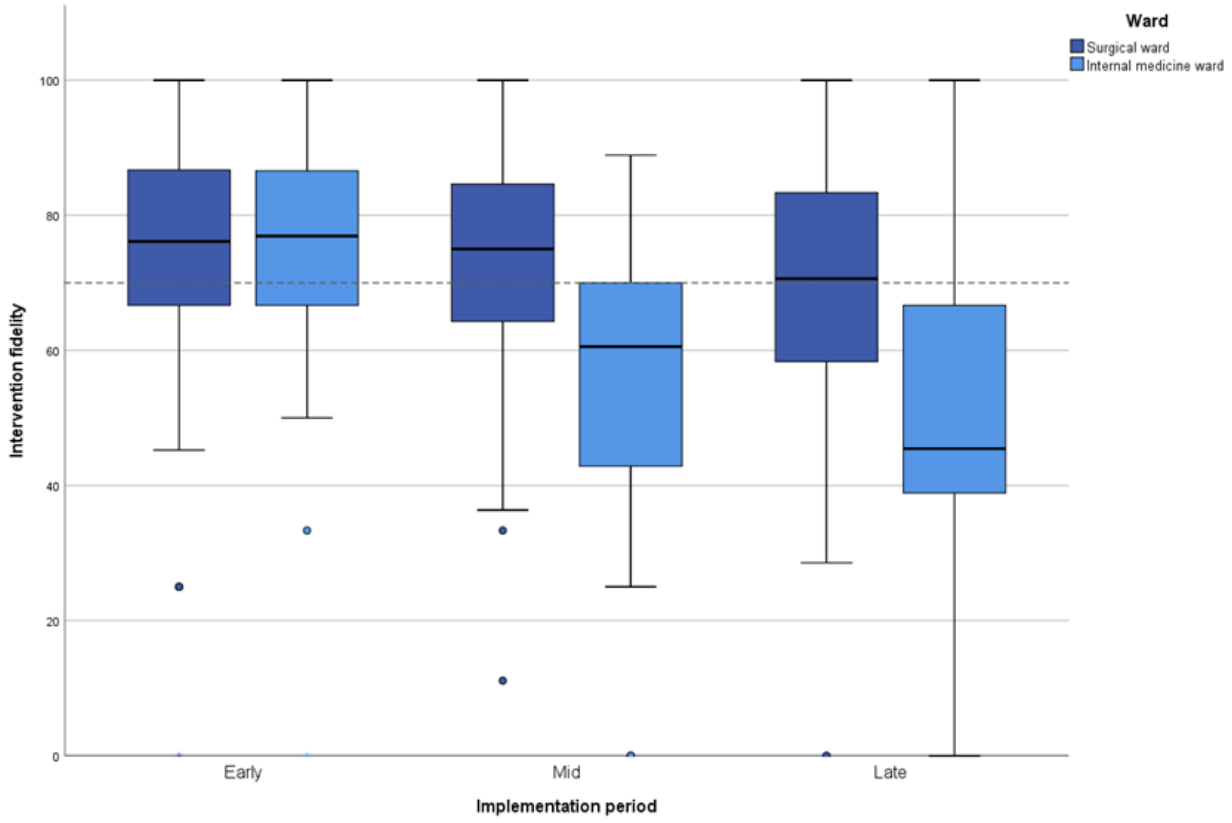

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Table 4. Intervention, implementation, and technical fidelity.

	Total	Surgery	Internal medicine	*P* value
Intervention fidelity				
Written nurse reports, n (%)	6142 (100)	3134 (70.8)[a]	1153 (67.3)[b]	.008[c,d]
Patients >70% threshold, n (%)	198 (55.3)[e]	150 (60.5)[f]	48 (43.6)[g]	.003[c,d]
Overall fidelity (%), mean (SD)	70.7 (20.4)	73.6 (18.1)	64.1 (23.7)	<.001[c,h]
Early implementation (months 1-2)	75.8 (17.2)	75.6 (17.2)[i]	76.3 (17.4)[j]	.80[h]
Midimplementation (months 3-4)	67.4 (21.4)	73.8 (18.5)[k]	56.5 (21.8)[l]	<.001[c,h]
Late implementation (months 5-6)	65.9 (22.3)	70.7 (18.8)[m]	48.2 (25.9)[n]	<.001[c,h]
Recruitment rate, n (%)	358 (98.3)[o]	248 (98.4)[p]	110 (98.2)[q]	>.99[r]
Retention rate, n (%)	358 (99.4)[s]	248 (99.2)[t]	110 (100)[u]	>.99
Implementation fidelity				
Nurses who attended e-learning module, n (%)	147 (93)[v]	60 (89.6)[w]	87 (95.6)[x]	.21[r]
Monthly evaluations, n (%)	10 (100)	5 (100)	5 (100)	N/A[y]
Exposure, n (%)	358 (28)[z]	248 (33.6)[aa]	110 (21.8)[ab]	<.001[c,d]
Technical fidelity (n=340)				
Monitoring time (hours), median (IQR)	96.6 (47.6-163.6)	96.2 (47.5-164.9)	97.4 (47.3-157.8)	.60[ac]
Total measurements, N	1,017,467	729,622	287,845	N/A
HR[ad] measurements, N	508,226	364,285	143,941	N/A
HR measurement artifacts, n (%)	136,753 (26.9)	83,527 (22.9)	53,226 (36.9)	<.001[c,d]
ReR[ae] measurements, N	509,281	365,377	143,904	N/A
ReR measurement artifacts, n (%)	74,785 (14.7)	51,758 (14.2)	23,027 (16.0)	.04[c,d]
D-EWS[af], N	32,730	24,267	8463	<.001[c,d]
Score of 0, n (%)	6610 (20.2)	5500 (22.7)	1110 (13.1)	
Score of 1-2, n (%)	24,385 (74.5)	17,849 (73.6)	6536 (77.2)	
Score of ≥3, n (%)	1734 (5.3)	917 (3.8)	817 (9.6)	
Sensors replaced, n (%)[e]	37 (10.3)	27 (10.9)	10 (9.1)	.71[d]

[a]N=4428.
[b]N=1714.
[c]Significant with *P*<.05.
[d]Chi-square test.
[e]N=358.
[f]N=248.
[g]N=110.
[h]Unpaired *t* test.
[i]N=104.
[j]N=51.
[k]N=65.
[l]N=38.
[m]N=79.
[n]N=21.
[o]N=364.
[p]N=252.
[q]N=112.

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[r]Fisher exact test.
[s]N=360.
[t]N=250.
[u]N=110.
[v]N=158.
[w]N=67.
[x]N=91.
[y]N/A: not applicable.
[z]N=1242.
[aa]N=738.
[ab]N=504.
[ac]Mann-Whitney *U* test.
[ad]HR: heart rate.
[ae]ReR: respiratory rate.
[af]D-EWS: partial Modified Early Warning Score.

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Table 5. Documented nursing activities in continuous monitoring of vital signs reports.

	Surgery (n=248)	Internal medicine (n=110)
No reports available, n (%)	0 (0)	5 (4.5)
No activities, n (%)	168 (67.7)	78 (70.9)
Activities performed by a nurse, N	75	26
Assessment (wait and see), n (%)	61 (81.3)[a]	13 (50)[b]
Additional manual check measurement with MEWS[c], n (%)	14 (18.7)[a]	13 (50)[b]
Activities performed in consultation with a physician, N	59	14
Consulted physician but wait and see, n (%)	1 (1.7)[d]	2 (14.3)[e]
Diagnostics, n (%)	18 (30.5)[d]	5 (35.7)[e]
Blood test—blood culture	5 (8.5)[d]	2 (14.3)[e]
Chest x-ray	4 (6.8)[d]	0 (0)[e]
Electrocardiogram	2 (3.4)[d]	2 (14.3)[e]
CT[f] scan	3 (5.1)[d]	0 (0)[e]
Urine sediment	2 (3.4)[d]	1 (7.1)[e]
Blood test—arterial blood gas	1 (1.7)[d]	0 (0)[e]
COVID-19 PCR[g] test	1 (1.7)[d]	0 (0)[e]
Therapy, n (%)	40 (67.8)[d]	7 (50)[e]
Analgesics	18 (30.5)[d]	0 (0)[e]
Oxygen administration	6 (10.2)[d]	2 (14.3)[e]
Bronchodilators	6 (10.2)[d]	0 (0)[e]
Fluid challenge	3 (5.1)[d]	0 (0)[e]
β-blockers	2 (3.4)[d]	1 (7.1)[e]
Diuretics	2 (3.4)[d]	2 (14.3)[e]
Breathing exercise	2 (3.4)[d]	1 (7.1)[e]
Digoxin	1 (1.7)[d]	0 (0)[e]
Antibiotics	0 (0)[d]	1 (7.1)[e]

[a]N=75.
[b]N=26.
[c]MEWS: Modified Early Warning Score.
[d]N=59.
[e]N=14.
[f]CT: computer tomography.
[g]PCR: polymerase chain reaction.

Implementation Fidelity

Regarding implementation fidelity, most nurses attended the e-learning module, all elements of the strategy were delivered, and monthly evaluations were performed. There were 27 implementation measures conducted but no major changes in the intervention itself (Table 4 and Multimedia Appendix 9). Furthermore, recruitment and retention rates were 98.4% and 99.4%, respectively, and did not significantly differ between the wards (Table 3). Exposure to the intervention was 33.6% (248/738) of patients at the surgical ward versus 21.8% (110/504) of patients at the internal medicine ward (P<.001). In addition, the proportion of patients who participated over time in the internal medicine ward was 46.4% (51/110) at early implementation, 34.5% (38/110) at midimplementation, and 19.1% (21/110) at late implementation.

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Technical Fidelity

Regarding technical fidelity, a total of 45,113 hours of monitoring was available (Table 3). The median monitoring time was 96 (IQR 48-163) hours per patient, resulting in 1,017,467 vital sign measurements. The monitoring data from 340 patients were successfully retrieved. There were artifacts in 26.91% (136,753/508,226) of the HR measurements and 14.68% (74,785/509,281) of the ReR measurements. HR artifacts were significantly higher in the internal medicine ward (53,226/143,904, 36.99% vs 83,527/364,285, 22.93%; $P<.001$) for unknown reasons. Of all the devices, 10.3% (37/358) were prematurely replaced owing to technical failure. A total of 32,730 D-EWSs were generated by the system, of which 5.3% (1,734/32,730) were ≥3. The distribution of scores was different for the 2 wards (Table 4; $P<.001$).

Nurses' Surveys

A total of 194 surveys were returned (Table 6). At the start of the study, surgical nurses found the intervention sufficiently appropriate in contrast to internal medicine nurses (median score 4.0 vs 3.1; $P=.03$). In addition, the overall attitude toward the adoption of new interventions was high (score of 3.5) in both wards ($P=.82$). Nurses in both wards found the intervention sufficiently acceptable during the study but not at the end (score of 3.5 vs 3.0; $P=.02$). Acceptability was significantly lower in the internal medicine ward at the end of the study ($P=.02$). Usability was rated as marginal in both wards at both measurement times. Feasibility was rated as sufficient but decreased at the end of the study (score of 4.0 vs 3.4; $P=.002$).

Table 6. Nurses' survey[a].

	Total	Surgery	Internal medicine	*P* value (wards)	*P* value (time)
Appropriateness, median (IQR)	3.75 (3.0-4.00)	4.00 (4.00-5.00)	3.13 (2.31-4.00)	.03[b,c]	N/A[d]
Adoption, median (IQR)	3.47 (3.33-3.73)	3.50 (3.33-3.68)	3.47 (3.27-3.3.73)	.82[b]	N/A
Openness	4.00 (3.75-4.00)	4.00 (3.75-4.00)	4.00 (3.75-4.00)	.54[b]	
Divergence	3.00 (2.50-3.00)	3.00 (2.50-3.00)	2.75 (2.38-3.25)	.94[b]	
Appeal	4.00 (3.75-4.00)	4.00 (3.75-4.00)	4.00 (3.50-4.00)	.28[b]	
Requirements	3.67 (3.00-4.00)	4.00 (3.00-4.00)	3.67 (3.00-4.00)	.75[b]	
Acceptability, median (IQR)					.02[c] (overall); .10 (surgery); .07 (internal)
T_1[e]	3.5 (2.75-4.00)	3.75 (3.00-4.00)	3.25 (2.25-3.75)	.08[b]	
T_2[f]	3.0 (2.25-3.75)	3.00 (2.44-4.00)	2.5 (2.00-3.25)	.02[b,c]	
Usability , mean (SD)					.79 (overall); .51 (surgery); .69 (internal)
T_1	60.4 (10.8)	62.0 (10.8)	58.6 (10.6)	.23[g]	
T_2	61.0 (13.0)	63.8 (10.7)	57.2 (15.1)	.049[c,g]	
Feasibility , median (IQR)					.002[c] (overall); .02[c] (surgery); .02[c] (internal)
T_1	4.00 (3.5-4.0)	4.00 (3.75-4.50)	3.75 (3.13-4.00)	.08[b]	
T_2	3.38 (3.0-4.0)	3.75 (3.00-4.00)	3.00 (3.00-3.75)	.03[b,c]	

[a]Appropriateness, acceptability, and feasibility: Likert scale from 1=disagree to 5=agree. Adoption: Likert scale from 0=disagree to 4=agree. Usability: scale from 0 to 100 (score ≥68=sufficient).

[b]Mann-Whitney *U* test.

[c]Significant with $P<.05$.

[d]N/A: not applicable.

[e]T_1: month 3.

[f]T_2: month 6.

[g]Unpaired *t* test.

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Qualitative Data

Characteristics

A total of 21 semistructured interviews were conducted with a mean duration of 10.9 (SD 3.3) minutes. Of the 21 interviewees, 11 (52%) worked at the surgical ward, 8 (38%) were senior nurses, and 3 (14%) were male. In total, 5 themes were identified.

Theme 1: Prioritizing CMVS

Nurses indicated that the prioritization of CMVS depended on the caseload during the shift. A commonly mentioned factor was perceived workload, frequently mentioned as tasks that they must perform during their shift. A nurse said the following:

> *Yes, I think it is when the workload is high, and then it easily forgotten because of it is not your priority to check and report the trend. If it's just a quiet shift, then it's easier to perform.* [Internal medicine nurse 2]

In addition, some nurses indicated that this varied by type of shift. Day shifts had a higher workload than evening and night shifts. Although night shifts were predominantly experienced as quieter, the actual intervention fidelity was not better during evenings or nights. A nurse explained the following:

> *During night shifts, I do not assess the vital signs trends because patients are supposed to be asleep and the standard manual measurement rounds are enough to assess their condition properly.* [Internal medicine nurse 5]

Nurses also experienced CMVS as a relatively unnecessary addition to their manual measurements, especially during the morning rounds, when the priority for additional trend assessments was lower. A nurse said the following:

> *Because in the morning you still measure your vital signs with the spot-check monitoring and then CMVS is on top of that. I am able to perform without those trends.* [Surgical nurse 9]

Furthermore, they indicated that, if the patients had an uncomplicated course, the direct need for assessing the vital sign trends was also considered less, and thus, regular trend assessments were less likely to be performed. However, when deemed clinically relevant, for instance, when the patient already had deviating vital signs or complications, they indicated that the correct assessment of trends was performed better. A nurse said the following:

> *If I only just once had a case where you can actually see deviating trends, then you'll probably use CMVS better. My experience is (mainly) with stable patients who have CMVS that shows the same (stable) trends over three consecutive shifts; I think in that case actual use and usefulness fades a bit.* [Internal medicine nurse 9]

Theme 2: The Importance of a Bedside Nursing Assessment

Related to the priority of CMVS in the previous section, nurses mentioned the importance of their clinical bedside assessment. During routine morning rounds, vital sign measurements allow for the assessment of other dimensions besides vital signs, such as skin color, presence of sweating, dyspnea, and mental status and pain symptoms. In addition, other dimensions of nursing care can be assessed, such as checks on infusion therapy and excretion, but the need for physical care and care needs for upcoming discharge could also be inventoried through patient interaction. A nurse said the following:

> *During rounds we assess more than just measuring the values of the vital signs. For instance, in patients with oxygen supplementation, you really want to know what that the breathing looks like. ... Besides, by talking to the patient you can also obtain a more comprehensive impression of the patient who is lying in bed.* [Internal medicine nurse 8]

Many nurses found CMVS an addition to and sometimes support for their nursing work. Several said that trends were often a confirmation of their clinical perspective of the patient rather than it prompting them to reconsider their assessment. This was well reflected in the following statement:

> *I do find that when a patient is more ill, you assess the CMVS more often. ... But I do not often experience that it really detects something I did not know yet. ... However, I think it's a very nice addition to our work and may possibly stimulate clinical reasoning; especially for young nurses.* [Surgical nurse 7]

In addition, a few nurses indicated that they did not yet fully trust the accuracy of the technology without physically assessing the patient. They indicated that they regularly found discrepancies between what they observed and what the trend indicated in ReR in particular. A nurse said the following:

> *And you have to compare trends to the patient context. For instance, with the respiratory rate. You have to verify if the patient is mobilized and assess if the trend deviation is clinically relevant.* [Surgical nurse 9]

Theme 3: Experiencing CMVS as an Added Value for Patient Care

Nurses differed in their opinions regarding the benefits for patient care of the intervention. Nurses who were positive about the added value of CMVS mentioned that it provided more insights into the patient's clinical status, especially during night shifts and in patients who are critically ill. However, they also indicated that these types of patients do not often present at the general ward. In addition, several nurses mentioned that they had limited experience with the intervention and even no experience with deviating vital sign trends and taking action on them. Therefore, nurses questioned whether proactive trend assessment was feasible as standard care as, in many cases, it did not alter their nursing care at that time. A nurse said the following about this:

> *You have to assess regularly with most of the time not performing any actions based up on the trends. In my opinion, this does not bring any benefit to the patient, nor to us as professionals.* [Internal medicine nurse 2]

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However, some nurses mentioned that, when they had witnessed a deviating trend and taken action as a result, the added value of the intervention had become clearer afterward. A nurse said the following:

> *I had a patient during my night shift with deviating trends, so I did an extra check and administered additional pain medication.* [Surgical nurse 8]

Theme 4: Experienced Usability of the CMVS System

The nurses frequently mentioned the experienced usability of the hardware and software as an explanation for the decreasing intervention fidelity. Although some nurses found that the necessary time investment was limited and CMVS was feasible during their shifts, several barriers to regular daily use were mentioned. The most often-mentioned barrier was the pairing of the sensor with the software platform as this had to be done through a separate web-based application on a prepared mobile phone rather than via the regularly used phone with a call system. A nurse said the following:

> *Sometimes the separate mobile phone with the specific codes malfunctions and it simply takes too much time, which eventually results in that you leave it at that.* [Internal medicine nurse 5]

Another barrier mentioned was the convenience of gaining visibility of the trends. The software for assessing trends was not integrated well enough into the EHR. Although the bed overview with patient names and numbers was paired, they preferred the trends to be also presented in the EHR or to be able to view them through a central monitoring display on the ward. Finally, removing the sensor when performing diagnostics for the prevention of interference was considered a barrier; in particular, they felt this was important as diagnostic tests such as electrocardiograms or computer tomography scans are often ordered for patients who are ill. A nurse said the following:

> *It is annoying when a sick patient has to go for a scan and then just at that important moment, the sensor must be removed.* [Surgical nurse 4]

Theme 5: Future Perspectives of CMVS on the General Ward

Several nurses shared their thoughts on what improvements are needed for future routine use. In addition to full integration of the software into the EHR, as mentioned in the previous section, nurses considered it important that the sensor be able to measure more vital signs than only HR and ReR. The main reason for this was that manual measurements of the other routine parameters (such as blood pressure and blood oxygen saturation) are still considered necessary, and therefore, CMVS with just HR and ReR does not result in measurable time-saving benefits. This would only be possible when all vital sign measurements and trends are directly visualized in the EHR. Although this would save time, it would not eliminate the need and value of bedside nursing assessments during rounds, as discussed in the previous section. A nurse said the following:

> *It would help enormously (all data and trends visible in the EHR), but even if everything is measured automatically, you still have to go and assess the patient yourself.* [Surgical nurse 11]

Another future perspective mentioned by some nurses was that specific alarm strategies for deviating trends could be an alternative to timely detect deterioration. However, they questioned whether the current MEWS is sensitive enough to detect many of the common complications where deviated vital sign values are not always present. A nurse said the following:

> *Yes I also hear my colleagues about it: when scoring a (MEWS of) 3 or higher, they do not perform repeat measurements because the respiratory rate is normal for this patient. ... I do think it's sometimes way too sensitive for a lot of patients.* [Internal medicine nurse 7]

Furthermore, some nurses thought that there might be benefits in continuing the intervention after discharge from the hospital. A reason given for this was that remote clinical assessment is more difficult in a home situation. Moreover, they found that it could potentially encourage early discharge by incorporating CMVS into an early recovery protocol, such as Enhanced Recovery After Surgery.

Finally, nurses indicated that the use of assistive technology is desirable for the future of nursing care, considering the enrichment of nursing care and in view of future challenges in terms of capacity shortages. A nurse said the following:

> *I do support the inclusion of technology and innovation in nursing care. I think we still integrate technology too little and therefore we are less familiar with it in nursing care. Support by technology can bring so much, and I think my colleagues sometimes forget that.* [Internal medicine nurse 6]

Discussion

Principal Findings

In this study, we evaluated the process of implementation of CMVS on 2 general wards. Using a comprehensive implementation strategy, our overall results suggest that CMVS was sufficiently implemented in both wards, although intervention fidelity was highly variable and decreased over time. This decrease was explained to a large extent by the declining intervention fidelity in the internal medicine ward (it remained stable in the surgical ward). Another contributing factor was that nurses in both wards perceived little added value to the intervention. Taken together, the results show the complexity and interconnectedness of implementation and intervention fidelity with the technology and the perceptions of nurses.

Although the recruitment and retention rates of the intervention were high, indicating high patient acceptance, both wards showed a decline in several dimensions of implementation: intervention fidelity (although not statistically significant for surgery), perceived acceptance, usability, and feasibility. Interestingly, this decline was lower in the surgical ward than in the internal medicine ward. There are several possible explanations for this discrepancy between the surgical and internal medicine wards. Although 110 patients were included

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in the internal medicine ward, compared with the surgical ward, exposure to the intervention was still limited (110/504, 21.8%) and decreased over time—especially during the last 2 months of implementation. Second, nurses in the internal medicine ward considered the intervention less relevant to their practice. A first possible explanation as far as the internal medicine department is concerned, is the hospitalization procedure for emergency patients. After presentation in the emergency room and subsequent admission to the acute ward for a maximum of 48 hours, the patient is then transferred to the internal medicine ward. At that time, the diagnosis is established, and treatment starts, and so these patients have already passed the precarious, critical stage of their condition, and deviations in vital signs may be considered of lower clinical relevance [46]. This was different in the surgical ward, where CMVS was started directly after surgery, the period in which the patient is at the highest risk of complications and deterioration [47]. This may also be an explanation for the low appropriateness ratings from nurses in the internal medicine ward. Nevertheless, it is noteworthy that the proportion of patients with abnormal D-EWSs was highest in the internal medicine ward, but this was not deemed clinically relevant.

Although a broad range of interventions was performed by nurses based on the trend assessments, several reasons might explain the perceived low added value of the intervention for nursing care. First, the rationale for using CMVS is likely to be less convincing when also maintaining the conventional manual nurse measurements to calculate the MEWS. This could be explained by the fact that nurses highly value being at the bedside and observing the patients themselves while performing their manual measurements. Nurses explained that they use this moment to perform a more comprehensive patient evaluation, including assessing domains of clinical deterioration other than vital signs as well as other nursing domains through patient interaction. Second, the high degree (246/358, 68.7% of all patients) to which no subsequent activities were initiated based on the trend analysis may indicate that intervention fidelity was limited for this reason. In general, nurses stated that they had little or no experience interpreting deviating vital sign trends. In specific cases, trends may have prompted more timely additional measurements or diagnostics, such as blood tests or imaging, or the initiation of a physician's consultation, but overall, it remains difficult to determine to what extent vital sign trend monitoring actually contributed to decision-making.

In addition, the current state of the technology may have affected intervention fidelity. Despite the generation of a very large amount of data, technical difficulties remain. Approximately 10.3% (37/358) of the sensors had to be replaced prematurely owing to different types of failure, such as malfunctioning of the sensor during pairing, unexplainable sensor failure, or high artifact ratios in some patients. This was also reflected in the high artifact rate for HR measurements, which may have had a negative influence on intervention fidelity and acceptability. A possible explanation is that adequate HR measurements using an accelerometer may be more complicated, but this has not yet been adequately studied [35]. The higher HR artifact rate in the internal medicine ward is also unclear. We checked patients with high artifact rates for incorrect sensor placement, but this was rarely the cause. Current limitations of the technology likely contributed to the low usability scores during the implementation period in both wards. In the interviews, nurses commented that these issues made it cumbersome to use the system while reducing trust in the technology. Furthermore, the current threshold-based D-EWSs to guide trend assessment do not sufficiently consider the context of the patient (eg, "in bed" or "actively mobilizing"), resulting in contamination of vital sign trends (eg, simultaneously HR and ReR) that are actually normal as the patient is actively mobilizing. Consequently, it will be harder to recognize true deterioration early. In contrast, when nurses manually record an abnormal set of bedside vital signs, CMVS trends may show an important correlation with the current (abnormal) bedside observation and can support the nurse's decision to seek consultation with the on-call physician. The correlation between vital signs and direct bedside observations is important for clinical decision-making, which is missing when relying entirely on remote trend assessments.

Comparison With Other Work

Comparison of our results with those of previous studies is challenging because of differences in patient populations, monitoring devices, and outcomes addressed. Intervention fidelity in this study was somewhat lower than in our previous feasibility study over a period of 3 months with a similar CMVS intervention [15]—71% versus 81%, respectively. However, if we compare the first months, this difference is smaller (75.8% vs 80.5%).

The need to still perform manual vital sign measurements and the lack of experience in assessing deteriorating trend patterns—as previously mentioned by nurses—are likely to have affected nurses' perspectives and may have influenced intervention fidelity. This observation is also in line with the results of our previous feasibility study [15]. Moreover, although abnormal HR and ReR are important signs of patient deterioration, evidence is still lacking that CMVS monitoring of only 2 vital signs is sufficient to capture most cases of deterioration. In contrast to our results, Verrillo et al [48] showed that, when CMVS using a bulkier multiparameter device was used as the single method for vital sign monitoring, nurses' acceptance and compliance over a period of only 6 weeks increased (initially 38% to a sustained average of 62% compliance). This may indicate that automating the manual measurements is better for the acceptability of nurses. Nonetheless, larger devices measuring all vital signs may result in poorer patient acceptance. Early termination of the intervention was rare in our study, which is in contrast to the 21% of patients in a previous study with a wrist-worn multiparameter device [14]. However, in our study, approximately 10.3% (37/358) of the sensors were prematurely replaced owing to technical errors such as connectivity issues. Furthermore, the need to gain experience with the use of the wearable device in clinical practice was also mentioned by nurses in the study by Izmailova et al [49]. Moreover, in line with previous studies, nurses also sometimes questioned the accuracy of the device and doubted the benefits of being able to observe their patients' vital signs remotely [50,51]. In contrast, many nurses also expressed a positive attitude toward CMVS interventions, mentioning that it could increase patient

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safety by providing more insight [52]. Finally, experienced usability of a similar wearable patch device in ward nurses was higher in the study by Boatin et al [53], although this may be because of the relatively small, short-term study of 32 pregnant women.

Other studies have also reported on technical fidelity. Our observed artifact rates were slightly higher compared with a validation study in patients of surgery at the postanesthesia care unit with the same sensor [35]. A potential explanation is that motion artifacts are more prevalent in patients in wards than in patients during the early stages of recovery after anesthesia and surgery in the postanesthesia care unit.

Limitations

To our knowledge, this is the first study that extensively focused on evaluating the process of CMVS implementation at scale in daily clinical practice in general hospital wards. The data can provide valuable information to other hospitals considering CMVS implementation and highlight some important issues to consider when developing an implementation strategy. However, several limitations should be considered when interpreting the results. First, in both wards, exposure to the intervention was still limited, which forced nurses to work with 2 systems of vital sign monitoring (intermittent and continuous) and may have hampered implementation. Second, it is important to note that the development of the implementation strategy and intervention took place in the surgical ward, which might have resulted in an intervention more suited to a surgical ward than to an internal medicine ward. In addition, goodwill toward the project manager, a former nurse in the surgical ward, might partly explain the higher intervention fidelity in the surgical ward. Third, even after analyzing every individual nurse trend assessment report, it is still not possible to determine with certainty to what extent these vital sign trends actually influenced subsequent diagnostic or therapeutic decision or both. This is mainly because several other factors contribute to additional activities and medical decision-making. Moreover, it is not clear how large the variation is between nurses interpreting similar trends. This would require a separate study. Finally, we did not include the magnitude of nurses' exposure to the intervention as a factor in the regression analysis, which could cause bias. However, we extensively focused on education and bedside training in the implementation strategy.

Implications

Our study highlights the complexity of implementing a CMVS system with wearable wireless sensors in hospital nursing wards. Therefore, policy makers should involve nurses early in establishing the intervention and implementation strategy and selecting the appropriate patient populations to enhance the fit with the needs of current nursing practice. To leverage the full potential of CMVS in general wards, several barriers to implementation in the routine workflow need to be addressed, for which we suggest the recommendations outlined in Textbox 2.

Textbox 2. Recommendations to address the barriers to implementation in the routine workflow.

- Secure full and seamless integration of the continuous monitoring of vital signs (CMVS) into the hospital electronic health record, avoiding any separate software platforms or dashboards. This will improve fidelity and usability for caregivers.
- Use advanced and validated multiparameter CMVS sensors, which are sufficiently accurate and comprehensive to allow for the discontinuation of standard manual vital sign measurements by nurses, thus reducing nursing workload.
- Combine CMVS with reliable personalized clinical decision support tools to facilitate correct and timely interpretation of these measurements. Algorithms still need to be developed that can incorporate patient-specific baseline data, facilitate routine automated input of contextual factors such as patient movement, and perform automated trend analysis and event detection to timely detect and alert on clinical deterioration [22]. When such systems are available, this will obviate the need for vital sign trends to be proactively monitored and interpreted by nurses, which currently increases nursing workload and is difficult because of their lack of experience in this respect.
- Finally, carefully select (high-risk) patient populations that are likely to benefit most from CMVS. This could potentially include all acute care admissions (especially those without a clear diagnosis at admission) and all patients undergoing intermediate- or high-risk surgery in the postoperative phase (both in the ward and at home directly after discharge). Thus, the intervention could be integrated into an early discharge protocol with extended telemonitoring at the patient's home [54].

Conclusions

We successfully implemented a system for continuous wearable remote vital sign monitoring at scale in 2 hospital wards, but our results show that intervention fidelity decreased over time, to a larger extent in the internal medicine ward than in the surgical ward. This decrease appears to be dependent on multiple ward-specific factors. Nurses' perceptions regarding the value and benefits of the intervention were variable. Our study provides valuable insights into the optimal implementation of CMVS in general wards. Specifically, we conclude that implementation of a CMVS while at the same time maintaining routine manual vital sign measurements is not advisable as it increases nurse workload. Proactive vital sign trend assessment by nurses is feasible but challenging to embed sustainably at scale in current workflows even when using an extensive implementation strategy. Wearable wireless monitoring technology should be further developed and optimized, including seamless integration into the EHR and development of more sophisticated decision support tools for interpretation and alarms that are suitable for general wards, before it can consistently improve nursing workflows, increase patient safety, and enhance quality of care.

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Acknowledgments

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Conflicts of Interest

The manufacturer of the wearable sensors and digital platform (Philips Healthcare) did not play a role in the design, implementation, interpretation, or reporting of the study. The sensors were provided at a reduced price for this study.

Multimedia Appendix 1
Admission indications of patients.
[DOCX File , 12 KB - nursing_v6i1e44061_app1.docx]

Multimedia Appendix 2
The Philips Healthdot wearable sensor.
[DOCX File , 63 KB - nursing_v6i1e44061_app2.docx]

Multimedia Appendix 3
Example of the Philips IntelliVue Guardian Solution dashboard.
[PDF File (Adobe PDF File), 253 KB - nursing_v6i1e44061_app3.pdf]

Multimedia Appendix 4
Thresholds of the partial Modified Early Warning Scores.
[DOCX File , 14 KB - nursing_v6i1e44061_app4.docx]

Multimedia Appendix 5
Contents and study goals of the e-learning module for nurses.
[DOCX File , 15 KB - nursing_v6i1e44061_app5.docx]

Multimedia Appendix 6
Topic list for the semistructured interviews with nurses.
[DOCX File , 12 KB - nursing_v6i1e44061_app6.docx]

Multimedia Appendix 7
List of admission indications.
[DOCX File , 13 KB - nursing_v6i1e44061_app7.docx]

Multimedia Appendix 8
Outcomes of multiple linear regression of intervention fidelity for both wards.
[DOCX File , 15 KB - nursing_v6i1e44061_app8.docx]

Multimedia Appendix 9
List of implementation measures of the monthly evaluations.
[DOCX File , 13 KB - nursing_v6i1e44061_app9.docx]

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Abbreviations

CMVS: continuous monitoring of vital signs
D-EWS: partial Modified Early Warning Score
EHR: electronic health record
EWS: Early Warning Score
HR: heart rate
IGS: IntelliVue Guardian Solution
MEWS: Modified Early Warning Score
ReR: respiratory rate

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Original Paper

Usefulness of a Digitally Assisted Person-Centered Care Intervention: Qualitative Study of Patients' and Nurses' Experiences in a Long-term Perspective

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Abstract

Background: Person-centered care responsive to individual preferences, needs, and values is recognized as an important aspect of high-quality health care, and patient empowerment is increasingly viewed as a central core value of person-centered care. Web-based interventions aimed at empowerment report a beneficial effect on patient empowerment and physical activity; however, there is limited information available on barriers, facilitators, and user experiences. A recent review of the effect of digital self-management support tools suggests a beneficial effect on the quality of life in patients with cancer. On the basis of an overall philosophy of empowerment, guided self-determination is a person-centered intervention that uses preparatory reflection sheets to help achieve focused communication between patients and nurses. The intervention was adapted into a digital version called digitally assisted guided self-determination (DA-GSD) hosted by the Sundhed DK website that can be delivered face-to-face, via video, or by the combination of the 2 methods.

Objective: We aimed to investigate the experiences of nurses, nurse managers, and patients of using DA-GSD in 2 oncology departments and 1 gynecology department over a 5-year implementation period from 2018 to 2022.

Methods: This qualitative study was inspired by action research comprising the responses of 17 patients to an open-ended question on their experience of specific aspects of DA-GSD in a web questionnaire, 14 qualitative semistructured interviews with nurses and patients who initially completed the web questionnaire, and transcripts of meetings held between the researchers and nurses during the implementation of the intervention. The thematic analysis of all data was done using NVivo (QSR International).

Results: The analysis generated 2 main themes and 7 subthemes that reflect conflicting perspectives and greater acceptability of the intervention among the nurses over time owing to better familiarity with the increasingly mature technology. The first theme was the different experiences and perspectives of nurses and patients concerning barriers to using DA-GSD and comprised 4 subthemes: conflicting perspectives on the ability of patients to engage with DA-GSD and how to provide it, conflicting perspectives on DA-GSD as a threat to the nurse-patient relationship, functionality of DA-GSD and available technical equipment, and data security. The other theme was what influenced the increased acceptability of DA-GSD among the nurses over time and

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comprised 3 subthemes: a re-evaluation of the nurse-patient relationship; improved functionality of DA-GSD; and supervision, experience, patient feedback, and a global pandemic.

Conclusions: The nurses experienced more barriers to DA-GSD than the patients did. Acceptance of the intervention increased over time among the nurses in keeping with the intervention's improved functionality, additional guidance, and positive experiences, combined with patients finding it useful. Our findings emphasize the importance of supporting and training nurses if new technologies are to be implemented successfully.

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KEYWORDS

digital technology; digital nursing; digitally assisted guided self-determination; empowerment; self-management; person-centered care; qualitative; service design; patient care; nurse; quality of life; interview; web-based questionnaire; functionality; support; training; implementation; self-determination; autonomy; agency; person centered; patient centered; client focus; gynecology; oncology; health knowledge; health care professional; health care provider; HCP; mobile phone

Introduction

Background

Person-centered care that is responsive to individual preferences, needs, and values is recognized as an important aspect of high-quality health care [1,2], and patient empowerment is increasingly viewed as an important core value of person-centered care [3,4]. To cope with the increasing burden of chronic diseases, enabling patient empowerment is considered essential for achieving high-quality health care systems in the future [4].

A 2013 systematic review investigating the effect of web-based interventions aimed at increasing patient empowerment and physical activity in chronic conditions assessed the relevance of the interventions for cancer survivors [5]. The authors concluded that web-based interventions beneficially affected patient empowerment and physical activity; however, limited information was provided on barriers, facilitators, and user experiences [5]. A 2021 review examining the effect of digital self-management support tools in patients with cancer found that they also seemed to have a beneficial effect on quality of life, whereas the effects on other outcomes were inconsistent [6].

Empowerment is the underlying philosophy of guided self-determination (GSD), in which the overall goal is to support patients' development of life skills to improve their self-management of chronic conditions [7,8]. A randomized controlled trial testing the analog version of the GSD adapted for gynecologic cancer in a hospital setting invited 719 women to participate; 82 women declined because they thought the time they had to spend on transportation was excessive. Other reasons for declining participation were comorbidities and a lack of energy. Several participants who lived far away requested access to a digitally assisted version of the GSD to participate in the intervention [9]. Another study supports this finding, which indicates that technology-based approaches can be used to alleviate long travel times and provide better supportive care in rural districts [10]. Furthermore, research shows that important disparities exist in mental health outcomes between rural and urban cancer survivors [11].

To increase access to health care, digitalizing and incorporating the option of using video conversations in person-centered interventions is of great importance. From 2016 to 2017, the Danish National Health Portal (DNHP), Sundhed DK [12], developed the digitally assisted GSD (DA-GSD) intervention based on the analog version, but it has new functionalities and the option of using videoconferencing [13]. The intervention is described in further detail in the *Methods* section.

Objective

DA-GSD was implemented in 2018 at 3 hospital departments in Denmark treating women with cancer and endometriosis. Documenting the maturation of the technology when switching from an analog to a digital version that uses not only face-to-face but also video conversations is important in terms of successfully developing future interventions. Other aspects that are important to examine and document include barriers and facilitators, user experience, and identification and fulfillment of the individual's need for support in the digital environment. This paper reports on the implementation process with the aim of exploring the experiences of nurses, nurse managers, and patients with DA-GSD over a 5-year period from 2018 to 2022.

Methods

Design

Inspired by action research [14], this qualitative study involved the implementation of DA-GSD, in which the users were expected to acquire new skills and adjust their mindset, leading to the generation of important knowledge at the individual and organizational levels. Therefore, action research offers an ideal foundation for taking a reflective approach that provides a stepwise transformation of DA-GSD and progressive understanding in an iterative, cocreative process that focuses on reflection in relation to functionality, barriers, facilitators, user experience and a continuous adjustment to the individual needs of the patients and nurses.

Setting

The study was conducted from 2018 to 2022 at 3 different departments at a university hospital in Copenhagen, Denmark, that were implementing DA-GSD: a gynecology department surgically treating patients with gynecological cancers as well as women with endometriosis as of 2020, an oncology department treating patients with various cancer diagnoses, and

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an oncology rehabilitation unit counseling patients with a variety of cancer diagnoses.

DA-GSD Intervention

Overview

DA-GSD is based on the analog version of GSD [7,8], in which the main features are reflection sheets designed to help patients prepare before speaking with health care professionals (HCPs) trained in using GSD. The reflection sheets help patients clarify their values and initiate reflection on their needs and resources. The completed reflection sheets form the foundation for mutual person-centered counseling, with some of the sheets specifically designed to support shared decision-making. The HCPs are certified in GSD and advanced communication to facilitate person-centered dialogue and problem-solving. The analog version of GSD was originally developed for patients with diabetes but has since become a method used and evaluated for various other diseases and conditions [15].

DA-GSD was developed from 2016 to 2017 by the DNHP Sundhed DK website [12] in an agile process that involved actor and stakeholder analyses and collaboration between project managers, IT architects, and researchers [13].

Service Design in Health Care

Throughout the process of converting the traditional analog reflection sheets into a digital version for patients and HCPs, a service design methodology was used [12], which involves taking a holistic approach that prioritizes identifying and meeting user needs and optimizing their service journey [16].

The partnership established among the HCPs; patients; and cross-functional team of the Sundhed DK website [12], which comprised product managers, designers, user experience specialists, and software developers, was highly collaborative and productive. The main focus of the project was to ensure that the digital aspects did not compromise the existing GSD method but instead created a seamless and sophisticated solution that leveraged the capabilities of digital technology to empower patients and provide HCPs with a highly effective tool, while integrating it into the daily lives of users.

Log-in

HCPs used their secure work digital ID to access DA-GSD via the DNHP Sundhed DK website [12] to create specific sessions targeting individual patients and reflection sheets to be completed by the patient. After this step, the patients were asked to log in with their secure personal digital ID to fill out and save their sheets.

Analog Versus Digital Reflection Sheets

The content of the digital reflection sheets was the same as that of the analog sheets, but their functions had changed. Some digitalized sheets were interactive and responsive to mobile devices. One of the analog sheets asks the patients to draw a picture of their experience of living with their disease, whereas the corresponding digital version permits the users to upload images to illustrate their experience. Finally, the problem-solving analog sheets, which comprised 4 pages on feelings, observations, goals, and actions concerning a specific problem, were now completed digitally and could be condensed into 1 page summarizing all 4 aspects to support problem-solving.

DA-GSD Provided Face-to-face, via Video, or a Combination

DA-GSD allowed nurses and patients to collaborate on the digital sheets in a face-to-face meeting to discuss them on a shared computer screen, via videoconference and screen sharing, or by using a combination of the 2 approaches (Figure 1).

Pexip (Figure 2), which was the first video feature developed, involved a cumbersome process requiring user information for patients and nurses to initiate a video meeting. The nurses had to copy and paste guest codes to send to patients and themselves, which had to be typed on the day of the video conversation because codes generated by Pexip were frequently identified as spam. Another disadvantage of Pexip was that the image visible to the patients was small when they shared their digital sheets on the screen.

In the autumn 2020, video consultation using VDX was introduced [12], which is a public, cross-sector video infrastructure commonly used by hospitals across Denmark and is adapted to PCs and mobile devices. To plan a meeting, nurses must copy and paste a link to the web-based meeting room they have created and send it to the patient with a specific date and time for the meeting. Nurses and patients use their secure digital IDs to log into the web-based meeting room, where full-scale digital reflection sheets can be shared.

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Figure 1. Digitally assisted guided self-determination provided face-to-face, via video, or as a combination of the 2. HCP: health care professional.

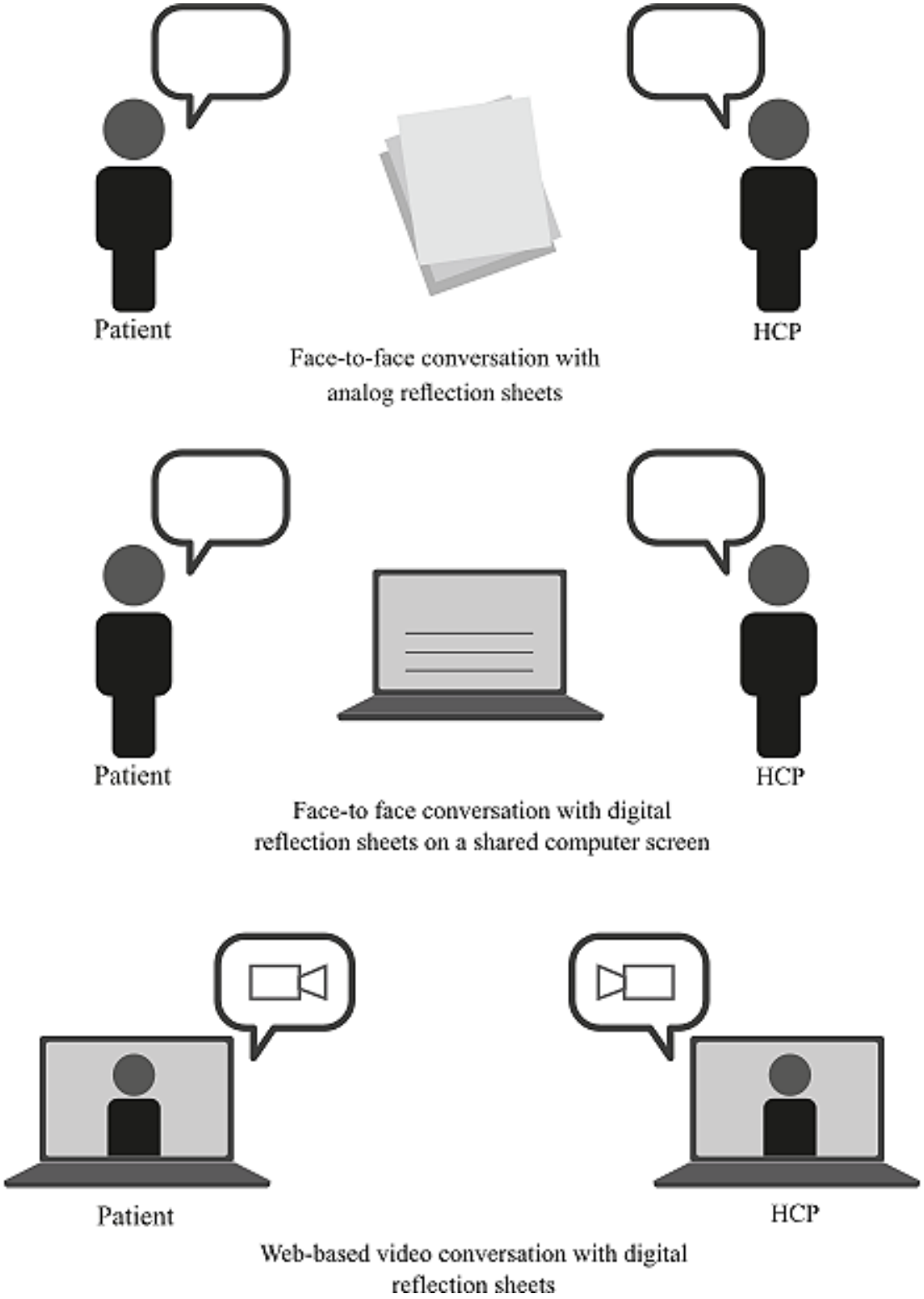

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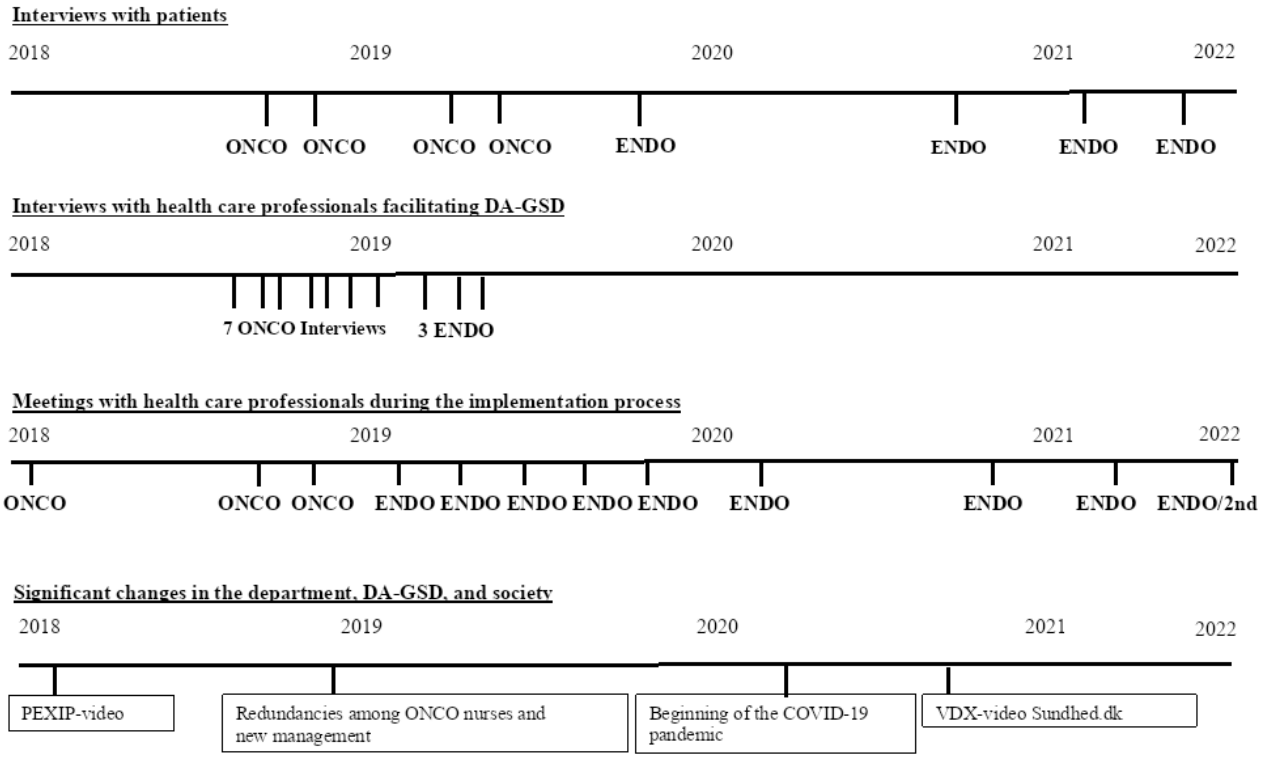
Figure 2. Timeline. DA-GSD: digitally assisted guided self-determination; ENDO: endometriosis; ONCO: oncological disease.



Population and Inclusion Criteria

There were different inclusion criteria for nurses with managerial responsibility and the other nurses. Inclusion criteria for the former were: managerial responsibility for staff who were implementing DA-GSD, and not necessarily possessing certification in GSD or DA-GSD, or in facilitating them. Inclusion criteria for the latter were: being certified in GSD [17] and in facilitating DA-GSD. The inclusion criteria for patients were as follows: they must be aged >18 years; be able to understand, read, and write Danish; have a cancer or endometriosis diagnosis; and participate in DA-GSD via face-to-face conversation, videoconference, or a combination of the 2.

A total of 10 nurses with a median range of 40 to 49 years of age with 4 to 37 years (median 26.5 years) of nursing experience participated from the 3 departments. Of the 10 nurses, 5 (50%) nurses had a master's degree and 3 (30%) had managerial responsibility, 1 of whom facilitated GSD, whereas the remaining 2 nurses facilitated the implementation of GSD in their department. Nurses had generally conducted 10 GSD conversations on average, but the number ranged from 5 to >100, as shown in Table 1, which presents the patient characteristics.

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Table 1. Characteristics of participating patients (N=17).

Number or ID	Age (years)	Relationship	Education	DA-GSD[a] conversations	Video conversation	Interviewed
Patients with an oncological disease (N=6)						
1	45-49	In a relationship	≥1 shorter course	4	N/A[b]	✓
2	50-54	Single	3-4 years of higher education	4	4	✓
3	>60	In a relationship	≥1 shorter course	4	2	✓
4	55-59	In a relationship	3-4 years of higher education	5	N/A	✓
5	50-54	In a relationship	Vocational education or skilled worker	5	N/A	N/A
6	>60	Single	>4 years of higher education	4	N/A	N/A
Patients with endometriosis (N=11)						
1	40-44	In a relationship	Vocational education or skilled worker	3	N/A	✓
2	<30	In a relationship	3-4 years of higher education	3	2	✓
3	30-34	In a relationship	3-4 years of higher education	4	N/A	✓
4	40-44	In a relationship	Vocational education or skilled worker	3	3	✓
5	>45	In a relationship	3-4 years of higher education	3	N/A	N/A
6	35-39	In a relationship	None	4	N/A	N/A
7	35-39	In a relationship	Vocational education or skilled worker	3	N/A	N/A
8	30-34	Single	Vocational education or skilled worker	2	N/A	N/A
9	>45	In a relationship	3-4 years of higher education	4	N/A	N/A
10	35-39	Single	3-4 years of higher education	3	N/A	N/A
11	35-39	Single	Vocational education or skilled worker	3	3	N/A

[a]DA-GSD: digitally assisted guided self-determination.

[b]N/A: not applicable.

Recruitment and Data Collection

Nurses and patients were recruited between 2018 and 2022. The participating nurses and nurse managers were recruited by the first author (MLO). The patients were included continuously by the participating GSD nurses. We did not register patients who declined to participate in the study.

Semistructured interviews with 10 nurses were conducted during the initial implementation of DA-GSD. One nurse who participated throughout the entire study was interviewed twice, once at the beginning and again in 2022. The interview guide for nurses focused on their experience of using DA-GSD and covered functionality, the perceived need for DA-GSD, favorability of the surrounding circumstances, barriers, challenges, need for support, their role in facilitating DA-GSD, and data security. During the 5-year implementation period, MLO and a project assistant held regular implementation meetings with the nurses regarding their current experiences and challenges. Interviews and meetings were audio recorded, transcribed, and included as data. Knowledge from these meetings, specifically regarding the functionality of DA-GSD, was continuously reported back to Sundhed DK website [12] to provide a foundation for adjusting the intervention.

The included patients reported their sociodemographic details before their first DA-GSD conversation. After the last DA-GSD conversation, all patients were asked to complete a web-based questionnaire that contained an open-ended question about their overall experience with the digital reflection sheets. These answers were included in the data. Individual semistructured interviews were conducted with a convenience sample [18] comprising 8 patients who had finished participating in the DA-GSD (Table 1). The patient interview guide focused on

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their experience with DA-GSD, including functionality, what worked well or poorly, the need for support, how they felt about using technology for disease management, and how they experienced their relationship with the nurse during DA-GSD. The interviews were audio recorded and transcribed. Figure 2 provides an overview of the overall data collection process.

Ethical Considerations

All participants received oral and written information and were given time to consider their participation before providing written informed consent. The study was conducted in accordance with the Declaration of Helsinki and was registered with the Danish Data Protection Agency (file RH-2017-248, I-Suite 05720). Ethics approval was not legally required.

Data Analysis

The data were analyzed thematically by following a 5-step process [19]. First, the authors read the transcriptions of the interviews, meetings, and questionnaire responses. Second, preliminary codes were noted in the margins during the reading. Next, the codes were discussed in meetings that involved searching for themes, which resulted in meaningfully collecting the codes into 4 preliminary themes covering various perspectives on the ability of patients to engage in DA-GSD, the nurse-patient relationship, DA-GSD's functionality, and data security. Upon reviewing these themes, all authors agreed that they could be categorized as subthemes under the overarching theme of nurses and patients having different perspectives on the barriers to DA-GSD. Other data reflected a change in nurses' attitudes toward DA-GSD over time, with the ongoing analysis generating an additional theme regarding this change and subthemes describing what influenced the change. Fourth, the themes and subthemes were reviewed and checked in relation to the coded data and overall data set. Finally, the themes were named and defined.

Results

Demographic Characteristics

A total of 10 nurses and 17 patients were included from 2018 to 2022. Of the 17 patients, 12 (71%) patients received DA-GSD via face-to-face conversations, 3 (18%) via video only, and 2 (12%) via a combination of face-to-face and video conversations (Table 1).

Themes

Overview

There were 2 main themes, one on conflicting perspectives that contained 4 subthemes and the other on the development of DA-GSD over time that comprised 3 subthemes (Textbox 1).

Textbox 1. Themes and subthemes.

Different experiences and perspectives of nurses and patients concerning barriers to using digitally assisted guided self-determination (DA-GSD)

- Conflicting perspectives on the ability of patients to engage with DA-GSD and how to provide it
- Conflicting perspectives on DA-GSD as a threat to the nurse-patient relationship
- Functionality of DA-GSD and available technical equipment
- Data security

What influenced the increased acceptability of DA-GSD among the nurses over time

- Re-evaluation of the nurse-patient relationship
- Improved functionality of DA-GSD
- Supervision, experience, patient feedback, and a global pandemic

Different Experiences and Perspectives of Nurses and Patients Concerning Barriers to Using DA-GSD

This theme comprises 4 subthemes describing aspects that some users experienced as barriers to using DA-GSD and about which they, in several cases, had opposing perspectives. Many of the barriers that most nurses described were not reflected in the patients' experiences.

Conflicting Perspectives on the Ability of Patients to Engage With DA-GSD and How to Provide It

In general, the nurses were positive about technology and GSD being digitalized, but they had many deliberations about the patients' prerequisites for participating in DA-GSD, especially during the beginning of the implementation process. This involved, for example, concerns about age, digital skills, cognitive function, fatigue, and the level of digital literacy. They appeared to protect the patients from the challenges they expected to arise from DA-GSD. Only 2 nurses experienced DA-GSD as easy to use from the outset, and they were younger or positively motivated by the unpredictability of their work tasks:

> *I think it's super exciting and it's modern. And that's how it's going to be; it's part of technological development that we also start doing things like this...and that everything shouldn't be in paper form, and it's clearly aimed at a target group that is younger and thus comfortable with all this...I have a concern that it may exclude someone who does not have strong [digital] literacy because they're not safe inside that world.* [Nurse 3]

As expected by the nurses in the beginning, many patients said that DA-GSD was challenging in terms of their memory, fatigue, and sometimes the length of the reflection sheets. Furthermore, using the save feature (a flashing heart in the middle of the

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screen) was a lengthy and challenging process that made filling out the digital sheets difficult, in addition to the fact that they did not always work as intended, and the video feature had a complicated log-in process. Nevertheless, they did not mind overall and were generally highly positive about DA-GSD throughout the whole process, and they felt that the intervention fulfilled an unmet need.

During the implementation process, nurses' assumptions or understanding of patients' digital skills were sometimes not in agreement with patients' actual experiences and skill levels. In one case, a nurse described how she included a patient who she felt did not have the skills to participate:

> *I felt that I...twisted the arm of someone [patient] who was not very digitally literate and who chose to say, well, I want that, because I want these conversations with you [the nurse] so much...That was a big challenge I just gave her.* [Nurse 3]

This did not fully align with the patient's experience, which the patient described as not only challenging but also good and successful:

> *I hadn't visited Sundhed.dk [DNHP] before...but I got in and found all the sheets. I was so happy. Because my memory does not work as well as it should, I find it difficult to remember.* [Patient 1, oncology]

Other patients said the following about DA-GSD: "works great," "I could easily figure it out," and "I'm used to logging in and checking test answers and stuff like that." In general, their descriptions of the benefits overshone the challenges they experienced. One woman was especially excited about digitalized sheets that facilitated the problem-solving process:

> *It was visual somehow, wasn't it...? It was pretty good...I remember thinking while I was answering the questions, I thought: "It can't be connected. It just doesn't add up"...and then it was presented on that page [where reflections on feelings, observations, goals, and actions about a problem are summarized on a final sheet]..."It does add up! ", it's like a SWOT [strengths, weaknesses, opportunities, and threats] analysis, in reality.* [Patient 3, oncology]

Initially, the Pexip video feature was somewhat cumbersome for nurses and patients. Moreover, because they felt responsible for the technical functionality of DA-GSD, including the video feature, they were concerned when the patients requested video conversations:

> *As a professional, I'm a little bit worried about the technology...in terms of whether it causes any problems and whether it can...make it difficult to have a conversation.* [Nurse 2]

A pattern emerged throughout the implementation period that involved the nurses trying to screen the patients' digital skills to ensure that they could manage the challenges involved in using DA-GSD:

> *It has to be a patient who really understands IT and is not afraid of it and who is completely ready for it...* [Nurse 7]

Although the patients described difficulties in getting the video feature to work, being challenged was not the dominant narrative that emerged when they were interviewed regarding the video conversations. Their focus was primarily on the benefits of the conversation:

> *I felt like I really got something out of it when we finished the hour-long videoconference, and I had some tasks to work on for the next time a fortnight later. And I actually looked forward to having that conversation again, because there were some things I was looking forward to talking about.* [Patient 2, oncology]

Importantly, this quote is from the time when the intervention had just begun and Pexip provided the first video feature, which was even more difficult to install for this patient as she used an Apple computer. Nevertheless, the patient described using the video feature as crucial to her because she would otherwise have been unable to participate:

> *If I had to show up [in person], I wouldn't have come.* [Patient 2, oncology]

She lived far away and did not have the strength or money to pay for a long trip.

Conflicting Perspectives on DA-GSD as a Threat to the Nurse-Patient Relationship

Initially, during the commencement of the implementation, most nurses were concerned that DA-GSD would negatively affect or be a threat to their relationship with the patients. This sense of uneasiness was reflected in both face-to-face conversations using digital sheets on a shared PC and video conversations that involved collaborating on the sheets with screen sharing:

> *The thing about constantly having to look at a screen [face-to-face conversations with reflection sheets on a shared screen]. I really like making eye contact with people. And there's also something about keeping an eye on reactions and (...). You can get a little preoccupied with a screen like that, so (...) maybe I could also see such a barrier in relation to the conversation itself, how...so it might be a slightly different conversation. I don't know, it's not certain.* [Nurse 3]

In relation to the video conversations, their considerations focused on their ability to comfort the patients:

> *If you have to do that video...that slightly close contact you have with the patient when you normally sit next to each other and can hand them a handkerchief and bring them a glass of water...you don't have that option long distance, so it could well be a bit negative to have them further away.* [Nurse manager 8]

Although the nurses with managerial responsibilities also hesitated about the quality of the relationship via video conversations, all the nurses (including those without the managerial responsibilities) recognized that video conversations

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were better than no access to health care for patients living far away:

> *Well, I think I have a foot in two camps because..., for me, communication is when you sit and have eye contact, and you can sense each other, and you sit across from each other, and you're just people sitting and having a conversation. And I know that well, we can't keep doing that because patients, especially here with us, come from far away [Faroe Islands, Greenland, and Jutland], and I think it would be a shame if those patients were prevented from having conversations because of the distance is a barrier.* [Nurse manager 5]

The nurses shared feedback during the regular implementation meetings. They discussed patients who wanted to do video conversations, and if they agreed that it was a good idea, they would recommend that the first conversation take place face-to-face at the hospital to help establish the relationship. This approach aligned with patients who combined face-to-face and video conversations. The nurses felt that the initial face-to-face conversation added value and believed that it was the reason video conversations were experienced positively subsequently.

In general, the patients experienced no deterioration in their relationship with the nurses when using DA-GSD with both types of conversations. By contrast, some saw video conversations as an advantage:

> *...when you're sitting in the comfort of your own home, you can open up a little more than if you sat and were met head-on. I've built up a...a minor phobia of doctors...and then you can say that this [video conversation] is way better because there's that kind of barrier somehow (...) I have to say, so I think it has worked.* [Patient 2, endometriosis]

Functionality of DA-GSD and Available Technical Equipment

During the data analysis, it became clear that many of the initial challenges patients experienced early in the study and the ones the nurses discussed at the implementation meetings disappeared over time, that is, patients did not mention them later in the implementation process. One possible reason for this is that DA-GSD and the video features were continuously adjusted during the study period based on feedback from the intervention [12], accelerating the maturation and improvement of the technology.

Patients included early in the study found that the save feature in the digital sheets, a flashing heart in the middle of the screen, was an annoying hindrance "...and then suddenly that heart appeared, almost as if it had to update something" (Patient 3, oncology). This issue continued for quite some time:

> *Sometimes, if you wrote it quickly, it couldn't keep up...then the heart blinked...in the end, I gave up and wrote everything down by hand.* [Patient 4, oncology]

Early in the study, the complicated setup of the Pexip video feature and its instability were perceived as challenges:

> *...how do we do it now [use video]...and it never worked out and then suddenly it crashed when I finally had to having a video conversation. The system didn't work...* [Nurse 7]

Neither the nurses nor the patients described having trouble logging in to the DNHP on Sundhed DK website [12] with their digital IDs to initiate their DA-GSD, although some had difficulty retrieving their digital reflection sheets because they forgot the name of the intervention.

In addition to the challenges concerning functionality, the nurses lacked the technical equipment needed to conduct video conversations, making them even more skeptical about video conversations:

> *Well, yes...[pause], secondly, it's at least important that all departments have a computer with a camera. And the desktop computers don't have that, at least the way things are in the department right now. I've been thinking about it lately...In any case, we must have access to a computer equipped with a camera...* [Nurse 2]

Data Security

Almost all patients felt completely safe about having sensitive data hosted at DNHP Sundhed DK website [12]:

> *I feel very comfortable with that. I was a little surprised that it [this question] was asked at all.* [Patient 3, endometriosis]
>
> *I think there's so much other data about me that is digital.* [Patient 2, endometriosis]

There were only a few who had thought about whether unauthorized individuals could gain access to and see data or whether data could be leaked:

> *Actually, I feel completely unworried, and yet, I know very well that everything can be leaked in the end. It's not because I have something to hide, but whether I fully trust that it won't get leaked one day, I don't know if I do...* [Patient 4, oncology]

This was somewhat in contrast to what most nurses felt, who did not consider data security an issue when using the DNHP, Sundhed DK website [12]:

> *I don't think that's a problem, we already have data there, right?* [Nurse 9]

Several patients wanted other HCPs besides nurses to be able to see their data and the challenges they were collaborating on with the nurses during their DA-GSD conversations:

> *Others should be able to see the data so that you don't have to explain yourself so many times...that they [the completed reflection sheets] would become part of your medical record, perhaps...so the doctor can also see how the person is actually doing.* [Patient 1, endometriosis]

Both patients with endometriosis and cancer thought that data of this nature should be accessible to the multidisciplinary team surrounding the patient:

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> *I want the doctors to be able to see it, so they can see how I feel!* [Patient 1, oncology]

What Influenced the Increased Acceptability of DA-GSD Among the Nurses Over Time

Re-evaluation of the Nurse-Patient Relationship

As the nurses gained more experience using DA-GSD, their concerns about whether the nurse-patient relationship might deteriorate disappeared, regardless of how the intervention was provided. The following quote is about face-to-face meetings, which include sharing digital reflection sheets:

> *It's going really well. During the conversation, we sit opposite each other and occasionally look at the screen. I don't see it as a problem that the computer screen becomes part of the conversation. I don't see it affecting the relationship between me and the patient* [Nurse at endometriosis implementation meeting 2019]

One nurse who had used DA-GSD continuously throughout the implementation process was interviewed twice, once at the beginning and once toward the end of the implementation period. Her experiences also illustrated the general increase in recognizing that the relationship remained intact. Despite her concerns regarding the nurse-patient relationship at the beginning of the study, using videos for DA-GSD became a tool that she offered to every patient by the end of the study period. At that point, she did not worry about or even consider its effect on forming a relationship and stated the following at her follow-up interview:

> *I actually had someone [patient] the other day who I had to book [for DA-GSD], and then I asked what she preferred...she was from XXX [less than 20 kilometers away], but she wanted video.* [Nurse manager 8]

A common pattern was that the nurses saw a trusting relationship developing with patients when they used DA-GSD:

> *You get closer to the patient, I think...and when I meet her, it's a big hug in the hallway and she feels very attached to me.* [Nurse 7]

Improved Functionality of DA-GSD

Over time, the nurses experienced that the functionality of DA-GSD matured, for example, the annoying blinking heart that served as the save feature completely disappeared:

> *After Sundhed.dk ran DA-GSD again, they [the patients] don't find that it [DA-GSD] freezes anymore. It's not something that the patients complain about.* [Nurse at endometriosis implementation meeting 2019]

The improved functionality coincided with the nurses describing that they were increasingly unconcerned about whether patients requested the analog version or DA-GSD:

> *Now I have tried both the digital one and what was printed out [analog GSD], and I think that the digital one just works really well. It's easy for the patients to fill in and I don't have to think about whether I have to print something out...it's easy to log in to Sundhed.dk and...well, I'm comfortable with that. I actually don't think of it as being anything special at all.* [Nurse 10]

The final video feature at DNHP Sundhed DK website [12] also appeared to run seamlessly:

> *We had to try it once to see if it worked [video conversations]...it worked. We continued with it...and it worked fine.* [Patient 2, endometriosis]

At the end of the implementation process, the digital reflection sheets were prioritized over the analog ones, and the nurses viewed video conversations as an excellent supplementary resource to offer patients whom they would otherwise have been unable to reach and support owing to long distances:

> *It's a great extension of the method, isn't it?...and also a resource, I think. Another tool we can have on the shelf, which might serve...? People who live far away.* [Nurse 9]

Notably, the statements supporting the mature, well-functioning version of the DA-GSD were made by patients and nurses who used it toward the end of the implementation process.

Supervision, Experience, Patient Feedback, and a Global Pandemic

At the beginning of the implementation process, the nurses had various preferences about how they would like to be taught about DA-GSD: "...for me it would be really nice with a little summary [of DA-GSD]" (nurse 7). Although written instructions were sufficient for some nurses, others wanted one of the researchers to join them in the beginning. Written instructions were drawn up and adjusted on an ongoing basis, and individual needs for instruction were met as much as possible. In addition, guidelines for the video conversations were prepared jointly with the intervention partners who provided the video features. In addition, tips and tricks that were presented at meetings were drawn up in writing and covered issues such as those concerning the physical and confidential setting of a video conversation, location in relation to the camera, and the use of headsets to optimize the sound. During the meetings inspired by action research, the nurses gave one another feedback and shared experiences about the challenges they encountered and how they approached them.

During the implementation process, the nurses became more comfortable with DA-GSD, owing to its improved functionality, ongoing instruction, the support provided by the researchers, and an increase in confidence arising from their own experiences and those of their colleagues. On the basis of their own experiences, they began to emphasize the advantages of the digital version over the analog version. Several nurses emphasized the advantage of being able to safely store reflection sheets on the web so that it could be easily retrieved by all parties in relevant contexts before and after the conversations:

> *The electronic GSD is perceived as much better than the analogue one. Patients won't lose the sheets, and you can easily find what you've talked about. As an HCP, you can easily look at the sheets again, if*

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necessary. [Endometriosis implementation meeting 2019]

As described earlier, the nurses felt technically challenged, especially at the beginning of the implementation process. They felt professional responsibility for the DA-GSD's functionality when offering it to patients. Their evaluation of DA-GSD was positively affected by patients who apparently embraced the intervention and described it as useful and supportive, despite technical challenges:

It's the best sessions I've ever attended, and I've attended a heck of a lot. [Patient 4, oncology]

Some of the positive benefits of DA-GSD that the patients described were that they were being seen as a whole person, as it enabled them to exchange knowledge with an HCP familiar with their disease and receive support for successful self-management.

Positive patient feedback about DA-GSD video conversations also appeared to influence the nurses' attitudes toward the use of video:

I think it worked quite well and, for me, it's been a good opportunity to do it digitally. [Patient 2, endometriosis]

I have tested that [DA-GSD] with some patients...they liked it...they think it made sense...now it's young women I've had, and they use digital tools—without generalizing—very easily, yes. So, exactly for that patient group, because they are young women, I think it works fine. At least those are the ones I've done it with. [Nurse 10]

In March 2020, the COVID-19 pandemic changed the delivery of health care worldwide and also affected how the nurses experienced the usefulness of DA-GSD using video instead of face-to-face conversations:

An interesting observation was that, during video conversations, they saw the whole patient and could see the subtleties of their body language. When they meet face-to-face, only the eyes are visible [owing to the use of masks during the COVID-19 pandemic]. [Report from endometriosis implementation meeting 2020]

For other patients, using personal protective equipment during the pandemic meant that a video conversation was preferable to meeting face-to-face. Interestingly, they focused primarily on interpreting the nonverbal language:

I actually almost think that, with this corona, it's been easier over video because you can see each other, instead of sitting with masks and shields and all that, so in that way, it's actually been better. [Patient 4, endometriosis]

The nurses agreed that the pandemic quickly made collaboration via video more common among both patients and HCPs. The pandemic also resulted in the provision of additional technical equipment for video conversations in departments:

In relation to facilities for video conversations in the outpatient clinic, there are also some new resources that were not there before the pandemic, for instance, video and computers that allow you to facilitate video conversations...We have three computers that are equipped with cameras...and then I found out that this, a portable camera that you can take with you, also works. [Follow-up interview, nurse manager 8]

Discussion

Principal Findings

This study aimed to investigate the experiences of nurses, nurse managers, and patients with DA-GSD in a long-term implementation process. Our results show that nurses and nurse managers were more concerned about using DA-GSD and the various ways of using it than the patients. The nurses' doubts regarding the ability of patients to use DA-GSD, as well as their concerns about it having a negative impact on the nurse-patient relationship, were baseless. Although DA-GSD did not always work optimally, the patients embraced the intervention and found it useful and rewarding. The improved functionality, nurses' own experience with using DA-GSD, and patients' positive feedback seemed to affect the acceptability of DA-GSD over time among the nurses. Of note, the global pandemic required rapid implementation of video consultations in health care worldwide, which likely also played an important role in its acceptability. In contrast to the nurses, only a few patients had concerns about data security.

Discussion of Principal Findings

Ability of Patients to Engage With DA-GSD

The nurses and patients had conflicting perspectives on the ability of patients to engage with DA-GSD. Our study showed that the nurses' concerns about patient characteristics that would be a barrier to using DA-GSD and would prevent them from benefiting from the intervention were unfounded, although other studies have found that they were warranted [20]. A previous study reported that cognitive impairment, older age, and difficulties in coping with technology are barriers to using telehealth [20], whereas a systematic review found that these factors, with the exception of cognitive impairment, are also patient-related barriers to adopting telemedicine [21].

The nurses in our study felt responsible for the functionality of the technology and ensuring that the individual patients had the necessary digital skills before engaging in DA-GSD. A scoping review on the role of nurses and the skills needed to master technology and digital solutions [22] found that communication skills, adaptiveness, and problem-solving were needed to adapt the interaction to the patients' digital skills and digital knowledge. Therefore, training nurses in new communication and technological skills was important for advancing their readiness to adopt telemedicine [22]. This is in line with our findings, which showed that the nurses felt responsible for the technical functionality and needed individual supervision in DA-GSD, and is reflected in feedback about the challenges they experienced to increase their confidence in facilitating DA-GSD.

In our study, the patients embraced DA-GSD and found it useful, which is in line with a review of web-based psychosocial interventions for cancer survivors [23] that found that most

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studies reported that patients welcomed web-based interventions positively.

The Nurse-Patient Relationship

Nurses' expectations and concerns about DA-GSD affecting the nurse-patient relationship were a central aspect in our findings. According to the person-centered practice framework, the relationship is important [24] and the development of nurses' relationship skills is a prerequisite for person-centered care that warrants the nurse's ability to communicate on different levels using verbal and nonverbal communication [24]. One of the person-centered care processes that the framework describes is that nurses must be sympathetically present and recognize the uniqueness and value of the person by appropriately responding to cues [24]. The nurses in our study described initial concerns regarding their ability to communicate adequately being challenged because of impaired nonverbal cues and thus an inability to respond properly to them. Our findings are in line with a systematic review of qualitative studies examining nurses' experiences as facilitators of telehealth applications [20]. Similar to our study, their findings show that nurses experienced a dilemma regarding the nurse-patient relationship when using telehealth; on the one hand, they reported a negative and changed relationship as a barrier and, on the other, an improved nurse-patient relationship as a facilitator [20]. The barriers in the review included loss of human contact [20], which was also the case in our study, although video conversation was only used in a small percentage of DA-GSD sessions, whereas another barrier was difficulty in getting to know the patient, which was not described as a barrier in our findings. This was perhaps the case because DA-GSD comprised the use of reflection sheets filled out in advance before sessions with an HCP and the systematic sharing of person-specific knowledge [15]. The review mainly identified positive experiences with using telehealth [20], which is in line with our findings, wherein most barriers disappeared when the nurses had positive experiences with DA-GSD. A study examining the use of video consultations by doctors also reported the fear of deterioration in the physician-patient relationship, for example, not shaking the patient's hand and having eye contact prevented access to a great deal of important information that the doctors were reluctant to miss [25]. However, they found that they could maintain good contact and assess patients satisfactorily while achieving more relaxed interaction in video consultations [25]. This is completely in line with our findings, which showed that the relationship remained good and that some patients felt more secure doing video calls at home.

Functionality of DA-GSD and Lack of Technical Equipment

Our study found that 2 barriers to implementation were DA-GSD's functionality and a lack of technical equipment, which is in line with a systematic review of the barriers and facilitators of eHealth services [26] that identified three categories of barriers: (1) individual, such as motivation, accessibility, and trust; (2) environmental and organizational, such as financial, political, and organizational structures; and (3) technical, such as services and design that do not suit user needs. These findings are in accordance with ours in which the nurses lacked motivation to initiate video conversations in the beginning because the initial Pexip video feature did not meet their needs for functionality, turning its functionality into a personal and technical barrier. Interestingly, the patients did not experience the technical barriers to the same degree as the nurses, perhaps because the benefits of DA-GSD outweighed the technical challenges and the nurses felt a great deal of professional responsibility toward its functionality. A study on patient rounds with relatives consulted on video also found that the nurses felt a huge responsibility for the technical setup and organizing it [27]. Other studies reported that HCPs resisted using telemedicine because it represented a threat to their clinical work [21,27]. Organizational barriers became visible in our study during the COVID-19 pandemic, which accelerated organizational readiness for the use of video consultations and, specifically, the purchase of additional technical equipment. Other barriers to adopting telemedicine are its cost and outdated equipment [21].

Comparison With Prior eHealth Intervention Based on the GSD Studies

GSD was previously digitalized in an eHealth intervention targeting patients with type 2 diabetes in Norway [28-31] and as a web-based GSD program in Australia [32,33]. The Norwegian version, eHealth intervention based on the GSD [28-30], was used in a general practice in 4 e-consultations. After the initial face-to-face meeting, the patients submitted completed digital reflection sheets and a nurse provided an asynchronous response in writing. The authors concluded that the intervention might be conducive to support the self-management of diabetes but that in-person consultations may be necessary to achieve the full potential of GSD [29]. eHealth intervention based on the GSD influenced the nurse-patient relationship by facilitating reciprocal understanding and flexibility [30], whereas GSD without face-to-face encounters reduced participant motivation to engage in the intervention [28]. Asynchronous writing, which may hamper the opportunities that nurses have to use basic and advanced communication skills, may not be adequate to replace the communication skills currently used in clinical practice [31]. This is in keeping with our findings, which show that the nurses were concerned about the deterioration of the nurse-patient relationship if videos hindered the interpretation of body language or if the conversations moved the focus to a shared screen. However, the nurses in our study found that they were able to communicate adequately and establish the type of relationship that was important for person-centered care during video conversations. The Australian web-based GSD program targeting young adults with type 1 diabetes, which used smartphones on Apple and Android platforms and Zoom (Zoom Video Communications) [32], found that the program not only promoted reflection and solutions, in addition to facilitating young adults' journey based on their needs and goals, but also changed the way HCPs and patients collaborated. Issues regarding a lack of mobile responsiveness and saving material, which is also a factor in our study, required improvement [32]. To our knowledge, Denmark is the first country to host a web version of GSD on a national health portal, which increases the

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possibility of scaling up the intervention for wide implementation.

Strengths and Limitations

Various factors may have affected our data, analyses, and findings. First, the oncology patient group provided feedback on the newly developed version of the DA-GSD and the endometriosis patient group did so on a more mature version, which may have negatively affected the experience of the former group. Second, the patients with cancer were older and perhaps more cognitively affected because of their diagnosis and treatment than the patients with endometriosis, who were younger, of childbearing age, and especially challenged by pain, making the comparison of their technological skills difficult. Third, in March 2020, the COVID-19 pandemic affected treatments, priorities, and the development of technology in the Danish health care system, although video consultations were quickly implemented to reduce the spread of COVID-19. These circumstances likely accelerated the implementation of the DA-GSD video feature. Fourth, the prospective use of a systematic evaluation tool, such as nonadoption, abandonment, scale-up, spread, and sustainability-complexity assessment tool, from the beginning of the research project may have amplified the attention given to the complex social and political aspects of the implementation process [34]. Fifth, only women participated in evaluating DA-GSD, which means that our findings are not directly applicable to men.

One of the strengths of this study is that it examines the perspectives of both nurses and patients regarding DA-GSD. Another strength is the longer-time perspective of 5 years. Moreover, several researchers participated in the analysis and interpretation of results, which enhances their reliability.

Conclusions

In this study, the nurses experienced more barriers to DA-GSD than the patients. The acceptance of DA-GSD increased over time among the nurses once DA-GSD's functionality improved, they had received guidance, and had had their own positive experiences, combined with the fact that the patients found DA-GSD useful and beneficial. Our findings emphasize the importance of focusing on supporting and teaching nurses if new technologies are to be implemented successfully.

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Conflicts of Interest

None declared.

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Abbreviations

DA-GSD: digitally assisted guided self-determination
DNHP: Danish National Health Portal
GSD: guided self-determination
HCP: health care professional

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Original Paper

The Use of Social Media by Clinical Nurse Specialists at a Tertiary Hospital: Mixed Methods Study

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Abstract

Background: Recently, many health care professionals, who use social media to communicate with patients and colleagues, share information about medical research and promote public health campaigns.

Objective: This study aimed to examine the motives, barriers, and implementation of social media use among clinical nurse specialists in Oman.

Methods: A mixed methods study was conducted among 47 clinical nurse specialists at Sultan Qaboos University Hospital between November and December 2020. Qualitative data were collected using an open-ended questionnaire and analyzed using thematic analysis, and quantitative data were collected with a questionnaire and analyzed using SPSS (version 21.0; IBM Corp).

Results: Of the 47 clinical nurse specialists surveyed, 43 (91.5%) responded. All respondents reported using social media applications, with WhatsApp being the most commonly used platform. Most respondents (n=18, 41.9%) spent 1-2 hours per day on social media. The main motives for using social media were increasing knowledge, communication, reaching patients easily, and reducing the number of hospital visits. The main barriers to social media use were privacy concerns, time constraints, and a lack of awareness of legal guidelines for social media use in the workplace. All participants requested clear rules and regulations regarding the use of social media among health care providers in the future.

Conclusions: Social media has the option to be a powerful institutional communication and health education tool for clinical nurse specialists in Oman. However, several obstacles must be addressed, including privacy concerns and the need for clear guidelines on social media use in the workplace. Our findings suggest that health care institutions and clinical nurse specialists must work together to overcome these impediments and leverage the benefits of social media for health care.Bottom of Form

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KEYWORDS

social media; clinical nurse specialist; cross-sectional; tertiary hospital; Oman; health education tool

Introduction

Several previous studies have revealed that the rapid development of technology has influenced every aspect of human lives, including health care services. The presence of the latest technologies among health care professionals (HCPs) has improved the services provided to their patients [1]. Social media (SM) has become a popular tool for HCPs to manage and interact with patients, promote healthy behaviors, and develop professional network [2-4]. In addition, the use of SM platforms by HCPs is increasing globally [5,6]. Studies have shown that SM can effectively improve health care outcomes and debate issues in health care policy and practice [7]. Furthermore, SM can be used by HCPs to educate and motivate patients, track progress, answer patient queries, and increase patient service satisfaction [8-11]. Scholars have noted that SM

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tools can be effective in meeting individual and population health needs, especially during the COVID-19 pandemic [8,12]. However, there are very few studies on reflections of SM use among HCPs.

A survey of 658 Chinese nurses found that all participants were SM users, with 84.5% of them believing that SM positively influenced their clinical practice [13]. Furthermore, Wang et al [13] found that nurses use SM for a variety of purposes ranging from receiving messages from work and news to relaxing and networking. SM's applications in health care have been used to engage with the community through providing mutual education and interaction with patients, caregivers, students, and colleagues [14,15]. Studies have shown that patients want to communicate with their doctors or clinic through SM for sending information regarding laboratory investigations, reports, scheduling appointments, and reminders and for receiving responses to their queries [16]. Furthermore, SM has also been shown to have an impact on rapid information and knowledge dissemination to the people who need it most during the COVID-19 pandemic [8,17].

However, the expansion of SM platforms carries potential risks to HCPs and patients in regard to the dissemination of misleading information, risks to patient confidentiality, the violation of personal-professional limitations, and the potential for the impairment of the professional image [17-19]. There are also potential legal issues, such as maintaining privacy and the lack of control and oversight that could have a negative impact on patient satisfaction [20].

In the Middle East, there is potential for SM to be adopted to improve patient outcomes [21]. A survey by the Centre for Statistics and Information in Oman revealed that the average daily use of SM among Omanis was 6 hours a day. WhatsApp was the most commonly used platform among students, while Snapchat and Facebook were the least used [22]. The Arab Social Media Forum highlighted that the high demand for SM in Oman comes with huge amounts of potential, particularly because SM users account for 77% of the total population, and user growth rates continue to rise [23]. According to Hagg et al [24] and Rahmat et al [25], there is a need for research on SM to expand the geographical focus and test strategies to facilitate the effective and efficient use of social media for health care purposes in the Middle East.

There are 47 clinical nurse specialists (CNSs)—a category of advanced practitioner nurse (APN)—at Sultan Qaboos University Hospital (SQUH). APNs are considered the first line of HCPs when it comes to communicating with patients [26]. APNs play a crucial role in patient care, and their ability to communicate with patients and provide timely and accurate information is essential in improving patient outcomes. According to the National Association of Clinical Nurse Specialists, CNSs are integral to the delivery of cost-effective, high-quality, and patient-centered care [27-29].

However, how SM should be used among CNSs in Oman is not yet well defined. Most of the literature investigated SM usage in nursing or medical education. In addition, there is a dearth of knowledge to understand nurses in general and CNSs in particular and their use of SM in the Middle East and Oman. Therefore, in response to this gap in knowledge, the aim of this study was to examine the use of SM applications among CNSs at SQUH and the motives and barriers that CNSs are facing in implementing SM usage.

Methods

Study Design and Setting

A mixed methods design was used to collect data to uncover the best practices of CNSs in terms of SM use. A paper questionnaire was used to collect both qualitative and quantitative data.

Data collection took place at a tertiary hospital in Oman, located in a well-populated area of Muscat. The study setting was the main tertiary teaching hospital that receives patients throughout the country, who require subspecialty evaluation and treatment. This tertiary teaching hospital is the main health care setting in Oman that recruited CNSs in their services since 1998.

Sample

A convenience sample consisting of nurses working as CNSs in the hospital for a minimum of 1 year and using a smartphone was considered a provision for participation in the study. The study sample size was calculated for the population of CNSs at the tertiary hospital, using the Raosoft web-based sample size calculator (Raosoft Inc) with a confidence level of 95% and a 5% margin of error, and determined to be 42. After obtaining ethical approval, the PI explained the purpose and scope of this study to the nursing administration of the hospital to obtain permission. Once approved, the principal investigator (PI) explained the inclusion criteria and sampling technique to the CNSs at the hospital. The PI distributed the paper questionnaires to participants who met the inclusion criteria. Participation was voluntary. Participants answered individually during work hours and returned the questionnaire to the PI.

Data Collection

A self-administered questionnaire was adapted from the literature, which evaluated HCPs' SM use. The tool underwent both internal and external validation before the data collection process. Two expert researchers were consulted to validate and assess the reliability of the content of the tool. The questionnaire was piloted on 5 CNSs to determine the level of understanding, ambiguity or repetition, any difficulties with language or phrasing, comprehension, and length of time to complete the survey. No changes were needed.

The tool consisted of 5 sections. The first section included an outline of the demographic data, CNSs' professional experience, and the use of smartphones in the work area, using closed-ended questions to assess the frequency of use. The second section investigated the usage of phones and SM using a Likert scale to assess the frequency of use. The third section investigated further the CNS motives for health-related SM use with a focus on the use of the WhatsApp mobile app, as it is the most common SM platform. The fourth section examined the types of barriers (factors that prevent the use of SM) and obstacles (factors that can be overcome or improved by the use of SM) faced by HCPs regarding health-related SM use among CNSs,

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using a Likert scale. The fifth section was reserved for qualitative assessment with open-ended questions with free-text, extended responses to encourage suggestions for improvements in the use of SM for health-related reasons in the future from the perspective of the participants. To minimize the frequency of missing data, the research team provided participants with clear explanations about completing the questionnaire and answered any of their questions [30].

Data Analysis

Correlation frequency, percentage, and mean values of the data were analyzed using SPSS software (version 21.0; IBM Corp). Descriptive statistics were used to present the participants' demographic data, and a distribution was used to represent the data. *P* values were used to test any correlations between 2 variables; that included evaluating years of experience and the use of SM by gender. A *P* level of ≤.05 was considered significant. The associations between some selected independent variables and the use of SM was assessed using a chi-square test. In the Likert scale shown below, the frequency of each response was assessed using a 5-point scale ranging from "Never" to "Always." The responses were then coded as follows: 1="Never," 2="Rarely," 3="Sometimes," 4="Often," and 5="Always." On assessing the professional barriers to health-related SM use among CNSs, the Likert scale was coded as follows: 1="Strongly Disagree," 2="Disagree," 3="Neutral," 4="Agree," and 5="Strongly Agree." Then, the frequency of each response was reported as the percentage of each option. After using the previous coding scheme, the data were analyzed quantitatively. Thematic analysis was performed to analyze participants' suggestions, which comprised 6 steps: familiarization with the data, generation of initial codes, searching for themes, reviewing of the themes, defining the themes, and finally write-up.

Ethical Considerations

Ethical approval was attained from the medical research ethics committee at the College of Medicine and Health Science, Sultan Qaboos University (REF.NO.SQU-EC/169/2020, MREC#2205). The data were collected anonymously, and consent was obtained from all participants.

Results

Quantitative Findings

Table 1 shows that the surveys were distributed to 47 CNSs, which is the total number of CNSs working in SQUH. Of them, 43 (91.5%) CNSs responded to the questionnaire and 4 (8.5%) did not respond. Thirty-six (83.7%) CNSs were female, and the majority of respondents (n=30, 69.8%) were 30-35 years old. Thirty-nine (90.7%) respondents had more than 10 years of experience. In total, 27 (62.8%) CNSs used 1 smartphone, while the remaining 16 (37.2%) used 2-3 smartphones. All respondents were using SM, of whom 22 (51.5%) were using 4-6 SM apps. There was almost an equal number of participants who spend 1-2 hours (n=18, 41.9%) and those who spend 3-4 hours (n=15, 34.9%) on SM apps to respond to the patients and other HCPs, with 27 (62.8%) CNSs using SM it during work, at home, and at leave times. Only 5 participants reported using hospital Wi-Fi during work time, indicating that the vast majority of the respondents were covering their own phone bills in order to communicate with patients and other HCPs.

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Table 1. Demographic data of the participants (N=43).

Characteristics	Participants, n (%)
Gender	
Male	7 (16.3)
Female	36 (83.7)
Age (years)	
30-35	30 (69.8)
35-40	13 (30.2)
Years of experience (years)	
5-10	4 (9.3)
>10	39 (90.7)
Certification	
MSc	9 (20.9)
BSc with a high diploma	5 (11.6)
BSc	29 (67.4)
Number of smartphones used[a]	
1	27 (62.8)
2	15 (34.9)
3	1 (2.3)
Number of social media apps currently in use	
<3	15 (34.9)
4-6	22 (51.2)
>6	6 (14)
Average cost per month for smartphones used for communication with patients and health care providers communication (Omani Rial; 1 Omani Rial=US $2.6)	
0	5 (11.6)
2-10	19 (55.9)
11-20	14 (32.6)
21-40	5 (11.6)
Average hours per day of social media use in responding to patients and health care professionals[a]	
1-2	18 (41.9)
3-4	15 (34.9)
5-6	9 (20.9)
>7	1 (2.3)
Using smartphones for hospital issues	
Only during working hours	11 (25.6)
During work hours and at home	5 (11.6)
During work hours, at home, and during leave time	27 (62.8)
Do you prefer health-related social media articles?	
Never	1 (2.3)
Rarely	0 (0)
Sometimes	21 (48.8)
Often	18 (41.9)
Always	3 (7)

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Characteristics	Participants, n (%)
How much do you believe in news on social media?	
100%	0 (0)
80%-90%	11 (25.6)
50%-70%	15 (34.9)
<50%	17 (39.5)
How do you feel when you cannot use social media?	
Relieved	18 (41.9)
Unable to leave the phone	3 (7)
Afraid that you will miss important news	22 (51.2)
Have you ever experienced any physical discomfort as a result of using social media?[b]	
Yes	34 (79.1)
No	9 (20.9)
Have you ever experienced any psychological discomfort as a result of using social media?[b]	
Yes	21 (48.8)
No	22 (51.2)
Have you ever been humiliated or criticized by social media?	
Yes	8 (18.6)
No	35 (81.4)
Have you ever sued (by law) any patient, doctor, or any health care professional due to social media humiliation or assaults?	
Yes	0 (0)
No	43 (100)

[a]No significant difference in the number of mobile phones used and the number of hours spent on using social media (*P*=.46).

[b]Significant correlation in the number of clinical nurse specialists who reported physical and psychological discomfort and the number of hours spent in using social media apps (*P*=.003).

Multimedia Appendix 1 shows that the most frequently used SM apps among CNSs in this study were WhatsApp (n=41, 95.3%), Instagram (n=24, 55.8%), and YouTube (n=12, 27.9%), and in comparison, the least used apps were Snapchat (n=4, 9.3%), Twitter (n=9, 20.9%), LinkedIn (n=4, 9.3%), and Facebook (n=4, 9.3%). Yet, a few CNSs in this study use other SM apps (n=1, 2.3%) as well, such as Zoom.

CNSs' Main Motives for Using SM

Table 2 displays the 11 motives listed for CNSs to acknowledge the main reasons for using SM. More than half of the CNSs in this study were using SM to increase their knowledge and to communicate with patients and other HCPs (n=37, 86%). In addition, the same number of CNSs also agreed that using SM helped them to reach patients easily (n=32, 74.4%), reduce their number of hospital visits (n=32, 75.0%), increase efficacy (n=33, 76.7%), and increase patient satisfaction (n=34, 79.1%), while around one-third of CNSs were not interested in using SM for publicizing their achievements (n=13, 30.3%).

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Table 2. Clinical nurse specialists' motives or reasons for using social media.

Reasons for using social media	Never, n (%)	Rarely, n (%)	Sometimes, n (%)	Often, n (%)	Always, n (%)
Increase knowledge	2 (4.7)	1 (2.3)	9 (20.9)	21 (48.8)	10 (23.3)
Nurse-to-patient communication	0 (0)	4 (9.3)	10 (23.3)	13 (30.2)	16 (37.2)
Nurse-to-doctor communication	0 (0)	2 (4.7)	6 (14)	14 (32.6)	21 (48.8)
Nurse-to-nurse communication	0 (0)	0 (0)	5 (11.6)	18 (41.9)	20 (46.5)
Reaching patients easily	1 (2.3)	3 (7)	7 (16.3)	11 (25.6)	21 (48.8)
Efficacy	0 (0)	4 (9.3)	6 (14)	24 (55.8)	9 (20.9)
Maintaining a good image of the health care institution	2 (4.7)	6 (14)	11 (25.6)	18 (41.9)	6 (14)
Publicizing your specialty achievements or your efficiency (or both)	4 (9.3)	14 (32.6)	12 (27.9)	11 (25.6)	2 (4.7)
Communicating well with other health care providers	0 (0)	0 (0)	6 (14)	20 (46.5)	17 (39.5)
Helping patients reduce the number of hospital visits	4 (9.3)	0 (0)	7 (16.3)	13 (30.2)	19 (44.2)
Increasing patient satisfaction	2 (4.7)	0 (0)	7 (16.3)	17 (39.5)	17 (39.5)

On the other hand, Table 3 shows that the motives for using WhatsApp were extending their network (n=28, 65.1%), updating colleagues about workflow, and sharing information about work with colleagues (n=29, 67.5%). In addition, they were using it to share information on medical conferences, workshops, symposia (n=29, 67.5%), etc. Furthermore, introducing the achievements of their hospital to the outside world was not an area of interest for using SM among 18.6% (n=8) of those using WhatsApp. There was no significant difference in the number of mobile devices used and the number of hours spent using SM (P=.46). Moreover, there was no significant difference between the educational level (in terms of certification) and the number of hours spent using SM (P=.57).

Table 3. Clinical nurse specialists' motives for health-related social media use at the item level for WhatsApp.

Clinical nurse specialists' motives for health-related social media use at the item level for WhatsApp	Never, n (%)	Rarely, n (%)	Sometimes, n (%)	Often, n (%)	Always, n (%)
Extending the network with colleagues	1 (2.3)	2 (4.7)	12 (27.9)	15 (34.9)	13 (30.2)
Updating colleagues about workflow	1 (2.3)	3 (7)	10 (23.3)	15 (34.9)	14 (32.6)
Presenting the hospital to the outside world	1 (2.3)	7 (16.3)	17 (39.5)	12 (27.9)	6 (14)
Sharing information on medical conferences, workshops, and symposia with others	1 (2.3)	1 (2.3)	12 (27.9)	15 (34.9)	14 (32.6)

Professional Barriers and Obstacles Regarding Health-Related SM Use

Table 4 shows that time constraints (n=26, 60.4%), privacy concerns (n=26, 60.5%), and unawareness about the legal grounds (n=22, 51.2%) of SM use were the main barriers faced by more than half of the CNS. In addition, there were obstacles faced by two-third of the CNSs in using SM, such as receiving messages from patients whom they did not know who were asking for help (n=29, 67.4%), difficulties in receiving videos, images, or electrocardiographs (n=28, 65.2%), etc, from patients via SM, and lack of landlines (n=28, 65.2%).

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Table 4. Professional barriers regarding health-related social media use among clinical nurse specialists.

Professional barriers regarding health-related social media use	Strongly disagree, n (%)	Disagree, n (%)	Neutral, n (%)	Agree, n (%)	Strongly agree, n (%)
Inefficiency (uncertainty about the trustworthiness of social media applications and gives patients the wrong idea when they see a clinical nurse specialist holding a phone)	0 (0)	6 (14)	17 (39.5)	14 (32.6)	6 (14)
Lack of skills	5 (11.6)	12 (27.9)	16 (37.2)	10 (23.3)	0 (0)
Legal ground (not knowing the legal aspects of social media)	1 (2.3)	6 (14)	14 (32.6)	18 (41.9)	4 (9.3)
Privacy concern	0 (0)	4 (9.3)	13 (30.2)	20 (46.5)	6 (14)
No need for its use	8 (18.6)	21 (48.8)	8 (18.6)	6 (14)	0 (0)
Time constraints	0 (0)	9 (20.9)	8 (18.6)	25 (58.1)	1 (2.3)
Receiving messages from patients whom you do not know, or from patients seeking help from practitioners of other medical specialties	0 (0)	4 (9.3)	10 (23.3)	21 (48.8)	8 (18.6)
Need to receive videos from patients	1 (2.3)	3 (7)	11 (25.2)	22 (51.2)	6 (14)
Lack of landlines or busy landline	0 (0)	2 (4.7)	11 (25.2)	2 (51.2)	6 (14)

Furthermore, as shown in Table 1, overall, 79.1% of CNSs listed that they were experiencing some physical discomforts such as insomnia, carpel tunnel syndrome, eye dryness, eye pain, headache, joint pain, wrist pain, nausea, neck pain, and thumb pain as a result of using SM applications. Furthermore, 21 (48.8%) CNSs reported experiencing some psychological discomfort including anxiety, sadness, stress, and anger. There was noticeable significance in the number of CNSs who reported physical and psychological discomfort and the number of hours spent in using SM applications (P=.003). Nonetheless, 22 (51.2%) CNSs reported that they felt afraid of missing something if they did not use SM. Furthermore, less than a quarter of the study participants reported that they were humiliated by SM either by a patient or an HCP (n=8, 18.6%) but no one has ever sued a patient or HCPs due to SM humiliation or assault.

Qualitative Findings

The open-ended questions asked about participants' suggestions for the future use of SM among CNSs at SQUH. Indeed, the CNSs proposed new ideas, which they thought (if applied) would help regulate and develop the use of SM in the health care setting. Two key themes from these data emerged: organizational support and mitigating the risks of SM.

Organizational Support

The CNSs in this study were aware of the benefit of the SM in their daily work; therefore, they suggested, "the organisation could add the WhatsApp platform in the hospital computers for easy access and conversation tracking."

In addition, half of the CNS suggested that the "organisation could have a formal account in SM, that all the employee could use for health education, hospital orientation, hospital workflow instruction, and guidance for the community and give a message to users that this is being monitored."

Half of participants suggested having "an official specialized platform to interact with their patients and conduct virtual clinics."

Other participants suggested, "the organisation provide a mobile phone to CNSs with high patients' number to facilitate direct communication when it's needed. Providing free, strong and fast WIFI network coverage was suggested by the participants to encourage CNSs to use SM."

Mitigating Risks of SM

The CNSs' concerns were compounded by their experiences and lack of knowledge about the legal aspect of using SM. Therefore, they suggested, "a focal person (who knows the legal aspects) in the organisation to refer to when they are faced with a legal issue related to SM." Other CNSs suggested, "clear regulation and guidance in the use of SM including legal and professional instructions." Some believed that health care institutions should regulate the usage of SM activities and "the Hospital Information System to programme the most used SM platforms (like WhatsApp) for an automatic phone response to patients who are calling the CNS during their leave or when they are off duty and redirecting them to the HCP who is covering that CNS."

Discussion

Principal Findings

This was the first study reporting the use of SM applications by CNSs in Oman and the Middle East in order to acknowledge the motives, barriers, and future aspects of SM usage. The results of this study showed that all participants used SM in the hospital, and WhatsApp was the most frequently used application. SM was mostly used to communicate with patients or to increase their knowledge. However, there were 2 main concerns regarding the use of SM: privacy and legal concerns.

The results of this study show that all respondents were engaged with SM and were using 1 or more SM apps on their phones, which is similar to the findings of Wang et al [13]. However, Surani et al [31] reported that 87.9% of the nurses in their study were SM users; that can be explained by the time difference between the 2 studies [31].

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Our results show that CNSs were spending 1-2 hours per day on SM use. These findings are similar to those of a study undertaken by the University of North Texas [31]. While the average daily use for SM among Omanis is 6 hours per day according to a previous study conducted by Al-Kindi [22], this might be explained by the difference in the age group and the purpose of using the SM platform.

Our results also show that WhatsApp is most preferred SM application used in the clinical area because it is free, easy to use, and has an international pool of users. Indeed, a study from the Kingdom of Saudi Arabia revealed that Twitter, YouTube, Instagram, Facebook, Snapchat, and LinkedIn were the most frequently used SM platforms, in descending order, for professional development among HCPs [32]. This indicates that SM has the potential to be a multifocal platform through which every segment of the society can have their voices heard, facilitating knowledge exchange and improving networking opportunities [33].

The top benefits that CNSs agreed on for using SM apps on smartphones were that they offered opportunities that cannot be achieved through the use of regular landlines, and other benefits have been anecdotally reported in the wider literature [14,15,34]. Moreover, it was reported that SM is a tool for the health care community to improve quality and professional practice at a low cost [35]. When communicating with user patients, SM allows for real-time interaction and provides tools and spaces to access and exchange information and to improve opportunities for participation and expression. The health professional networks are used to disseminate results, discussions, and networking for outreach and research [14,15,34]. According to Wang et al [13] SM will soon be the preferred communication tool for health care corporations. In regard to hospital organizations, the available studies were not conclusive concerning the use of SM. However, there are hospitals with a highly visible profile and with brand recognition on SM platforms, such as the Mayo Clinic, the Cleveland Clinic, and Mount Sinai Hospital, all of which are in the United States [36]. Overall, despite the widespread commitment to SM, hospitals continue to undercommunicate their corporate identity, with little variety in the range of SM used. This is in line with the poor use of content and applications in the context of limited professionalization of the corporate presence on SM [37].

Regardless the benefits of SM use, CNSs were always pressured with time restrictions; this could be because nurses are always busy in the clinical area with administrative and clinical jobs. The second barrier was confidentiality. Patients' private information can be interspersed and might reach other family members of the patient [38]. The risk borne by commenting on the internet about any patient condition or having excessive trust in SM when connecting with HCPs regarding patient health status, and the neglect of other traditional communication channels are also seen as barriers. Given this situation, Koehler et al [38] suggested that providing staff with smartphones from the institution could address these restrictions. The third barrier was unawareness about the legal grounds of SM use in clinical practice [38]. This problem was also seen in most of the hospitals worldwide [31]. For example, Surani [31] reported that doctors were more aware of legal policy for SM use in their hospitals as compared to nurses. This is an area that needs to be highlighted to the CNSs by the hospital administration, using clear guidelines that need to be established at the institution. The fourth barrier was inefficiency [31]. CNSs were concerned when the clients saw them holding their phone, they might perceive them to be using the phone for a nonwork purpose. In fact, Koehler et al [38] explained this perception in a way that HCPs may think that patients are not aware that smartphones can be used for medical purposes. Most of the CNSs mentioned that some people felt that there was no need to use SM in clinical practice [38]. However, 2 key reasons that SM use was seen as beneficial were (1) landlines were difficult to locate, which make it time-consuming when searching for a free landline to communicate with patients; and (2) the necessity of some specialties to receive some images, electrocardiographs, videos, laboratory results, x-ray images, reports, etc, from their patients to help them in the continuity of care and reduce the number of hospital visits.

Most of the CNSs preferred health-related SM articles but one-third of them did not trust whatever they read. Prasad [39] described that being cautious on the topic of the health information on the internet originated from unregulated sources and is an important consideration. Because the source is not always well defined or is not stated and the messages are not clear or are not well referenced, people question the reliability of the content disseminated on SM [40].

A high percentage of physical symptoms was identified among CNSs as a result from extensive use of SM. Velthoven et al [41] described the reason as increased use of the thumb to text and operate smartphones can damage the thumb muscle, causing tenosynovitis. This condition led to the coining of a recent medical term called "Whatsappitis." Furthermore, "text neck" is another term generated to define tilting the head forward for prolonged times, thus forcing the neck muscles, ligaments, and tendons to strain when using smartphones along with SM texting. In addition to that, the prolonged use of SM platforms can lead to weakness in the hand muscles, tenosynovitis, nerve compression, and chronic neck pain [41].

Nearly half of the CNSs reported having psychological symptoms as a result of using SM. Studies have shown that compulsive SM use significantly triggered fatigue, which later results in elevated anxiety and depression [42]. Likewise, Dhir et al [43] reported the elevation of emotional fatigue, which later translates to poor physical performances and perceptions among Taiwanese Nurses.

Despite SM-induced physical and psychological discomfort, more than half of the CNSs reported that they continued using it. That condition was defined as fear of missing out (FoMO)—it is an apprehension or concern of being disconnected, absent from, or missing an experience which others (ie, peers, friends, and family) might receive or enjoy [44]. Our findings suggest that FoMO may be stemming from the responsibility of the CNSs. They do not want to miss information about patient health progress or administrative updates. Nevertheless, FoMO was found to be associated with negative health outcomes [45].

Although some of the CNSs were humiliated through SM, this study outcome indicated that none of them have taken legal

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action toward the aggressor. An elucidation of that by the limited knowledge of the HCPs about the legal aspects of SM use is also apparent in the wider literature [31]. In fact, a law on cybersecurity in Oman was issued in accordance with Royal Decree number 12/2011 of the Information Technology Crimes Act in Oman. The decree covers legal action to be taken in the following cases: infringement of the integrity, confidentiality, and availability of electronic data and information and information systems in all its forms, misuse of IT, forgery and information fraud, and content crimes [46]. We recommend teaching the HCPs the legal aspects and consequences.

Strengths and Limitations

The main strength of this study is the use of a mixed methods design, which allowed achieving the aim of the study. Moreover, it is novel to the Omani context. The limitations of the study are its small sample size, which was due to the small number of CNSs working at SQUH, which limits the generalization of results to the larger population. The application of the conclusions of the study may be limited by time and geographical location, which further limits its generalizability.

Recommendations

Future research should consider a larger sample size for similar studies to enhance the generalizability of our results. Moreover, examining SM usage and perception among patients and general nurses in other settings is recommended. Finally, health policy makers should consider addressing the legal aspects of SM usage in health care settings.

Conclusions

SM proved to be a powerful institutional communication and health educational tool. However, this is accompanied by risks to patients' privacy, time constraints, and efficacy. Critically, the health institution has to regulate the use of SM among HCPs and teach them how to minimize potential risks considering the legal aspects of SM usage in health care settings. The legal aspect and consequences should be documented in hospital policy, and a focal person should be allocated a role to help the staff who need support in that field.

Acknowledgments

The authors would like to thank all the participants of this study.

Data Availability

The data sets generated during and analyzed during this study are available from the corresponding author on reasonable request.

Conflicts of Interest

None declared.

Multimedia Appendix 1
The most frequently used social media apps among clinical nurse specialists.
[PNG File , 31 KB - nursing_v6i1e45150_app1.png]

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Abbreviations

APN: advanced practitioner nurse
CNS: clinical nurse specialist
FoMO: fear of missing out
HCP: health care professional
PI: principal investigator
SM: social media
SQUH: Sultan Qaboos University Hospital

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Original Paper

Experiences of a Novel Structured Foot Examination Form for Patients With Diabetes From the Perspective of Health Care Professionals: Qualitative Study

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Abstract

Background: Diabetes is a growing threat to public health, and secondary diseases like foot complications are common. Foot ulcers affect the individual's quality of life and are a great cost to society. Regular foot examinations prevent foot ulcers and are a recommended approach both in Sweden and worldwide. Despite existing guidelines, there are differences in the execution of the foot examination, which results in care inequality. A structured foot examination form based on current guidelines was developed in this study as the first step toward digitalized support in the daily routine, and was validated by diabetes health care professionals.

Objective: The study aimed to validate a structured foot examination form by assessing health care professionals' experiences of working with it "foot side" when examining patients with diabetes.

Methods: Semistructured interviews were held in a focus group and individually with 8 informants from different diabetes professions, who were interviewed regarding their experiences of working with the form in clinical practice. The users' data were analyzed inductively using qualitative content analysis. The study is part of a larger project entitled "Optimised care of persons with diabetes and foot complications," with Västra Götaland Region as the responsible health care authority, where the results will be further developed.

Results: Experiences of working with the form were that it simplified the foot examination by giving it an overview and a clear structure. Using the form made differences in work routines between individuals apparent. It was believed that implementing the form routinely would contribute to a more uniform execution. When patients had foot ulcers, the risk categories (established in guidelines) were perceived as contradictory. For example, there was uncertainty about the definition of chronic ulcers and callosities. The expectations were that the future digital format would simplify documentation and elucidate the foot examination, as well as contribute to the accessibility of updated and relevant data for all individuals concerned.

Conclusions: The foot examination form works well as a support tool during preventive foot examination, creates a basis for decision-making, and could contribute to a uniform and safer foot examination with more care equality in agreement with current guidelines.

Trial Registration: ClinicalTrials.gov NCT05692778; https://clinicaltrials.gov/ct2/show/NCT05692778

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(JMIR Nursing 2023;6:e45501) doi:10.2196/45501

KEYWORDS

diabetes; foot ulcer; prevention; primary health care; qualitative research; structured foot examination; validation; user experiences; participatory design

Introduction

General Background

Among persons living with diabetes, it is estimated that 5% have a foot ulcer [1-5]. This means that 23 million persons (5% of 537 million people with diabetes) at the global level [6] and 25,000 persons in Sweden have a diabetic foot ulcer (DFU) [7]. A large increase in people diagnosed with diabetes (increase to 783 million people) is expected by 2045 [6].

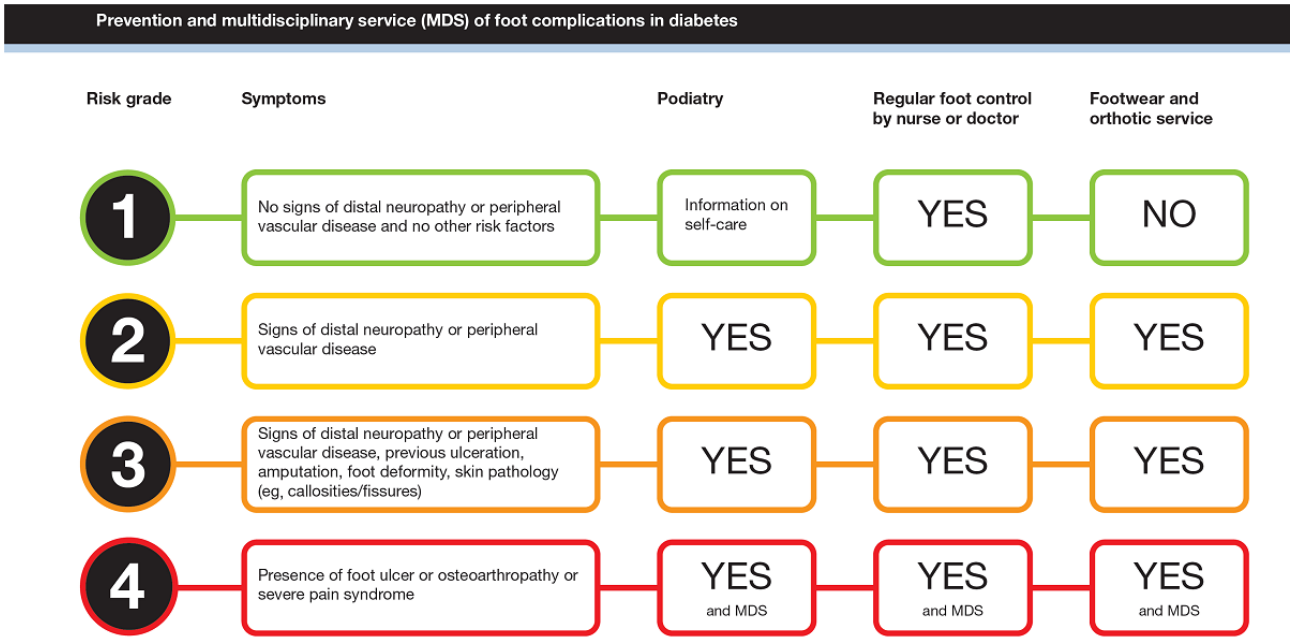
Groups with a low socioeconomic status have an increased risk of DFU, and men are more frequently affected [8-10]. A delay in detecting persons at risk of developing a DFU and a delay in access to treatment increase the risk of further complications, such as severe infections, leading to amputations [11].

The consequences of delayed treatment and a lack of foot screening are important for the individual and society. The quality of life of the individual is reduced in the presence of a DFU, and the costs are considerable [12-16]. The structure of health care differs between countries, as does the pathway toward prevention, and as a result, the treatment costs for DFUs vary among high-, middle-, and low-income countries [17]. Nevertheless, the impact on individuals in terms of their psychological well-being and their private economy is significant. The impact varies depending on the organization of health care in each country. In Sweden, health care is financed by taxes, and the 21 independent regions are responsible for delivering equal care of a high standard [18].

With effective prevention and structured processes among primary care, specialist care, and municipal care, DFUs can be successfully prevented [19-23]. Of the 500,000 persons with diabetes in Sweden, the majority are treated in primary care [7]. Promising examples show that, by using a structured standardized routine for foot assessment and risk stratification, greater quality of care is achieved [24,25]. In contrast, the lack of a structured foot assessment might lead to subjective risk stratification and inappropriate or nonactive consequences [26,27].

National and international guidelines recommend that an annual foot examination should be offered to all patients with diabetes [28-30]. However, figures from the Swedish Diabetes Register show that the feet of 25% of people with diabetes were not examined in 2022 [31]. Traditionally, in Sweden, patients' feet are examined at the same time as the annual diabetes examination in primary health care or at a clinic of medicine in specialist care. The examiner could be a physician, nurse, or podiatrist. After the examination is completed, the health care professional (HCP) should register in the Swedish Diabetes Register (1) that the person has undergone examination of the feet and (2) the risk grade of the person from 1 to 4 (1 [no risk of developing a DFU] to 4 [ongoing DFU]), with subsequent actions based on the risk category (Figure 1) [28]. The risk grade is based on findings of peripheral neuropathy, for example, identified with a monofilament test or the Ipswich Touch Test [32]; peripheral angiopathy; foot deformities; skin pathologies; foot ulcers; and previous foot ulcers/amputations [29].

Figure 1. A scheme of the risk categories, symptoms, and recommended actions to prevent diabetic foot ulcers according to the national guidelines. MDS: multidisciplinary service.



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Study Background

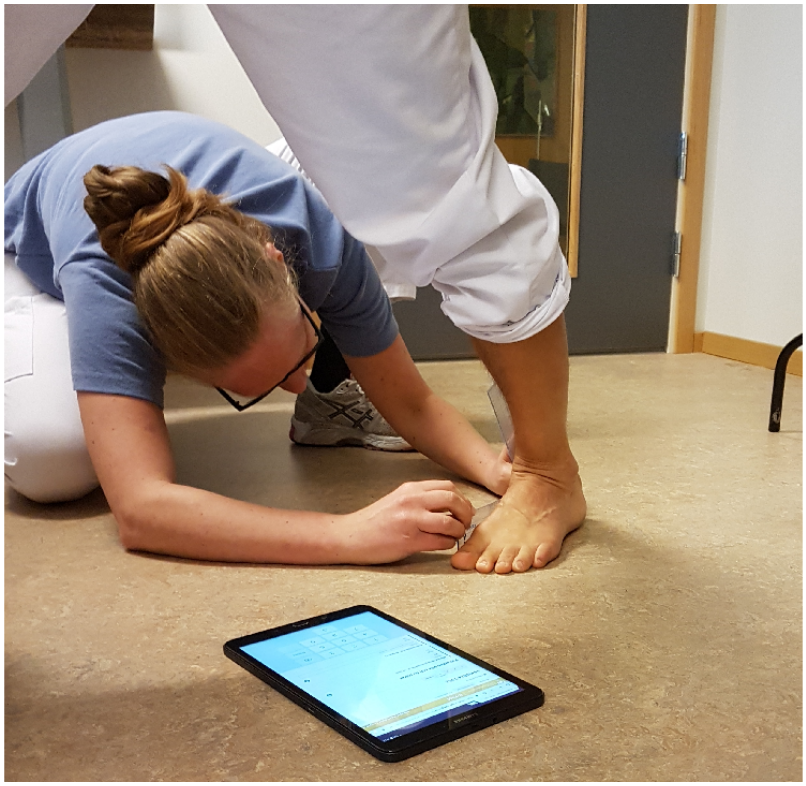
Patient representatives and HCPs found it necessary to improve the routine of the annual foot examinations for persons living with diabetes in Västra Götaland Region (VGR), with the aim of enabling all patients with diabetes to have their feet examined in *a structured uniform manner*. As a result, a novel structured routine in paper format, a paper form, was developed and tested by persons with special competence in the area (Multimedia Appendix 1). This paper form was suggested as an initial tool to help HCPs perform annual foot examinations, as recommended in national guidelines [28]. Adhering to participatory design (PD) principles, the research team was aware that the focus of PD is not only the improvement of the information system but also the empowerment of workers, so they can co-determine the development of the information system and their workplace [33]. For this reason, before the form is designed for creating an existing or future clinical decision support system (CDSS), it needs to be validated by real users, that is, the HCPs performing the actual foot examinations in primary care.

In a previous project in the same region, VGR, a pilot test of a digital prototype was performed by a certified orthotist and prosthetists. It was shown that, by using a structured eHealth solution, the foot assessment and the subsequent automatically generated risk category produced a reliable uniform assessment, thereby facilitating documentation [26].

Study Aim

Eliciting future users' real experiences is crucial in user-centered design (ISO 9241-210:2019) [34]. User experiences are differentiated from opinions, which could be held by designers, managers, or other secondary stakeholders of a system, as well as future users of that system. User experience is defined as "users' perceptions and responses, including the users' emotions, beliefs, preferences, perceptions, comfort, behaviors, and accomplishments, that occur before, during, and after use," and it is related to "the context of use" [34]. Here, the context of use often means *on the floor*, close to a sitting patient, where the HCP examines the feet using various techniques and tools (Figure 2). It is therefore important to validate not only the information in the new tool but also the fact that novel tools can actually succeed in the clinical work situation of an HCP. To prepare for a digitally supported routine of a structured foot examination in an annual foot assessment, the structured routine was validated by real users, that is, HCPs in daily practice, performing daily work tasks on the floor. This study aimed to describe HCPs' experiences of a novel structured foot examination form on paper (Multimedia Appendix 1) when performing annual foot assessments in patients with diabetes.

Figure 2. A health care professional measuring the passive range of motion at the ankle joint by using a goniometer close to the patient. The findings of the foot examination are registered on a tablet following a structured foot examination.



Methods

Design

The study is part of a larger regional project designed to optimize the care of persons with diabetes and foot complications. In this study, a qualitative descriptive approach was used to sum up the empirical data inductively in order to produce a common understanding that relates to general conditions within this context.

Context

The study took place in 5 primary health care centers and 3 hospital care centers located in southwestern Sweden. To

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optimize a digital routine, the form in a paper routine (referred to as "form") was used and tested by professional caregivers (Multimedia Appendix 1). The participants in the study were HCPs who usually examine the feet of individuals with diabetes, and they were strategically invited to test a form for annual foot examination. A total of 16 HCPs were asked to participate. Among these HCPs, 12 registered an interest in participating in the project and 8 were finally included. Three declined when asked to participate in the interview study and 1 person did not respond. Among the 8 participants, 3 were district nurses/specialist diabetes nurses, 3 were podiatrists, and 1 was a physician. The dropout resulted in a lack of nurses working in municipal care.

Data Collection

Semistructured interviews were held in March 2021 with 2 focus groups and 2 individual interviews including 8 respondents from different professions within diabetes care (Table 1).

The respondents were interviewed about their experience of examining the feet of patients with diabetes according to the new form (Multimedia Appendix 1). The respondents had each used the form on at least five patient visits. The interviews took place digitally where the interviewers and respondents could see and hear each other during the interviews, apart from one individual interview where only sound was recorded. The interviews lasted between 30 and 90 minutes, and were recorded digitally, listened to several times, and transcribed verbatim by 2 authors (UN and MV). Open-ended questions regarding the experiences of working with the form in clinical practice were addressed and a semistructured interview guide was used (see examples in Multimedia Appendix 2). The opening question was "How comfortable do you feel about using the paper form in routine work?" Examples of other questions were "What were your expectations of the effectiveness of the form?" "What were your expectations of the degree of effort?" "How well does the form correspond to the expectations/help you to achieve the goal of the foot examination?" and "What is important to you?" (for further questions, see Multimedia Appendix 2). The interview guide ensured that a certain area of questioning was covered [35].

Table 1. Participants' profession, context, and experience of diabetes care.

Participant	Profession	Context	Experience of diabetes care (years)
A	Nurse with an additional course in diabetes	Primary health care	1
B	District nurse/specialist diabetes nurse	Primary health care	1
C	District nurse/specialist diabetes nurse	Primary health care	7
D	District nurse/specialist diabetes nurse	Primary health care	17
E	Physician, internal medicine	Hospital care	15
F	Podiatrist	Primary health care	20
G	Podiatrist	Hospital care	20
H	Podiatrist	Hospital care	11

Data Analysis

The qualitative research tradition is based on an effort to develop an understanding of the human lived experience. Qualitative content analysis, as described by Graneheim and Lundman [26], was considered appropriate in order inductively to focus on and describe experiences and variations on an individual level and to identify differences and similarities on a manifest and latent level. The analysis was conducted in several steps. First, all the data were read several times to ensure immersion in the data. All interview text was regarded as a unit of analysis. The text was then divided into "meaning units" that corresponded to the aim of the study. Each meaning unit was condensed and labeled with a code. Codes are described as concrete and as close to the text as possible [36]. During this process, the authors (SA, UN, and MV) continuously returned to the original text to ensure that the core meaning of the meaning units was maintained. Similar codes were later grouped into subcategories, and sorted and abstracted into higher categories (Table 2).

Finally, the latent interpretative analysis was described as the main theme with a higher level of interpretation and abstraction.

A continuous verification of the interpretation was an ongoing process during the search for coherence among the different parts of the analysis. To ensure trustworthiness, there was an awareness of and an openness toward misunderstandings resulting from the interviewer's own preunderstanding. To avoid misunderstandings, the data were first analyzed individually and later compared by 3 researchers.

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Table 2. Analysis process example.

Meaning unit	Condensed meaning unit	Code	Subtheme	Theme
The expectations are...it should be a form that covers the area of feet and diabetes...can be read regardless of who has filled it in so you get an overview.	Easy form that completely covers the area relating to the feet, regardless of who fills in the form.	Easy form, covering the area relating to the feet in full.	The structure is clear and comprehensive.	Structured support
When I received the form, there was a lot of text to take in/…then I realized that we do these surveys, or have always done them during an annual check-up.	Lots of text to absorb, then I realized that we have always done it.	We have always done it.	This is what we are already doing, with some new elements.	Structured support
That we all do the same thing is very good both for us, if we take over other patients, or when the doctor conducts the annual check-up, so that they see exactly what it is we have assessed and looked at.	That we all do the same thing is good when we take over each other's patients so they see what it is we have assessed.	Everyone makes the same assessment.	Support for a standardized survey.	Structured support

Ethical Considerations

The study was approved by the Swedish Ethical Review Authority (diary number: 2020-02715 and 2020-05131) and was conducted according to the ethical principles described in the Helsinki Declaration [37]. All participants were informed, both verbally and in writing, about the study before obtaining their written informed consent. The participants were ensured confidentiality and were free to withdraw at any time. The transcripts were anonymized and given a letter (A-H), which was subsequently used in the analysis. The possible harm caused by the study was evaluated against the benefits. The participants were informed that any concerns could be clarified by contacting the authors. No such concerns were raised.

Results

Support of Professional Judgement

The results at the highest level showed that the participants felt that the theoretical support provided by the form was needed (Multimedia Appendix 1), but it also had to be verified by the HCP's judgement, experience, and knowledge, which was reflected in the practical implementation. The main theme was "structure and documentation as a support for professional judgement" (Table 3). Three themes were identified: (1) structured support, (2) professional evaluation is needed, and (3) documentation that simplifies and makes visible, referring to both patients and their feet. Multimedia Appendix 3 presents some examples of expressions that are cited in this study in Swedish and English.

Table 3. The subthemes, theme, and main theme emerging from the analysis.

Subthemes	Theme	Main theme
• This is what we are already doing, with some new elements • The structure is clear and comprehensive • Support for a standardized survey	Structured support	Structure and documentation as a support for professional judgement
• Risk rating simple – contradictory • Some steps may be evaluated	Professional evaluation is needed	Structure and documentation as a support for professional judgement
• The form makes the feet visible • Facilitating documentation provides time for the patient meeting • Easier with a digital format	Documentation that simplifies and makes visible	Structure and documentation as a support for professional judgement

Structured Support

The theme of structured support included the respondents' experience of the structured foot examination protocol and that it offered structure, clarity, and support in performing foot examinations.

This is What We are Already Doing, With Some New Elements

Initially, the form was perceived as rich in text, which required limited reading before the HCPs felt familiar with the structure. After practicing it in several examinations, they said that they learned the structure. New routines always require a period of practice, as it is a new way of doing things. One respondent commented:

> *The very first time, I was like this, wow! What shall I do? There is so much text before you get into what it really said.* [Respondent D]

The informative text, which was first perceived as compact, became helpful and supportive. The respondents said that the form was effective and useful as a basis for the annual foot examination after a running-in period.

The results showed that the steps and parts included in the form were largely familiar, were well known, and had already been

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performed every year in previous foot examinations. The form covered what was perceived as important, the very essence of the foot examination, according to existing guidelines. Respondent D commented, “This is definitely back to basics.” Although the form contained much that was familiar, the examination with the Ipswich Touch Test was new [32]. However, as the test was used with the structured examination, it was perceived as a simple useful test.

The Structure is Clear and Comprehensive

The form enabled an overview of the feet and was experienced as a supportive and comprehensive guide for the foot examination. The content was divided in a clear distinct way and could be read by everyone, which increased the common understanding between the different caregivers. They said that the form contributed to an evidence-based foot examination. Respondent A commented, “So I think it’s very clear and very good, because it’s safe.” The 3 areas of the structured foot protocol were described as being composed in a structured and appropriate manner.

> *It is structured in such a way that there are three parts, inspect and examine, palpate and examine and symptoms and previous ulcers. It is a very good and very logical division based on the different parts.* [Respondent F]

The experience of the form was that it was easy to use and follow, and it was a well-functioning basis for the preventive foot examination and an aid for those who worked in primary care and in specialist care. It was also described as something that could easily be used in daily patient work. The structured form was clearly designed and described as user friendly. The proposals for action on the back of the form were described as clear and good (Multimedia Appendix 1).

Support for a Standardized Survey

The form could be a support for examining feet for both beginners and those who are more experienced. It served as a support and provided new knowledge about the foot examination and subsequent measures for those who used the data. Even for experienced professionals, it could be useful as a basis for decision-making and documentation.

> *Sometimes I think things have been a bit fluid at the health center, that they have sensory impairments, but they do, so it was not clear what I would do when I found this. So I thought it would be nice to get a little more knowledge about foot examinations.* [Respondent A]

Although the form provided support for the implementation of the foot examination in various ways, there was also experience that the form was not needed as support. This was related to the fact that the participants already had a good structure to follow and had extensive experience in the field.

> *You check it anyway, so, for my part, I don’t think I need to have something like this to do the job I do now.* [Respondent H]

The use of the form highlighted the fact that foot examinations were performed in different ways by different HCPs at the same unit. Having a form to follow could contribute to the standardization of the foot examination. One respondent commented:

> *We realized quite quickly that everyone does things very differently and everyone has learned differently, too, so that you then have some form of action, that everyone does the same thing, which can be good.* [Respondent A]

After the introduction of the form, collaboration between colleagues was facilitated. The form was stated to structure and align the foot examination, which was thought to be able to lead to more equal care regarding the prevention of foot complications. This meant that the form was seen as useful and adequate in the work on foot examinations in patients with diabetes.

Professional Evaluation is Needed

The theme includes the need for professional judgement to evaluate certain aspects of the foot examination. Judgement was needed whenever the form was used, from the interpretation of the risk categories and different concepts to the actual conduct of the examination.

Risk Rating Simple – Contradictory

The experience of grading in the form was that it was confusing at first, but it became easier after conducting some surveys. There was some difficulty owing to contradictory risk categories, as foot ulcers could be classified as risk category 4, and subsequently, the patient might have risk category 1, which indicates a healthy foot.

> *It’s as though you are talking against yourself when you put a four, because it is such a high degree of risk and then you have to put a risk category, 1-4 to the right there for the others and we didn’t think that was easiest approach. Then, all of a sudden, you write that it is a healthy foot.* [Respondent G]

Although it was always the highest figure that gave the final risk category, the grading involving assessment points was illogical and contradictory, which made the grading itself difficult to understand, but it was otherwise easy to follow the form.

> *That was what we brought up, it was the grading that was a bit strange, so that’s it. Otherwise it’s not that strange, it’s just reading.* [Respondent H]

It was said that a healthy foot does not involve any risk and thus should be classified as risk category 0 and not risk category 1, but this was not perceived as an obstacle to continued use, because the participants quickly changed their minds and accepted risk category 1 as the lowest risk. After all, the HCP was the one who filled in the highest risk category in the summary box, which was identified during the examination.

The form simplified the documentation because the user could just tick and get a number for the risk category, instead of writing everything from the foot examination in free text as before. The number system for risk category (Figure 1) was said to be simple and good, with figures that corresponded to the various risks in a fair way. A number system, defining the

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risk categories, could also make the assessment clearer and could be reproduced in a simple way from one examination to another.

Some aspects were clinically difficult to assess, such as what was considered hardening skin (calluses), an ulcer that was difficult to heal, or reduced hair growth. The definitions for hardening skin and healing ulcers, and how medical records and patient narratives could be used to assess previous ulcers and reduced hair growth were discussed. The idea was raised that it might be valuable to line up ulcers of different types in categories. Ulcers were identified as serious, and it was therefore good that this was first on the form.

Some Steps May Be Evaluated

Professional judgement is used in different ways and in different parts. There was difficulty conducting the examination in some patients with dementia, for example, and uncertainty about whether the patients understood the given information and provided correct information regarding symptoms, especially emotional disorders. At the same time, the experience was that these difficulties have always existed and that you then had to do your best and make a professional assessment or estimate, but that the form still worked well in most cases.

> *No, I think that the form feels, as I see it anyway, completely correct, because, no matter how I say this, I have worked with … all the time and these difficulties with precisely these patient categories have existed all the time, so it's nothing new, but you have to find a way to move forwards in some way. I'm just mentioning it as an observation.* [Respondent B]

The respondents' experiences were that it could be difficult for patients to distinguish between the middle toes on the Ipswich Touch Test and that the test should not be performed too quickly, because the patient then would not have time to understand which toe was affected. During the study, some respondents made comparisons of different instruments to assess neuropathy to see if there was any difference in the assessment, for example, monofilament and the Ipswich Touch Test, but the conclusion was that the result was usually the same. A biothesiometer, an old instrument for measuring sensation, was used by some professionals before the Ipswich Touch Test. After a comparison, the respondents said that there was a difference in assessment between the Ipswich Touch Test, a tuning fork, and the biothesiometer, as they showed different results regarding the sensation in the foot.

Documentation That Simplifies and Makes Visible

The theme includes the structured form being perceived as making visible and clarifying the importance of foot examinations for both the patient and HCP, and the documentation needing to be facilitated and made visible, with the hope of simplification in the future digital format.

The Form Makes the Feet Visible

During the foot examination, the respondents talked about the feet, and explained what they did, why self-care was important, and what patients could do themselves. The structure of the form helped to focus on the feet, highlighting existing guidelines. In this way, it served as an educational tool during the foot examination.

> *… these guidelines have been around all the time I have been working, I can say, and the latest, they are here and they say exactly the same thing, being able clearly to show the patient what the criteria were for medical foot care was described as important, so that it would not be interpreted as meaning that the assessment was arbitrary, as many patients wanted to receive foot care even though they did not meet the criteria, as it says on this form that we have here now, so I think by far the best thing is that it is noticed. That's what happens, it is, made visible.* [Respondent B]

Self-care was described as being of great importance and an obvious part of the conversations with the patients, and the form could be a way of making visible the importance of self-care to prevent foot complications. Brochures or written advice on self-care were often distributed before, and written information in the form of a self-care brochure was seen as a good tool, provided that the patient had an interest.

What the guidelines were for foot examinations and what examinations were made during the visit were also made visible to other care providers and to the patient. The criteria for medical foot care, for example, were also made visible, and the form could be shown to justify why a referral was or was not written.

Being able to clearly show the patient what the criteria were for medical foot care was described as important, so that the assessment would not be interpreted as arbitrary, as many patients wanted to receive foot care, even though they did not meet the criteria.

> *If you have good sensation, then you can say it, but it's great that you still have good sensation so that you don't need medical foot care, you can show it and vice versa, if they really have reduced sensation and therefore need a referral to foot care, so that's good.* [Respondent E]

From a resource point of view, it was said to be impossible for everyone who wanted medical foot care to receive it. It was therefore important that the referrals were demand driven and based on clear criteria.

Facilitating Documentation Provides Time for the Patient Meeting

The form was filled in during the visit or close to it. The experience was that the documentation was extensive, but adjustments were made so as not to disrupt the meeting and contact with the patient. One example was to write words of support on the form during the visit or after the examination, so the HCP could dedicate time to the patient, be present, and have eye contact. Documentation in the medical record was sometimes started during the visit due to lack of time, but this usually happened after the visit.

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> *I document when I have the patient with me. I also have a piece of paper next to it where I also write some notes, because you want to have eye contact with the patient so that you have a dialogue. I do that…* [Respondent C]

Often, some own words were needed in addition to the form in order to remember and compare the foot status from time to time. This facilitated the memory image of the patient. It was very important for the form to facilitate documentation and not the other way around. The documentation must be effective and be made quickly.

> *So I feel that it is very important that the form is as easy to fill in as possible and that it is still as comprehensive regarding the foot, but it can be filled in quickly because you spend a lot of time on documentation.* [respondent E]

More time with the patient was important for a good meeting. A good form was therefore considered to be one that is comprehensive but at the same time flexible and easy to use, where the HCP does not have to write a lot.

> *Many patients are actually looking forward to this meeting and it's important that it's a good meeting and that the documentation can perhaps be straightforward.* [Respondent E]

Easier With a Digital Format

The results of this study include the evaluation of a form that can be implemented in a digital format. A request was made for the risk degree, risk category, and measures to automatically emerge when the assessment is made. It was also suggested that the mouse pointer could be placed at a certain point where it is possible to obtain more informative text, if necessary, to facilitate the overview, so that there would not be too much text in the form itself.

> *I have thought about it a bit and I wonder whether there shouldn't be some kind of combi box, i.e. that you are able to choose alternatives that then fall into risk category one, two, three and four and if there are then measures that pop up automatically.* [Respondent C]

There were also suggestions that it would be easier with a digital format because the respondents wanted to avoid the double documentation that is thought to take place at present.

> *As it is now, we have paper when we do it and then we put it in the medical record. We do things twice now and, if it is possible to deal with everything once, it would be easier.* [Respondent G]

The form was perceived as a uniform assessment with everyone working in the same way. In the future digital format, expectations were expressed that increased collaboration would be possible between different care units, regardless of care organization; between colleagues; and between different staff categories in order to achieve a higher quality of care.

Discussion

Principal Findings

According to the respondents, there were expected results, as well as some unexpected findings. First, the most important finding was that adherence to clinical guidelines was facilitated using the form. Similar experiences were expressed by both experienced professionals and those with less experience. Second, when evaluating the risk of developing DFUs, professional judgement was emphasized by the respondents. Just filling in a paper form does not improve the quality of care, as stated by the respondents. Judgement was needed throughout the use of the form, from the interpretation of the risk categories and the different contexts to the actual conduct of the examination, as well as when dealing with follow-up actions. However, the form provided the necessary structure and support in the decision-making process.

By using the form, the respondents also found that they had a new educational tool in their hands. The form could be used as an incentive, for example, to clarify the different parts of the foot examination for the patient and why these parts were checked, and as a result, it became an educational tool. One unexpected finding was that the respondents stated that it felt natural to use the form to initiate conversations about self-care, medical foot care, any need for insoles, and advice on choosing shoes. By creating processes that lead to the patient becoming involved, the potential for autonomy and self-determination also increases for the patient [38]. The form thus strengthens the patient's participation and partnership, in line with person-centered care [39] and the theories of shared decision-making [40] and self-determination [41].

As part of the completed foot examination, the respondents also found that time to form a professional judgement was required to evaluate the results based on each person's needs and to connect the results to the next activity in the care plan.

Evaluation of Outcomes

After using and validating the form according to current work practices, some expected results were obtained, for example, the structure helped to perform the examination and the form also required professional judgement to be taken into account when formulating the individual results and needs into recommendations and further steps in the care plan. The respondents were surprised that the form was also suitable as an educational support tool when discussing self-care with the patient. This is often the case, and positive side effects like this emerge when users are allowed to handle novel tools or prototypes in their real work setting or in a user situation [42]. It is crucial for users to be involved at an early stage in the design process [34]. From the point of view of the PD method used, we could also see that these unexpected findings could be the subject of future studies and included in the design of the next stage of digital CDSS development.

Involving a user-centered design process, this study followed the basic steps where an early design should be tested in a realistic setting, even before software is developed. Previous research on the process of user needs and context requirement

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gathering reminds us that "actual requirements pre-exist our effort to capture them" [43]. This means that, as developers, designers, researchers, and other work process experts, we must be careful not to create requirements that fulfill only our own technical or organizational desires. This concept is particularly important in domains where users are less familiar with digital tools [44]. To resolve this issue, the validation process used in this study aimed to emphasize real needs, as expressed by real users. An understanding close to "best practice" will enable us to design and develop a digital tool and simultaneously assist in structuring and enhancing the work process of HCPs managing patients with diabetes. Moreover, the results here will generate a detailed context of use analysis, based on the experiences of real future users, which in turn will result in a shorter and less expensive development phase. For future iterations, the respondents who were active in this study have already volunteered for further work, knowing that their points of view will be included. Another strength here is that the validation was carried out by HCPs with both long-term and short-term experiences of foot examinations, who had different professions and worked at different care units (both primary care and regional care).

Limitations

A qualitative method always involves subjectivity, as the researcher is part of the research. By being aware of one's own preunderstanding, this issue can be managed throughout the process. During the analysis, a continuous dialog took place and a broader understanding was created to achieve a reliable result [45].

The dropout of 4 participants meant that no individual from municipal care participated. Thus, the transferability of the study results might not apply to all forms of care. One weakness of the study was that the use of the form was not very high, but the data that emerged during the interviews were perceived to be rich and to have a high degree of validity.

Comparison With Prior Work

In line with previous studies, this study provided promising examples that the use of structured standardized routines for foot assessment and risk stratification can lead to higher quality of care [24,25]. The informants in this study stated that a structured routine would enhance care. Higher care quality for patients with diabetes and reduced health care costs are expected [13,46] after the early detection of risk factors, followed by rapid prevention, including a dialog on self-care, a referral to podiatry, and a referral for therapeutic footwear. Overall, the prevention of DFUs will preserve the quality of life of patients [24,25].

Conclusions

The foot examination form works well as a support tool during a preventive foot examination. It offers a basis for decision-making and could contribute to a uniform safer foot examination with more care equality, which is consistent with current national guidelines. The form may need to be supplemented with functionality to increase usability in connection with foot examinations, that is, printing and handing over personally adapted self-care advice based on the results of the foot examination. All the respondents appreciated participation in the validation of a digital tool for enhancing their daily routine.

Acknowledgments

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Authors' Contributions

SA designed the study, performed the analyses, interpreted the results, and contributed to writing the manuscript. IS designed the study, interpreted the results, and contributed to writing the manuscript. UHT designed the study, interpreted the results, and contributed to writing the manuscript. All the authors read and approved the final manuscript. UN and MV designed the study, performed the analyses, interpreted the results, and contributed to writing the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
The structured foot examination in paper format.
[PDF File (Adobe PDF File), 256 KB - nursing_v6i1e45501_app1.pdf]

Multimedia Appendix 2
Interview guide.
[PDF File (Adobe PDF File), 74 KB - nursing_v6i1e45501_app2.pdf]

Multimedia Appendix 3
Examples of expressions that are cited in the current manuscript in Swedish and English.
[PDF File (Adobe PDF File), 192 KB - nursing_v6i1e45501_app3.pdf]

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Abbreviations

CDSS: clinical decision support system
DFU: diabetic foot ulcer
HCP: health care professional
PD: participatory design

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VGR: Västra Götaland Region

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Original Paper

Home Health Care Clinicians' Use of Judgment Language for Black and Hispanic Patients: Natural Language Processing Study

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Abstract

Background: A clinician's biased behavior toward patients can affect the quality of care. Recent literature reviews report on widespread implicit biases among clinicians. Although emerging studies in hospital settings show racial biases in the language used in clinical documentation within electronic health records, no studies have yet investigated the extent of judgment language in home health care.

Objective: We aimed to examine racial differences in judgment language use and the relationship between judgment language use and the amount of time clinicians spent on home visits as a reflection of care quality in home health care.

Methods: This study is a retrospective observational cohort study. Study data were extracted from a large urban home health care organization in the Northeastern United States. Study data set included patients (N=45,384) who received home health care services between January 1 and December 31, 2019. The study applied a natural language processing algorithm to automatically detect the language of judgment in clinical notes.

Results: The use of judgment language was observed in 38% (n=17,141) of the patients. The highest use of judgment language was found in Hispanic (7,167/66,282, 10.8% of all clinical notes), followed by Black (7,010/65,628, 10.7%), White (10,206/107,626, 9.5%), and Asian (1,756/22,548, 7.8%) patients. Black and Hispanic patients were 14% more likely to have notes with judgment language than White patients. The length of a home health care visit was reduced by 21 minutes when judgment language was used.

Conclusions: Racial differences were identified in judgment language use. When judgment language is used, clinicians spend less time at patients' homes. Because the language clinicians use in documentation is associated with the time spent providing care, further research is needed to study the impact of using judgment language on quality of home health care. Policy, education, and clinical practice improvements are needed to address the biases behind judgment language.

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KEYWORDS

stigmatizing language; judgment language; health disparity; natural language processing; home health care; nursing informatics; racial biases; language barrier; cohort study; racial difference

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Introduction

Home health care is one of the fastest-growing outpatient settings in the United States, where about 200,000 clinicians (including registered nurses, physical or occupational therapists, and social workers) treat more than 5 million patients annually [1,2]. During home health care, clinicians treat patients' conditions (eg, wounds), provide health promotion interventions (eg, self-management education), and assist with medication management and reconciliation [3]. About 25% of home health care patients represent a racial and ethnic minority population (eg, Latinx and Black patients), which is higher than the number of minority patient populations in other outpatient settings [1].

Although quality of care is affected by numerous factors (eg, structural resources, levels of clinician education, and patient-per-clinician-ratios) [4-6], a clinician's biased behavior toward patients (such as evaluating one group and its members negatively relative to another) can affect the quality of care [7]. Recent literature reviews [8-10] report on widespread implicit biases among clinicians. For example, a recent review of 215 studies [11] showed that, most commonly, nurses exhibit biases in the area of race and ethnicity. These biases affect clinicians' behaviors and care decisions regarding their patients, affecting patient adherence and outcomes [12-14].

In home health care, health disparities are well documented, with Black and Hispanic patients receiving a lower quality of care [15-18] and having worse outcomes (eg, higher hospitalization rates) [19-23] compared to White patients. In light of growing recognition of the effects of racism on health disparities and inequities, reducing racial biases has become a key priority for many health care organizations around the United States [24-26].

Emerging studies in hospital settings show racial biases in the language used in clinical documentation within electronic health records. Specifically, several recent studies [27-29] used natural language processing (a computer science–based method that can help extract meaning from a large corpus of text) to search for instances of stigmatizing language and then compared the prevalence of stigmatizing language by race and ethnicity. A specific example of stigmatizing language is judgment language, conveying disbelief in patients' statements [27-29]. Other examples include using negative descriptors when referring to marginalized patients [27-29]. These recent studies found that clinical notes written about Black patients had 25%-50% higher odds of containing stigmatizing language than the notes written about White patients [27-29]. Some studies have also started to explore associations between stigmatizing language and quality of care. For example, a recent study showed that exposure to stigmatizing language in clinical notes is associated with more negative attitudes toward the patient and less aggressive management of the patient's pain [30].

Of note, stigmatizing language was reported to also be more frequent in the documentation of patients with substance use disorder and certain chronic conditions (eg, diabetes) [29]. Other potential factors that can affect clinical documentation quality and the use of specific language include the patient's culture (eg, Asian) [31], age [32], and clinical complexity [29]. This study focuses on associations between stigmatizing language and race and ethnicity in clinical documentation.

Our extensive literature search identified no studies investigating the extent of stigmatizing language in home health care. To bridge the gaps in the literature, this study aimed to understand how stigmatizing language might manifest in home health care electronic health records and whether the presence of stigmatizing language might be associated with quality of care. First, we developed a natural language processing system to detect the presence of a specific type of stigmatizing language—judgment language—in home health care clinical notes and explore racial differences in using such language in a racially diverse patient sample. Second, we explore the association between the use of judgment language and time spent by home health care clinicians in a patient's home as a reflection of care quality.

Methods

Study Setting

We used data extracted from a large urban home health care organization in Northeastern United States. The home health care agency provides skilled home health care services, including nursing, physical and occupational therapy, and social work.

Ethics Approval

The study was approved by the institutional review board of the participating organization, VNS Health (IRB I22-001).

Study Data Set

This study examined data collected during routine home health care services between January 1 and December 31, 2019. All data were extracted from the home health care agency's electronic health record system. The data included the patient's sociodemographic information, specifically the patient's gender and race or ethnicity, collected using a federally mandated assessment data set called the "Outcome and Assessment Information Set" (OASIS) that captures race or ethnicity with the following categories: Asian, White, Black, Hispanic, and other (eg, Native Hawaiian or Pacific Islander). Since only a small number of patients identified as "other" race or ethnicity, we removed this group from this analysis. Although the OASIS allows for multiselect in race and ethnicity, to establish mutually exclusive groups, if Hispanic was one of the selections, then the individual was categorized in the Hispanic group. In addition, we extracted narrative clinical notes, clinician information (ie, clinician author ID for each narrative note), and the length of time spent by a clinician in the patient's home (in minutes). Home health care clinicians in this study included nurses, physical or occupational therapists, and social workers.

Narrative notes were visit notes that home health care clinicians used to document the patient's symptoms and health care inventions that occurred during home visits. Overall, we extracted 264,146 visit notes documented for 45,384 patients, with an average of 6 visit notes per patient. Visit note average length was 298 characters, corresponding to about 4-6 sentences.

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Language Suggesting Judgment of Patients

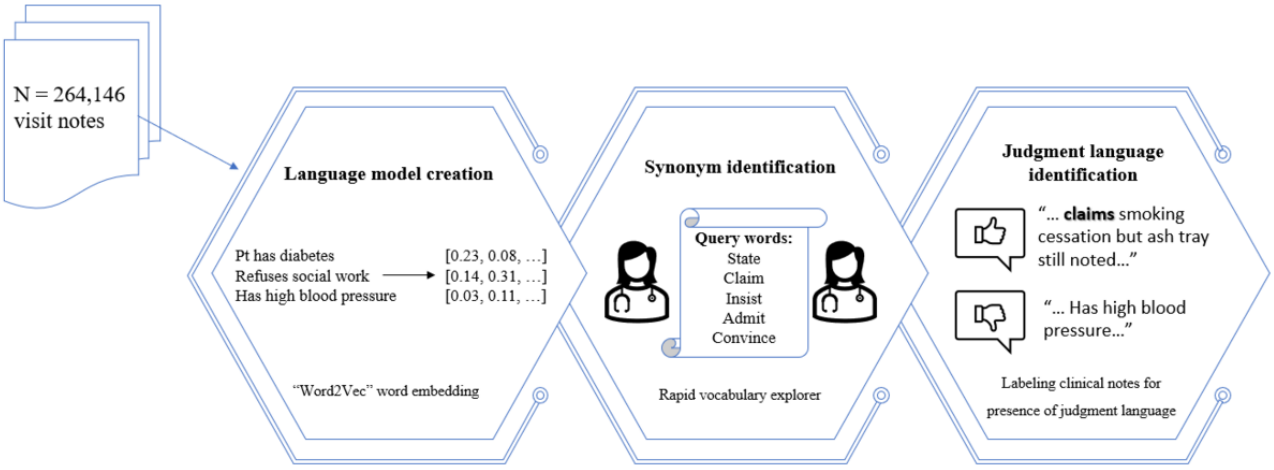
Based on previous literature [27,28], we identified a specific type of language that potentially suggests judgment of patients—"judgment words." Judgment words allow the speaker to distance themselves from the source of knowledge and directly question the speaker's credibility. The initial list of judgment words was extracted from previous literature and included the following terms: "adamant," "apparently," "claims," "insists," and "states" [27].

In previous work [27], the use of quotes was also found to indicate judgment of patient's claims; for example, "the patient reports she had a 'reaction' to the medication." However, in home health care clinical notes, we found that clinicians use quotes very infrequently. Hence, we decided to omit this category from the analysis.

Natural Language Processing System Development

We used our previously developed and validated open-source natural language processing system, NimbleMiner [33,34], to expand the initial vocabularies of evidential and judgment words. Specifically, NimbleMiner was implemented in 3 steps that are briefly described below and captured in Figure 1 (a complete software architecture description is available elsewhere [33,34]).

Figure 1. A diagram of the development of a natural language processing system. Pt: patient.



Step 1: Language Model Creation

Language models are numerical representations of semantic and lexical associations between words and expressions in large bodies of text. We generated a language model (word embedding model called word2vec) [35] using all home health care clinical notes available in our sample (N=264,146 visit notes).

Step 2: Synonym Identification

Using NimbleMiner's "Rapid vocabulary explorer" module, we queried the language model for synonyms and other lexical variants (eg, misspellings) of terms that indicate judgment language. For example, querying the language model for synonyms of the word "claims" results in the system presenting to the user a list of potentially similar terms, including synonyms such as "admits" and misspellings such as "claimes." Two home health care experts conducted language model queries independently, and their synonym lists were merged and finalized by the study team via discussion.

Step 3: Automated Identification of Judgment Language in Clinical Notes

We searched all clinical notes for terms identified in step 2. At this step, we also modified the software to exclude irrelevant and negated terms from the set of clinical notes with positive matches. For example, we excluded clinical notes that included irrelevant expressions such as "vn [visiting nurse] convinced pt [patient]," "cardiologist stated," and "primary care insisted." Such language was excluded since the focus of this study was on expressions that clinicians use to describe the patient rather than other individuals, such as other clinicians. The final product of this step included all clinical notes labeled as either having or not having the language of judgment.

Statistical Analyses

First, we used chi-square tests to conduct bivariate analyses to examine differences in the use of judgment language by patients' race or ethnic groups. Further, we conducted an adjusted analysis to explore associations between the patients' race or ethnic group and the use of judgment language in their clinical notes. To examine whether the analysis should be adjusted for individual clinicians' writing style, we implemented and compared the results of two logistic regression models: (1) a general logistic regression model adjusted for patients' gender and (2) a mixed-effects logistic regression model adjusted for patients' gender (fixed effects) and clinician ID (random effects). The most appropriate model was selected by comparing differences in the log-likelihood between the models [36]. Finally, we examined the association between visit time and the use of judgment words. Specifically, we implemented linear regression to analyze this association adjusted for the patient's gender and race or ethnic group. All analyses were implemented in Stata statistical software (version 17; StataCorp) [37].

Results

Using the "Rapid vocabulary explorer" module of the natural language processing software (NimbleMiner), judgment

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language vocabulary was expanded to include additional terms (eg, "convinced," "vehemently," "believes," and "admits"), linguistic variations of the judgment word terms (eg, "claim," "claims," and "claimed"), as well as misspellings (eg, "claimes," "clamed," and "clai med"). Table 1 provides examples of clinical notes that had judgment language.

Table 1. Examples of clinical notes with judgment language. Judgment words within the quotes are italicized.

Examples from clinical notes	Judgment language
"…*claims* smoking cessation but ash tray still noted on night stand."	claims
"pt [patient] *claims* he had fever in past, but no thermometer in use."	claims
"He has a rw [rolling walker] but pt [patient] only uses it to get up fr [from] the bed. pt demoed another safe method of getting out of the bed, but pt *insisted* of doing it on his own manner."	insisted
"pt [patient] also *insisted* vn [visiting nurse] to remove left foot dressing however no wound order suggested to do so."	insists
"has a rollator but husband is so *adamant* for pt [patient] not to use it."	adamant
"Patient has a straight cane but *adamantly* refused it in the apt [apartment] and patient prefer holding on walls and furnitures."	adamantly
"Patient *states* that she feels weak and dizzy patient *admits* to not testing blood sugars as ordered but *states* she takes her insulin."	states, admits
"patient refuses to wash legs and *claims* he is allergic to water. patient *convinced* genetic medicine is only solution for his wound care treatment."	convinced, claims
"pt [patient] has D.M. [diabetes mellitus] and H.F. [hear failure], but *convinced* they don't need to keep low sugar diet."	convinced
"s/p [status post] hospital d/c [discharge] where she was tx [treated] with hemodialysis after skipping 3 txs, as per d/c summary. pt *vehemently* denies this."	vehemently
"Patient *admits* to not testing blood sugars as ordered but *states* she takes her insulin."	admits, states

In total, judgment language was used for 17,141 patients, which is 38% of the overall patient sample. Further, 10% (26,306/264,146) of all clinical notes included judgment language. As presented in Table 2, there were significant differences in the distribution of judgment language in clinical notes by race or ethnicity. The lowest amount of judgment language was identified among Asian patients (1756/22,548, 7.8% of all notes had judgment language), followed by White (10,206/107,626, 9.5%), Black (7010/65,628, 10.7%), and Hispanic patients (7167/66,282, 10.8%). The relative increase in the proportion of notes with judgment language among Black and Hispanic patients reached about 14%, compared to White patients (P<.001). For Asian patients, the lowest rates of judgment language were observed.

Table 2. Distribution of judgment language by race or ethnicity.

Race or ethnicity	Total patients (N=45,384), n (%)	Total clinical notes (N=264,146), n	Clinical notes with judgment language (n=26,306), n (%)[a]	Relative change compared to White (%)	Odds ratios (95% CIs)
White	19,826 (44)	107,626	10,206 (9.5)	Reference	Reference
Asian	3921 (9)	22,548	1756 (7.8)	–18	0.91 (0.85-0.96)
Hispanic	10,503 (23)	66,282	7167 (10.8)	+14	1.05 (1.01-1.1)
Black	10,969 (24)	65,628	7010 (10.7)	+13	1.09 (1.04-1.14)

[a]P<.001.

In the adjusted analysis using logistic regression, the difference between racial or ethnic groups remained significant (P<.001). Specifically, Black and Hispanic patients had 5% and 9% (respectively) higher odds of judgment language presence than White patients (Table 2).

The random effect for clinician ID was significant, as indicated by comparing the log-likelihoods of regression models with and without the random effect for clinician ID. We found that removing the random effect causes a substantial drop in the log-likelihood (~20%), and the effect is statistically significant (P<.001). These results indicate that clinicians' writing style was associated with judgment language. In other words, some clinicians use more judgment language than others.

On average, clinicians spent 1 hour 8 and minutes in patients' homes. Further, clinicians spent 24 fewer minutes in the patient's home when they used judgment language in clinical notes (46 minutes average home health care visit length) compared to when no judgment language was used (70 minutes average home health care visit length). In the further linear regression analysis adjusted for the patient's race or ethnicity and gender, each judgment word was associated with a 21-minute decrease in the home health care visit time (CIs 22.9-19.9; P<.001).

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Discussion

Principal Findings

This study was the first to investigate the use of stigmatizing language in home health care. Specifically, we developed and applied a natural language processing system that identified the language of judgment in clinical notes. We found that such language appeared relatively frequently in clinical notes, with nearly 40% of patients having at least one instance of such language in their notes. Overall, approximately 1 in 10 clinical notes included judgment language, which is similar to the previous literature in hospital settings [27,29,38]. These numbers highlight the need for further studies with larger data sets of clinical data that will enable estimating the general prevalence and use of judgment language in health care.

Further, our findings helped identify racial and ethnic differences in the use of judgment language. Previous studies primarily focused on language differences between Black and White patients [27,29,38], while our sample also included a significant number of Hispanic and Asian patients. We found that judgment language was more frequently documented in clinical notes of Black and Hispanic patients. Specifically, in an adjusted analysis, Black and Hispanic patients had up to 9% higher odds of having judgment language in their clinical notes than White patients. These results are lower but in the same direction as previous findings from the hospital settings, indicating that Black patients have up to 25% higher odds of having judgment language in their clinical notes than White patients [27]. We further expand these results and show that similar to Black patients, Hispanic patients have high levels of judgment language in clinical notes.

Several potential explanations can help describe these differences. First, clinicians' personal biases might manifest in written documents [27-29]; hence, we find the language of judgment to be more prevalent in clinical notes of minority patient populations. Our analysis also shows that some clinicians are more likely to use the language of judgment than others. This further supports the need for more research to test the hypothesis that personal differences among clinicians play a significant role in shaping their language. In addition, institutional biases toward certain racial and ethnic groups might shape clinicians' views, resulting in documentation differences. For example, numerous previous studies found that racist institutional policies lead to worse quality of care and outcomes among Black patients [10].

In addition to the previously mentioned factors that may contribute to the use of judgment language in clinical notes, it is important to consider the role of patient-provider interactions in shaping the use of this type of language. The use of judgment language may not be solely the result of clinician biases but may also be influenced by the specific circumstances of the patient-provider interaction. For example, when a patient is not following instructions or refusing self-management, a clinician may be more likely to use judgment language in their documentation. Similarly, in complex clinical scenarios, a clinician may use more judgment language as they navigate a difficult case in which diagnosing a patient's condition is complicated. Further, in some clinical situations, clinicians might use harsher, more critical, or more negative language. Further research is needed to understand specific contextual factors that may contribute to the use of judgment language in clinical notes.

Finally, our results hint at the potential association between the language of judgment and quality of care. Specifically, we found that clinicians spend less time with patients for whom they document the language of judgment. This is concerning since shorter home health care visits are associated with a higher risk for poor outcomes (eg, higher risk of hospitalizations) [39,40]. Another testable hypothesis might be that home health care clinicians spend less time with patients they perceive negatively, which is reflected by judgment language.

Our findings have several implications at the health care policy and management levels. First, health care organizations might need to develop guidelines to help shape more inclusive and neutral documentation patterns. For example, certain words and expressions of judgment might need to be limited or require thorough justification when used. Further, targeted clinician training in improving documentation styles might be needed for some clinicians who frequently use such language in their documentation. In addition, counseling or educational interventions to reduce implicit clinician biases might help decrease stigmatizing language in clinical practice. Finally, clinicians might need more training about engaging with patients who are not following instructions or refuse self-management to increase time spent with those patients in productive motivational conversations and similar interventions [41].

Limitations

This work has several significant limitations. First, the judgment language in the notes might appear in descriptions of "nonjudgmental" clinical situations. For example, words like "state(s)" are often used to describe patient's symptoms and other reports with little evidence of judgment. Additionally, the study's approach to identifying judgment language is based on the frequency of certain words rather than considering the context in which they are used. This means that the study may not accurately capture the nuances of how judgment language is used in clinical notes, and therefore, may not fully capture the extent to which clinical notes are racially charged. Other natural language processing methods computationally tied to the clinical note context (eg, sequence of words, topic modeling, or Bidirectional Encoder Representations from Transformers [BERT]) [42] might help identify the judgment language more accurately.

Second, this analysis did not adjust for clinical factors that might interfere with judgment language prevalence (eg, the patient's cognitive status or mental health conditions). Further work is needed to generate comparisons adjusted for such additional health conditions.

Home health care visit length might not necessarily reflect the quality of care provided. Further, clinical encounter time as well as documentation time and quality might be affected by multiple factors, such as administrative concerns or needing to visit another patient's home as soon as possible. Associations

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between clinicians' documentation and encounter times should be explored in future studies.

Further work is needed to understand whether differences in judgment language prevalence exist between different disciplines (ie, nursing, occupational or physical therapy, and social work). In addition, further exploration of the effect of culture on the language used during and length of clinical encounters is needed. For example, Asian patients might respond differently during clinician interaction [43], which might affect clinician documentation. Further, future studies should emphasize the frequency of the judgment words used rather than focusing solely on the specific vocabulary used. This will test whether a higher frequency of judgment words in the clinical notes may indicate a more intentional use of judgmental language, as opposed to a lower frequency, which may suggest a less intentional use. Further qualitative research with the clinicians who wrote the clinical notes is needed to gain a deeper understanding of the use of judgment language and the context in which it was used. Finally, the generalizability of this work is limited to one, albeit large, home health care agency.

Conclusions and Implications

This study's findings indicate that language of judgment appears more frequently in clinical notes of Black and Hispanic patients as compared to White and Asian patients. We also found that clinicians spend less time in patients' homes when judgment language is used. Since the language clinicians use in documentation is associated with care quality, policy and clinical practice steps are needed to address biases associated with racial and ethnic differences in the prevalence of judgment language. Further research is needed to fully understand the prevalence and root causes of stigmatizing language and to test interventions to eliminate their use.

Acknowledgments

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Conflicts of Interest

None declared.

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Abbreviations

BERT: Bidirectional Encoder Representations from Transformers
OASIS: Outcome and Assessment Information Set

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Original Paper

Assessing the Acceptability of Home Blood Monitoring for Patients With Cancer Who Are Receiving Systemic Anticancer Therapy From a Patient, Caregiver, and Clinician Perspective: Focus Group and Interview Study

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Abstract

Background: Regular blood testing is an integral part of systemic anticancer therapy delivery. Blood tests are required before every administration of treatment to ensure that a patient is sufficiently well to receive it. Blood testing is burdensome for patients as they require either an extra visit within 48 hours of planned administration of treatment or a significantly long visit if performed on the day of treatment. The additional time for appointments can have a significant impact on the quality of life of someone who is living with cancer. In the United Kingdom, the COVID-19 pandemic created unprecedented disruption to the delivery of cancer care. Face-to-face hospital visits were reduced, resulting in the need to develop more innovative ways of working to minimize treatment interruptions. This led to significant uptake of digital technologies, with new models of care rapidly deployed across the UK health service to meet these challenges.

Objective: This study aimed to explore the acceptability of a point-of-care home blood monitoring device for people with cancer who are receiving systemic anticancer therapy, which is being developed in response to the increased need for remote care for patients with cancer.

Methods: Qualitative focus groups and semistructured interviews were conducted with patients (23/47, 49%), caregivers (6/47, 13%), and health care professionals (18/47, 38%) over a 19-month time frame from May 2019 to December 2020. Data were analyzed using framework analysis guided by the Unified Theory of Acceptance and Use of Technology model.

Results: Analysis identified 4 overarching themes: performance expectancy, effort expectancy, social influence, and facilitating conditions.

Conclusions: This study found that patients with cancer, their caregivers, and health care professionals had positive perceptions about home blood monitoring. Although they are often considered synonymously, self-testing and self-management are not mutually exclusive, and this study illustrated some disparity in opinions regarding patient self-management. Home blood monitoring has the potential to provide patients with cancer with a convenient option for blood monitoring. It would minimize hospital attendances, decrease late treatment deferrals, and provide prompt recognition of cancer treatment toxicities, thus enhancing the existing nurse-led protocols and clinical pathways. Home blood monitoring would create a long-term sustainable transformation for the delivery of cancer care, using digital health to act as a facilitator to address a pertinent issue regarding improving the efficiency of hospital resources and increasing the delivery of personalized patient care. Further studies are needed to determine how and where home blood monitoring would fit within clinical pathways, in a way that is robust and equitable.

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KEYWORDS

chemotherapy; digital technology; digital nursing; nurse-led care; oncology; point-of-care systems; self-management; self-testing; systemic anticancer therapy; telemedicine; mobile phone

Introduction

Overview

Cancer incidence rates in the United Kingdom are projected to rise by 42.5% over the next 20 years [1], with 50% of the population expected to receive cancer diagnosis [2]. Cancer represents a major health issue and economic burden on health care systems worldwide. Maximizing the efficiency of treatment pathways and optimizing patient outcomes are key priorities [3], with the COVID-19 pandemic greatly emphasizing this need. Approximately 28% of people who have been diagnosed with cancer receive systemic anticancer therapy (SACT) [4]. SACT refers to the systemic delivery of drugs that have antineoplastic effects [5]. These drugs include traditional cytotoxic chemotherapy and new, biological agents such as monoclonal antibodies, targeted therapies, and immunotherapy [6]. Patients receiving SACT experience treatment toxicities, which they must navigate and manage, with support from their caregivers and clinical team. Toxicities can vary in their severity and required management, ranging from supportive medication in an outpatient setting to hospitalization and dose interruptions (which may also include dose reductions) [7]. Before every administration of SACT, the patient undergoes a clinical assessment and full blood screening to ensure that it is safe to administer treatment. This blood test will incur either an additional visit within 48 hours of their intended SACT appointment or can be performed on the day of treatment administration, resulting in a long day for the patient. Either option is burdensome to the patient [8], and during the pandemic, these additional or longer hospital visits lead to increased potential risk of greater transmission of SARS-CoV-2 and increased footfall at the hospital. Neutropenia, thrombocytopenia, and anemia are common reasons for SACT deferral. They often do not directly cause the patient to be acutely unwell, and therefore, related blood levels are the first indication that the treatment cannot proceed.

A recent service evaluation conducted at a UK cancer center explored the incidence of last-minute deferrals owing to neutropenia; 7% (n=224) and 5% (n=169) of patients had their SACT rescheduled owing to neutropenia in the last quarters of 2019 and 2020, respectively [9]. This has a negative impact on the patient, as many patients were told that the treatment could not be administered after they had arrived at the hospital, and on the efficiency of hospital resources. There is anecdotal evidence suggesting that this is a worldwide problem; however, published data are limited. The creation of a point-of-care device that allows the patient to self-test a capillary sample at home to provide a full blood count (FBC) could revolutionize existing clinical pathways. At a time when the pandemic continues to affect care delivery, using innovative technologies can minimize treatment interruptions while promoting remote and ambulatory care. The point-of-care device will require a patient to perform a finger prick test in their own home, with the obtained sample subsequently being analyzed. The FBC will provide a value for total white blood cells, neutrophils, hemoglobin, and platelets, comparable with a venous FBC result analyzed in a hospital laboratory. This will enable clinicians to ascertain whether the patient's FBC is within the desired parameters to proceed with treatment, without the patient leaving their home. Patients whose FBC is not within the required range for treatment can be assessed remotely. If the patient is well, their treatment can be deferred accordingly. If this remote assessment highlights anything of concern, a proactive review can be arranged to ascertain whether any intervention is required. Prompt detection of neutropenia and monitoring of recovery could positively affect patients' quality of life and potentially individualize SACT delivery [8].

Background

The increased burden that an aging population has on our health service has instigated the need for new patient-centered models of care, with the patient being considered as an expert in their care, rather than a passive recipient [10]. Remote monitoring of patients using technology is becoming more prevalent, as is patient self-management, with patient education being a key facilitator to achieve high-quality, safe patient care [11]. A critical appraisal of peer-reviewed papers that explored the impact of mobile health apps for people with cancer who were receiving SACT found statistically significant differences in patient-reported outcomes collected remotely through a smartphone app or internet portal compared with those collected through usual care. These findings illustrated improved symptom control and, thus, quality of life, through remote monitoring [12]. Studies have developed self-management interventions for anticoagulation therapy, asthma, and diabetes. Results illustrated that when patients are trained in self-testing and self-management, anticoagulation therapy is improved [11], acute care interventions for asthma are reduced [13], and blood glucose levels and lifestyle are improved in a more sustainable manner [14]. Characteristics of successful patient self-management interventions include being embedded in clinical pathways and tailored to specific conditions and incorporating regular reviews with health care professionals (HCPs), educational reinforcement, and use of technology [15].

Before the COVID-19 pandemic, delivery of remote outpatient cancer care was being explored, but its progression was impeded by system inertia and slow speed of adoption. This appeared to be owing to several factors, including accreditation; reimbursement; and overall apparent reticence from patients, clinicians, and organizations, combined with a potentially immature digital health infrastructure [16]. The COVID-19 pandemic accelerated the digital health agenda, with many digital health tools moving from being perceived as a potential opportunity to becoming an absolute necessity, thus expediting developments and rapidly increasing uptake [17]. Consequently,

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remote monitoring and remote consultations have become the norm within oncology care, with benefits being seen in terms of improved patient access and convenience, while facilitating caregiver involvement and maintaining the delivery of clinical services [18].

The urgent and immediate necessity of moving most face-to-face care to remote and remote consultations because of the pandemic has meant that there has been little opportunity for evaluation of its efficacy. This was highlighted in a systematic scoping review of artificial intelligence, telehealth, and related technologies implemented during the pandemic, which identified that the extent of successful real-world applications of these technologies is unclear [19]. This emphasizes the need to ensure that the development of home blood monitoring is implemented with stakeholder involvement, so that it is accepted as a service development by those it will involve, while ensuring that it is fit for the purpose. This is supported by the Integrate, Design, Assess, and Share framework for development of digital health technologies, which outlines the importance of ensuring that any significant changes in pathways are explored with service users [20].

The Unified Theory of Acceptance and Use of Technology (UTAUT) model suggests that there are several factors that influence individuals' intention to use and actual use of new technologies [21]. This includes the extent to which a user believes that using the system will help them (performance expectancy), degree of ease of using the system (effort expectancy), influence of other people (social influence), and organizational and technical infrastructure to support the technology use (facilitating conditions). Therefore, before introducing a new technology to refine clinical pathways, it is important to evaluate the potential users' acceptance and usability of the system (where usability is defined by 5 quality components: learnability, efficiency, memorability, errors, and satisfaction) [22].

This study aimed to explore acceptability from patient, caregiver, and HCP perspectives regarding home blood monitoring for patients with cancer who are receiving SACT.

Methods

Design

A qualitative study, using focus groups and semistructured interviews, was conducted.

Participants

Patients were eligible to participate in the study if they were aged ≥16 years; had adequate English proficiency, without the need for an interpreter; and had received SACT within the past 12 months. Caregivers were eligible to participate if they were the caregiver of an eligible patient. HCPs were eligible if they were employed at the study site, and this group could include specialist registrars, fellows, consultants, nurses, and laboratory and information technology experts.

Data Collection

Focus group and semistructured interviews were conducted over a 19-month time frame, between May 2019 and December 2020. Initially, focus groups were planned for all data collection, but the COVID-19 pandemic necessitated their immediate suspension. After March 23, 2020, only remote, semistructured, and one-to-one interviews were conducted with participants. Topics in the focus groups and interviews were identical and explored concepts of self-testing at home, expectations regarding responsibility for the device, and reporting the results. Participants used a prototype device to assess the ease of obtaining a capillary sample and inserting the cuvette into the device chamber. All interviews and focus groups were recorded, and notes were made during the sessions, ensuring that no identifiable information was included to maintain confidentiality.

Procedure

Clinicians identified patients who were eligible to participate in the study, who were subsequently approached by the research team at their SACT administration visit or clinical review appointment. Before the COVID-19 pandemic, caregivers were approached at the same time as the eligible patients. During the pandemic, visitors to the clinical site were stopped, and therefore, no further caregivers were invited to participate after this time. Eligible HCPs from across the hospital were approached by the research team face to face, with details of the study provided in verbal and written form before agreement to participate.

Focus groups were formed based on participant availability, with patient and caregiver focus groups conducted separately from HCP focus groups. The focus groups had set objectives of areas that needed to be covered, as detailed in the topic guide (Multimedia Appendix 1), which informed the results. Once data saturation was achieved, no further focus groups or interviews were conducted.

Ethics Approval

The study received ethics approval from the East of England – Cambridge South research ethics committee (reference 18/EE/0343; Integrated Research Application System project ID 234137). Every participant was given a participant information sheet and co-design booklet, with an opportunity for them to ask any questions before providing informed written consent.

Data Analysis

Data collection and analysis occurred concurrently. Data collection ceased when data saturation was reached. Data were analyzed using a framework approach, guided by the UTAUT model. Framework analysis identifies commonalities and differences in the data, seeking to ascertain explanatory conclusions around themes [23]. This approach consists of 5 stages: familiarization, identifying a thematic framework, indexing, charting, and interpretation [24]. It is a highly systematic method of categorizing data using an inductive approach to generate themes [25]. All audio files were listened to and notes made during interviews and focus groups were read numerous times by 2 researchers (AV and ST) to familiarize themselves with the data. Key issues and concepts expressed by participants formed the basis of the thematic framework that was used to filter and classify the data. Transcripts were coded independently by AV and ST to create key themes. The themes

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were continuously reviewed to ensure the most accurate and concise representation of the data. Initial codes were cross-referenced with theory and previous studies. After creating a comprehensive code list, the final phase involved defining and naming themes. At this stage, both researchers reviewed the codes individually to decide which codes qualitatively described similar issues and therefore could be grouped together as an overarching theme. Both researchers created individual theme lists, and these lists were discussed to reach consensus. Following the creation of the framework, themes were indexed using the UTAUT model as a guide [21]. There were no significant differences in the data collected through interviews and focus groups across participant groups; therefore, a single thematic framework was created using all available data.

Rigor

There are many different interpretations of what rigor means within qualitative research [26]. We have ensured that this study meets 3 key criteria, as discussed in the following sections.

Reflexivity

Reflexivity is defined as the awareness of the researcher's role within a study and how it is influenced by the focus of the study, thus enabling the researcher to acknowledge the way in which they affect the research process and outcomes [27]. Interviews were conducted by the device development team alongside researchers employed by the National Health Service trust who were not part of the patients' clinical team. All of them have experience in interviewing people with cancer and conducted the interviews in an unbiased and balanced manner. Data analysis was conducted by 2 researchers (AV and ST), who used inductive approach and were unfamiliar with the relevant literature at that time. The researchers were not part of the device development team, which ensured transparency and quality, meaning that the data were analyzed without looking for preconceived ideas. The analysis included a process of self-critical reflection, acknowledging personal biases, preferences, and the research relationship.

Credibility

Credibility ascertains whether the research findings are representative of the information obtained from participants' original data and involve accurate interpretation of participants' original views [28]. The researchers used a systematic approach to analyze the data, and a detailed explanation of the analysis stages is presented in this paper. Discussion between the 2 researchers tested the credibility and clarity of the analysis, to ensure that it reflected the participants' experiences. Differences in interpretation were discussed, and agreement was reached.

Transferability

Transferability describes not only behaviors and experiences but also their context and determines applicability to other settings [29]. The study provides useful findings, which can be directly translated into oncology clinical practice. The principle of these findings could also potentially be transferred to other clinical groups considering the use of remote monitoring techniques.

Results

Participant Characteristics

Overall, 3 patient and caregiver focus groups, 2 HCP focus groups, and 12 semistructured interviews were conducted with 47 participants (Figure 1).

The 2 focus groups with HCPs were conducted before the implementation of COVID-19 restrictions. The first one, which was conducted on May 20, 2019, included a range of HCPs, both medical and nursing staff, and the second focus group, which was conducted on March 3, 2020, included SACT-trained nurses only. Of the 23 patient participants, most were women (n=19, 83%), with average age of 51 (SD 10.4; range 38-70) years. Of the 23 patient participants, 13 (57%) had breast cancer (Table 1).

Figure 1. Participant breakdown. CG: caregiver; FG: focus groups; HCP: health care professional; I: interviews; P: patient.

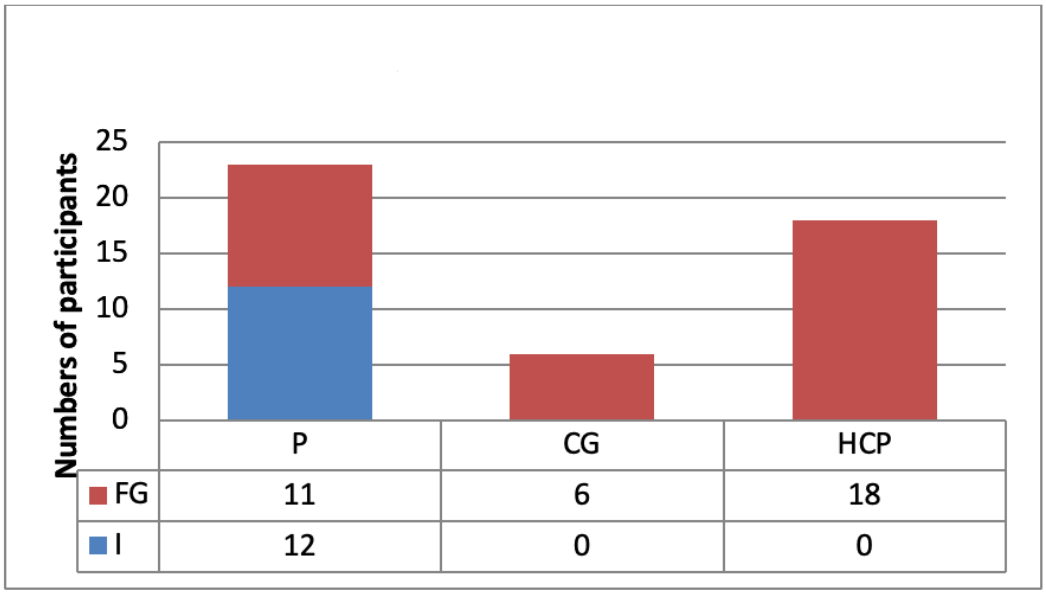

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Table 1. Patient characteristics (n=23).

Patient characteristics	Values
Age (years), mean (SD; range)	51 (10.4; 38-70)
Sex, n (%)	
Male	4 (17)
Female	19 (83)
Disease group (cancer) , n (%)	
Breast	13 (57)
Ovarian	3 (13)
Colorectal	2 (9)
Prostate	1 (4)
Lung	1 (4)
Lymphoma	1 (4)
Upper gastrointestinal	1 (4)
Head and neck	1 (4)

Thematic Analysis

In total, 4 overarching themes were identified, which aligned with the UTAUT model (Figure 2).

Quotations provided to support our analysis denote if the data were obtained from a patient, caregiver, or HCP focus group or patient interview, along with the date it was conducted (Table 2).

Figure 2. Themes. UTAUT: Unified Theory of Acceptance and Use of Technology.

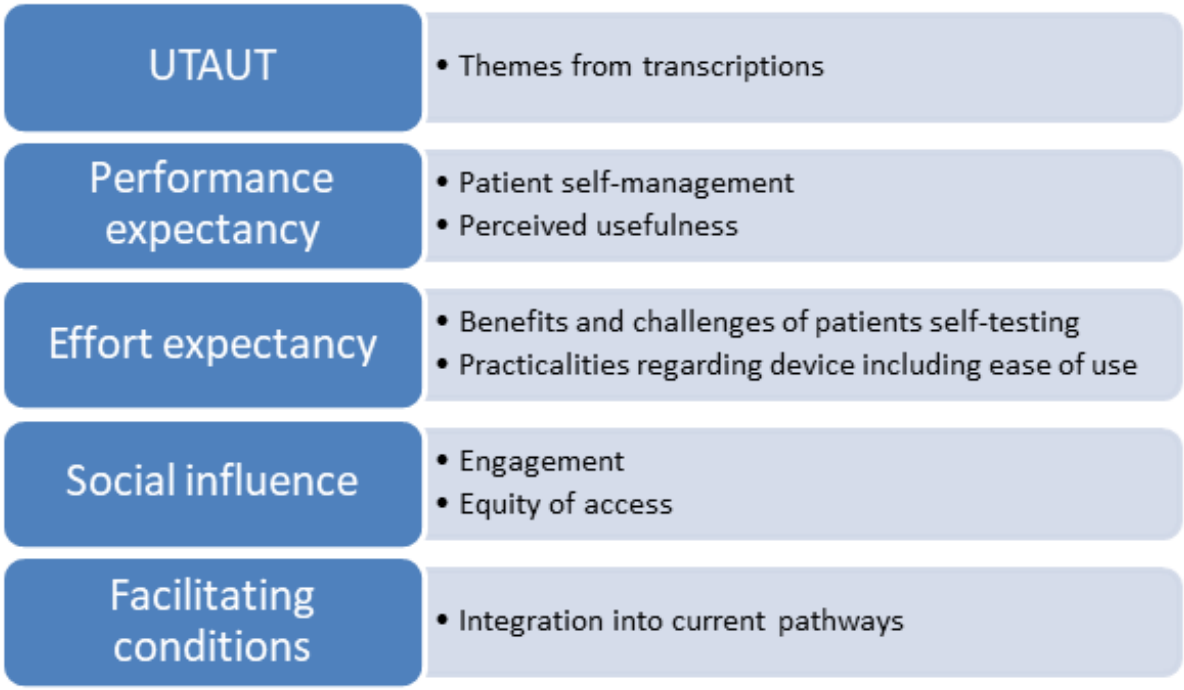

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Table 2. Participant quotes to illustrate themes.

Themes and participant quotes	Identifier	Date
Performance expectancy—patient self-management and perceived usefulness		
"I'd need a chart to interpret the results. There could be a high or low label and number, or a colour code. Like temperature checks; if it goes past a certain range you know to phone the hospital."	PI[a]	November 2, 2020
"I'd like to see the results, as I know my neutrophil count needs to be over 1 for my treatment to go ahead. Quick results would reduce my stress level."	PI	November 9, 2020
"I'm a nurse so I like to see my results as I understand what they mean. I run so I like to know how things are varying or stable. I monitor my results so that I know that I'm not being reckless to run."	PI	November 11, 2020
"It's often given a lot of importance to the blood test but it's about interpreting the results properly to avoid risks."	HCPFG[b]	May 20, 2019
"Anxious patients need to have it explained why they are being asked to do this kind of blood test; reducing the number of tasks required by the team and also the patient is key – support patient to interpretation. This is where the human factor is required."	HCPFG	May 20, 2019
Effort expectancy—benefits and challenges of self-testing		
"It will be good to regain some control by testing myself"	PFG[c]	June 17, 2019
"To get to the hospital means I have to take two buses...it's not an easy journey and COVID makes me not want to get public transport. It usually takes around 90 minutes to have my blood taken; waiting around isn't nice and makes me anxious. Testing at home would be much better."	PI	November 2, 2020
"I hate needles, so a finger prick test would be better."	PI	November 12, 2020
"It can be really difficult to get my blood as my veins are hard to find. I wouldn't sleep the night before; it stresses me massively...most stressful part of the treatment."	PI	November 11, 2020
Effort expectancy—practicalities regarding the device and ease of use		
"I'd value feedback that I'm doing it correctly."	PI	November 4, 2020
"It needs to be easy to use; if I can't use it, I won't use it."	PI	November 2, 2020
"Fewer steps will improve adherence."	HCPFG	May 20, 2019
"I would expect video format to get trained. Recording extra information will work well with the [NHS[d] Trust] way of working."	PFG	July 25, 2019
"I'm not bothered what it looks like, as long as it works."	PI	November 2, 2020
"I wouldn't have it out on display; it would remind me I am a patient. I would hide it in a cupboard. The smaller and nicer it looks the better."	PI	November 11, 2020
"The test would need to be clinician led – the patient should not be able to test whenever they want to."	HCPFG	May 20, 2019
"We would not want patients self-initiating tests because they could become obsessive...they could test out of hours when nobody is there to see it."	HCPFG	March 3, 2020
"If a patient hasn't done their planned test or has and it is grossly out of range, there needs to be a safety netting system to ensure this isn't missed."	HCPFG	May 20, 2019
"What happens if device doesn't work – would treatment be delayed?"	PFG	June 17, 2019
"A clear pathway is needed with a back-up solution if device fails."	PFG	June 17, 2019
"If the device doesn't work the patient should be advised to contact the hotline for clinical advice, while the company resolves the issue with the device."	HCPFG	May 20, 2019
Social influence		
"I'd be concerned about elderly patients using the technology."	HCPFG	May 10, 2019
"What about those people who aren't very tech savvy?"	HCPFG	May 10, 2019
"Not everyone has internet at home, so would that mean they wouldn't be able to use the device?"	HCPFG	May 10, 2019
"Someone with poor dexterity may find [a test] tricky to do."	PI	November 2, 2020
Facilitating conditions—integration into current pathways		
"A visual or audio reminder on the device about to take the test would be helpful."	PFG	July 25, 2019

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Themes and participant quotes	Identifier	Date
"Being notified when the results have been seen would be really helpful."	PFG	July 25, 2019
"It's really important patients receive confirmation that a test has been received."	HCPFG	May 20, 2019
"What happens if it's a 'bad' result and no face to face option? That would make me very anxious."	PFG	June 17, 2019
"There needs to be time within the [clinician's] job plan that is allocated to reviewing bloods taken on the device in order to ensure that results are reviewed in a timely manner."	HCPFG	May 20, 2019
"It is crucial to ensure results are not lost and are all reported on one system."	HCPFG	May 20, 2019
"Real time transmission of information is needed that can update all the scheduling systems to avoid future delays and issues."	HCPFG	March 3, 2020

[a]PI: patient interview.

[b]HCPFG: health care professional focus group.

[c]PFG: patient focus group.

[d]NHS: National Health Service.

Performance Expectancy—Patient Self-management and Perceived Usefulness

Performance expectancy relates to the degree to which a user believes that using the device will assist them to attain a perceived gain [30].

Our findings illustrate contrasting opinions from patients regarding what information is shared on the device and how and what level of autonomy is expected and desired in terms of interpreting that information. Some patients were very keen to see their blood results and felt that they could interpret what they meant, which would inform the self-management aspect of their care. However, other patients felt that knowing their blood test results would make them anxious, particularly if their results were not within the desired parameters to proceed with treatment. HCPs also expressed concern about patients being able to see their results and the associated anxiety regarding their interpretation. There was consensus that patients could see results, but strict guidance is needed to support patients' interpretation.

Effort Expectancy

Effort expectancy relates to the amount of perceived effort required to use a new technology, which, in this study, is a home blood monitoring device. If the device is perceived to be easy to use, it is more likely to be adopted [31].

Benefits and Challenges of Patient Self-testing

In our study, all patient participants (23/23, 100%) were happy with the concept of self-testing and could see how it would be beneficial to them. Patients highlighted that a reduction in time spent at the hospital and the reduced need for a venous blood test would be highly beneficial and welcomed, because several patients found having their blood taken as stressful. However, 22% (5/23) of the patients highlighted the potential for self-testing to increase anxiety if they could not obtain feedback about their results or discuss them with a clinician.

Practicalities Regarding the Device and Ease of Use

Regarding effort expectancy, participants stressed the importance of appropriate training and feedback to ensure that the device was being used correctly. Having appropriate feedback and training would greatly influence the patients' ease of use and confidence in the device. A participant supported home testing but felt more comfortable with communicating in person. Both patients and HCPs identified the need for simplicity of the testing process to improve engagement.

Video training was discussed in a focus group, and all participants (4/4, 100% of the patients and 2/2, 100% of the caregivers) agreed this would be useful. Most participants (32/47, 68%) were not concerned about the appearance of the device if they had the trust that it works effectively. Others highlighted that they would want to store it out of sight, so that they were not reminded of their status as a patient.

HCPs discussed the timing of testing. They felt that patients should only conduct a test when it was clinically required; it was suggested that the device should be locked remotely, with the patient only able to perform a test at a scheduled time. Their concerns related to patient safety, in terms of ensuring that patients' test results were not ignored or "lost" in the system. Both patients and HCPs expressed concerns regarding potential device failures and questioned what would happen in this instance.

Social Influence—Engagement and Equity of Access

Social influence refers to a belief about technology acceptance and use based on the influence of significant others, such as family and friends, whom they respect [32]. Social influence significantly affects the individual's intention to use home blood monitoring.

Patients and HCPs were concerned about equity of access, as they felt that not everyone may be able to engage for various reasons, with reference to those who had little or no support at home being less likely to conduct home blood testing. Concerns were raised, which were on a practical and physical level, highlighting issues around dexterity, digital naivety and inexperience, and internet access, all of which could impede the uptake of home blood monitoring.

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Facilitating Conditions—Integrating Into Current Pathways

Facilitating conditions is defined as the degree to which a user believes that an organizational and technical infrastructure exists to support the use of this technology [33].

Patients, caregivers, and clinicians discussed the logistics of how home blood monitoring would fit within the current care pathways and existing technical infrastructure. There are several components in this theme: communication between the patient and their clinical team regarding the test, practicalities of presenting the test results to the patient, and the digital interface between the device and hospital systems. Patients and caregivers were more focused on how the test would be scheduled, recorded, and reported, with particular emphasis on whether the test results will be displayed on the device. HCPs expressed the importance of allocating time within their job plans to ensure that the results are reviewed in a timely manner. All the parties highlighted that acknowledgment of receipt of results by the clinical team would be beneficial. Several HCPs (6/18, 33%) suggested that the device should be integrated into existing test reporting systems, rather than adding to what is already a complex landscape of digital technology systems.

Discussion

Principal Findings

This study explored patient, caregiver, and HCP perceptions about home blood monitoring for patients receiving SACT to guide prototype development and refine clinical pathways. A total of 47 participants participated in the interviews or focus groups. Framework analysis of transcripts was conducted using the UTAUT model to underpin the 4 themes that were identified.

The concept of home FBC monitoring has been under development for several years, with the goal of transforming the delivery of cancer care in a way that suits the needs of patients, while minimizing the burden on health care systems. Home blood monitoring has the potential to redefine cancer care, positively affecting the experience of patients and their caregivers, and improve the efficiency of health care resources. In addition to being easy to use, technological interventions should positively affect disease management and quality of life [26]. The UTAUT model highlights the different elements that influence whether and how an individual will use a technology. In this study, we found that participants felt that there were significant benefits of home blood monitoring, such as giving them more control across their cancer journey and reducing the burden associated with hospital appointments. This aligns with performance expectancy, which refers to how helpful a digital intervention is perceived to be by the user, which will influence intention for use [21]. In other diseases, such as asthma, chronic obstructive pulmonary disease, and diabetes, remote monitoring coupled with education and support from the clinical team has been proven to reduce health care use, improve patients' quality of life, and support patients to self-monitor and manage their condition more efficiently [34-36]. Participants in our study highlighted that many medical reviews had moved to remote consultations during the pandemic. This was positively accepted as it saved time and the associated travel costs in comparison with face-to-face appointments. Home blood monitoring coupled with remote clinical consultations would maximize the concept of remote monitoring, thus enabling a more thorough and robust assessment. HCPs felt that a test should be initiated by a clinician, rather than being patient-led, but some patients felt that they would want to test whenever they felt unwell. Other studies have found that self-tests are frequently performed owing to curiosity from the patient, to gain reassurance [37]. Self-testing can make patients feel empowered, but there is evidence that a danger of *lay ignorance* exists in conducting a test that is unlikely to provide the answer they are looking for [38]. Contrasting studies have found that some participants did not want to be burdened with self-testing owing to additional stress and negative connotations of sickness from having equipment at home [39]. This emphasizes the need for an opt-out option for patients, to minimize any feelings of coercion or discrimination.

A crucial predictor of technology acceptance relates to effort expectancy, and there is evidence suggesting that easy access to technical advice with low effort burden increases use [40]. Ensuring that patients feel confident and competent in using any home monitoring system is key to its effectiveness. If a digital intervention is usable, it promotes engagement, productivity, efficiency, and pleasure in use [22]. Patients raised concerns regarding their ability to perform the test correctly and questioned the availability of training and support. Usability refers not only to *ease of use* but also to infrequent and regular use, to enable users to achieve their goals, which, in this case, is to obtain an accurate FBC result [41]. A robust education program will improve the degree of ease associated with use of the device. Dexterity and sensory dysfunction were other concerns raised as potential barriers to the uptake of home blood monitoring. Of the 47 participants, 2 (4%) participants reported chemotherapy-induced peripheral neuropathy. Although this did not affect their dexterity, it may be an issue for some patients and needs to be considered and explored with potential users. Similarly, diabetes can cause sensory and visual disturbances, and a comparative study regarding the accessibility of blood glucose monitoring for people who are blind and visually impaired recommended that modifications needed to be made to the blood glucose monitors to make them equitable and safe for all [42].

Social influence was the third theme and is a significant factor in the use of a new digital intervention, with encouragement from surrounding people being a motivational factor [43]. Reticence to engage in remote monitoring may be because of feelings of isolation owing to loss of physical contact and face-to-face communication with the clinical team. Remote monitoring needs to be embraced by clinicians to ensure that patient communication, education, and support are not compromised and that strong patient-clinician relationships are maintained. It is important to communicate that not all patient care will be delivered remotely; there will always be a need for face-to-face consultations and further venous sampling. This corresponds with previous studies exploring remote monitoring, which found that including features facilitating patient-clinician interaction may encourage engagement [44]. Although all our

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participants (47/47, 100) had access to the internet, they raised concerns related to individuals who may not have that access. A cross-sectional study of 151 patients with cancer exploring barriers to and enablers of patients' current and desired uptake of health care technology found that more than one-fourth of their sample did not have daily access to the internet and approximately one-third did not own a smartphone capable of displaying mobile apps, with age being a factor [45]. The oldest participant in our study was aged 70 years (mean age of the sample was 51, SD 10.4 years). With an aging population, it would be beneficial to conduct purposive sampling to gain feedback from those aged >70 years to ensure that their input is used in the design process, as the strength between perceived usefulness and intention to use varies with age [46].

The final theme was facilitating conditions. This is a crucial predictor of technology acceptance [47]. The creation of guidelines and their integration into existing clinical pathways with review procedures are critical. If not addressed, common usability problems can affect adoption [21]. Adopting a theory-driven approach will increase buy-in and trust, thus improving effectiveness and scalability [34]. The decision to adopt a digital intervention is complex, with attitudinal, social, and environmental factors having an impact [48]. The UTAUT model acknowledges that broad contextual factors may facilitate or inhibit digital adoption [21]. This supports our study findings, which identified the importance of digital interoperability between systems to promote usability, reassurance, and communication. As emphasized by patient participants in our study, there was concern regarding how they would know whether their blood test result had been seen, and similarly, HCPs wanted to ensure that they had protected time to review the tests to promote patient safety and increase confidence in the pathway. In similar studies that have evaluated remote monitoring in diabetes, potential safety concerns were highlighted if clinicians were unable to review the results in a timely manner [37]. Increase in cognitive burden for clinicians is a known barrier to the adoption of digital interventions [49]. A crucial factor, raised by all stakeholders, was the need to ensure that there are safety measures implemented in case of device failure or lack of patient engagement. There should be an alternative solution to ensure that cancer care can still be delivered safely and equitably. To maximize the potential benefit from new innovations, guiding principles should involve transparency, equitable access, ethics, ownership, and sustainability [35]. Risk of harm and compromised privacy of users is unacceptable and will detrimentally affect acceptance and use [50]. In contrast, the more disabled a person is, the more willing they may be to accept technology that reduces privacy if there is a belief that the intervention will improve independence and quality of life [51].

Limitations

This study recruited participants from a single site in the National Health Service in the United Kingdom; therefore, the findings may not be generalizable to other cancer centers or health care settings, and further studies would be required to determine this. Focus groups and interviews were conducted over a prolonged period, with the COVID-19 pandemic having implications upon recruitment. Participants were purposively selected following insight from the clinical teams, meaning that those who would be most likely to engage were approached. An assumption can be made that by agreeing to participate, participants were already open to the concept of home blood monitoring.

Conclusions

The development of minimally disruptive health care strategies for people living with cancer who are receiving SACT is essential to optimize the quality of life, while simultaneously improving the efficiency of hospital resources. This study highlights patient, caregiver, and HCP acceptance of the concept of home blood monitoring. Several chronic conditions already use home monitoring and demonstrate clear benefits in terms of patient experience and disease management. To invest in medical devices and implement changes to existing clinical pathways, there must be evidence that this is financially viable and clinically beneficial. For patients with cancer receiving SACT, home blood monitoring could expedite FBC results and thus provide more timely access to evidence-based care. Feedback obtained in this study has demonstrated eager acceptance from all stakeholders. However, although they are often considered synonymously, self-testing and self-management are not mutually exclusive, and this study illustrated some disparity in opinions regarding patient self-management. Further studies are needed to determine how and where home blood monitoring would fit within clinical pathways, in a way that is robust and equitable.

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Disclaimer

The views expressed in this publication are those of the author(s) and not necessarily those of the National Institute for Health and Care Research (NIHR) or the Department of Health and Social Care.

Conflicts of Interest

None declared.

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Multimedia Appendix 1
Topic guide.
[DOCX File , 29 KB - nursing_v6i1e39815_app1.docx]

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Abbreviations

FBC: full blood count
HCP: health care professional
SACT: systemic anticancer therapy
UTAUT: Unified Theory of Acceptance and Use of Technology

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Original Paper

Differing Effects of Implementation Leadership Characteristics on Nurses' Use of mHealth Technologies in Clinical Practice: Cross-Sectional Survey Study

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Abstract

Background: Leadership has been consistently identified as an important factor in shaping the uptake and use of mobile health (mHealth) technologies in nursing; however, the nature and scope of leadership remain poorly delineated. This lack of detail about what leadership entails limits the practical actions that can be taken by leaders to optimize the implementation and use of mHealth technologies among nurses working clinically.

Objective: This study aimed to examine the effects of first-level leaders' implementation leadership characteristics on nurses' intention to use and actual use of mHealth technologies in practice while controlling for nurses' individual characteristics and the voluntariness of use, perceived usefulness, and perceived ease of use of mHealth technologies.

Methods: A cross-sectional exploratory correlational survey study of registered nurses in Canada (n=288) was conducted between January 1, 2018, and June 30, 2018. Nurses were eligible to participate if they provided direct care in any setting and used employer-provided mHealth technologies in clinical practice. Hierarchical multiple regression analyses were conducted for the 2 outcome variables: intention to use and actual use.

Results: The implementation leadership characteristics of first-level leaders influenced nurses' intention to use and actual use of mHealth technologies, with 2 moderating effects found. The final model for intention to use included the interaction term for implementation leadership characteristics and education, explaining 47% of the variance in nurses' intention to use mHealth in clinical practice ($F_{10,228}$=20.14; P<.001). An examination of interaction plots found that implementation leadership characteristics had a greater influence on the intention to use mHealth technologies among nurses with a registered nurse diploma or a bachelor of nursing degree than among nurses with a graduate degree or other advanced education. For actual use, implementation leadership characteristics had a significant influence on the actual use of mHealth over and above the control variables (nurses' demographic characteristics, previous experience with mHealth, and voluntariness) and other known predictors (perceived usefulness and perceived ease of use) in the model without the implementation leadership × age interaction term (β=.22; P=.001) and in the final model that included the implementation leadership × age interaction term (β=−.53; P=.03). The final model explained 40% of the variance in nurses' actual use of mHealth in their work ($F_{10,228}$=15.18; P<.001). An examination of interaction plots found that, for older nurses, implementation leadership characteristics had less of an influence on their actual use of mHealth technologies.

Conclusions: Leaders responsible for the implementation of mHealth technologies need to assess and consider their implementation leadership behaviors because these play a role in influencing nurses' use of mHealth technologies. The education level and age of nurses may be important factors to consider because different groups may require different approaches to optimize their use of mHealth technologies in clinical practice.

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KEYWORDS

mobile health; mHealth applications; nursing; leadership; implementation science; nursing informatics

Introduction

Background

The use of mobile health (mHealth) technologies—mobile computing and information and communication technologies to support health care systems, health service delivery, and the achievement of specific health objectives [1]—continues to be recognized, with these applications being used as innovative tools within health systems. As the largest group of health professionals [2], nurses are the largest group targeted as end users of mHealth applications. The size of the nursing workforce highlights the role of nurses—whether willingly or otherwise—as direct shapers of the potential for success or failure of the deployment and use of mHealth applications in health systems. Recognizing the central role of nurses in determining the success or failure of mHealth applications, coupled with the attractive vision of materializing transformative improvements in health outcomes by equipping the vast nursing workforce with mHealth applications, there are ongoing efforts to better understand how mHealth applications can be used to support nurses' work.

The dominant tools used to understand nurses' use of mHealth applications have laid important foundations and provided crucial insights [3-5], although there are notable limitations to these approaches. The understanding of nurses' adoption and use of mHealth applications is largely informed by models and frameworks of technology acceptance from the field of information science that have been used to understand the acceptance of various types of technologies among different end-user groups. Technology acceptance models approach the understanding of nurses' use of mHealth applications through the examination of individual-level factors (eg, computer self-efficacy and perceived pressure to use the technology), with the premise that individuals' attitudes toward technology ultimately shape use behaviors. Despite technology acceptance models growing in complexity through the incorporation of more variables that are thought to shape technology use behaviors (eg, the development of the Unified Theory of Acceptance and Use of Technology [UTAUT] [6-8] and the various iterations of the Technology Acceptance Model 3 [TAM3] [9]), there remains a limited ability to consider the role of structural factors in shaping technology use intentions and behaviors.

Leadership is a fundamental aspect of the nursing profession and an important structural factor that has been found to influence both nursing and patient outcomes [10-12]. The importance of leadership in nursing is further evidenced by position statements both nationally [13-15] and internationally [16-18]. The role of leadership is a commonality as a structural factor of leadership: as related to the use of mHealth applications and other health technologies by nurses [5,19-21], as related to the implementation of new innovations and evidence-based practice in nursing [22,23], and in implementation science models and frameworks [24-28]. Taken together, the consistent message is that *leadership is important* in shaping the use of mHealth applications, nursing practice, and implementation outcomes. However, a challenge in enabling effective leadership to support mHealth use is a lack of specificity as to what leadership entails and distinguishing the nature of leadership that is being referred to (eg, the characteristics of leaders, leadership behaviors, and supports provided by leaders). In the context of nurses' use of mHealth applications, there remains limited consideration of the structural factor of leadership in influencing nurses' mHealth use behaviors.

Implementation Leadership and First-Level Leaders

Implementation leadership is specifically concerned with the leadership behaviors of local-level leaders or *first-level* leaders because they are well positioned to facilitate the implementation of innovations [29] and are deemed critical to organizational effectiveness [30]. First-level leaders are described as those who supervise individuals providing direct services [29]. In nursing, first-level leaders would be individuals who oversee nurses providing direct patient care (eg, educators, charge nurses, and ward managers), thus having influence and decision-making responsibilities at the local unit or department level. In nursing, first-level leadership is commonly referred to as *unit-level* leadership, and there is support for the importance of these leaders in influencing the implementation and uptake of practice changes and other innovations among nurses [31-33].

Objectives

The objective of this study was to investigate the influence of leadership characteristics and behaviors specific to the implementation process (ie, implementation leadership characteristics) on Canadian nurses' use of mHealth applications in clinical practice while controlling for the known predictors of the use of mHealth applications and technology. We sought to address this objective by answering the following 3 research questions (RQs):

- RQ1: What is the relationship between (1) implementation leadership characteristics and (2) nurses' intention to use and (3) actual use of mHealth applications, after controlling for (4) perceived usefulness and perceived ease of use, (5) nurses' previous experience with mobile technology and voluntariness of use, and (6) nurses' demographic characteristics?
- RQ2: Do nurses' (1) demographic characteristics moderate the relationship between (2) implementation leadership characteristics and (3) nurses' intention to use and (4) actual use of mHealth applications?
- RQ3: Do nurses' (1) voluntariness of use moderate the relationship between (2) implementation leadership characteristics and (3) nurses' intention to use and (4) actual use of mHealth applications?

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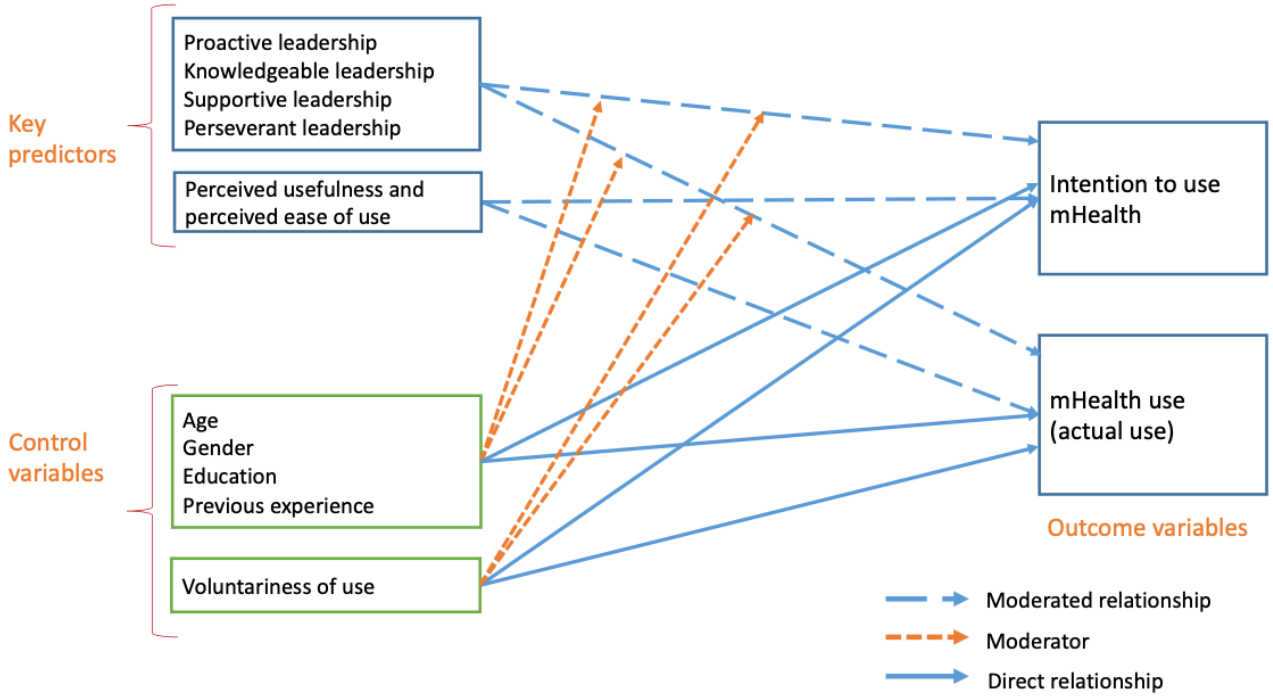
Methods

The Nurse Leadership for Implementing Technologies-Mobile Health Model

We developed the Nurse Leadership for Implementing Technologies-Mobile Health (Nurse LEAD-IT mHealth) conceptual model (Figure 1) to guide the conduct of the study. There are several well-established factors that have been found to influence the use of mHealth technologies, health information technology (HIT), and research among nurses and other health care professionals [3-6,16,17,33-35]. These characteristics are drawn from popular technology acceptance models and nurses' research use literature and include individuals' perceived usefulness and perceived ease of use of a technology, voluntariness of use, previous experience with technology, and demographic characteristics (age, gender, and education). The initial development of the Nurse LEAD-IT mHealth model has been described in detail elsewhere, including a more fulsome discussion of the definition and boundaries of leadership considered [34]; the model was further refined as the study progressed.

Figure 1. The Nurse Leadership for Implementing Technologies-Mobile Health model. mHealth: mobile health.



Understanding the unique role of leadership in influencing nurses' use of mHealth technologies requires an approach that leverages what is currently known about the factors that influence nurses' use of mHealth applications, HIT, and research as well as what is known about the role of leadership and how these influence the use of mHealth applications in nursing. As such, the NURSE LEAD-IT mHealth model integrates the known individual-level predictors of technology acceptance and use from the TAM3 [9], individual-level predictors of nurses' uptake and use of evidence-based practice [35-37], and the structural factor of implementation leadership characteristics to consider the importance of leadership in nursing. In the model (Figure 1), implementation leadership characteristics as well as the perceived usefulness and perceived ease of use of mHealth technologies are suggested to be associated with the intention to use and actual use of mHealth applications. Nurses' voluntariness of use and individual characteristics, which include demographics (age, gender, and education) and characteristics related to technology (previous experience with technology), are also considered in this model. Age, gender, education, and previous experience are posited to have direct effects on nurses' intention to use and actual use of mHealth applications. In addition, age, gender, education, previous experience, and voluntariness are suggested to exert moderating effects on the associations between key predictor variables (implementation leadership characteristics, perceived usefulness, and perceived ease of use) and the intention to use and actual use of mHealth applications. The process of development and an in-depth discussion of the theoretical foundations of the Nurse LEAD-IT mHealth model are described elsewhere [34,38], and this study represents the first instance of its operationalization and use.

Study Design

This was a cross-sectional exploratory correlational study. Study data were collected via an open web-based survey that was advertised and distributed to registered nurses (RNs) across Canada. In the following subsections, the web-based survey procedures are reported in accordance with the CHERRIES (Checklist for Reporting Results of Internet E-Surveys) [39].

Participant Inclusion Criteria

Study participants were RNs in Canada who had workplace-provided access to mHealth applications as a tool to support the delivery of direct patient care. The targeted sample for this study met the following inclusion criteria: they (1) held RN licensure in Canada, (2) provided direct patient care in any setting, (3) had access to employer-provided mHealth applications for use in the provision of direct patient care, and

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(4) spoke English. Participants were restricted to RNs (ie, we excluded licensed practical nurses, registered psychiatric nurses, and nurse practitioners owing to differences in the scopes of practice and autonomy regarding mHealth tools used in practice that may exist among different types of nurses).

Ethics Approval

Ethics approval was obtained from the University of British Columbia research ethics board (number: H17-02831).

Recruitment and Informed Consent

Given the exploratory nature of the study, both convenience sampling and snowball sampling were used. The nature of nurses' use of mHealth applications in Canada remains largely unknown, which did not allow for a more focused sampling strategy. More specifically, the dispersed nature of nurses' use of mHealth applications in the Canadian context required a broad reach that did not prematurely narrow down to a specific type of clinical service, setting, or type of mHealth application.

The study was advertised via the researchers' contacts in research and higher education organizations, as well as health and nursing informatics professional groups. The use of social media also constituted a major aspect of recruitment because nurses have been found to have high rates of social media use [40,41]. Survey advertisements were posted on publicly available professional nursing forums and groups on Facebook, Twitter, and LinkedIn. A dedicated web page and Facebook page with survey information were created. Paid advertisements were used on Facebook and Twitter to increase the visibility of the study pages. Information about the web-based survey was also distributed via specialty discussion lists such as JISCMail, which delivers messages to mailing list subscribers via email. Participant recruitment was also conducted via provincial RN regulatory bodies in Canada; however, recruitment in some provinces was not possible owing to regulatory or financial constraints (eg, Quebec was excluded because French is the primary language spoken in the province according to the regulatory body statements, and our study was conducted only in English).

Interested potential participants were directed to a landing page with information about the aims of the study, the survey structure, and the anticipated length of time it would take to complete the survey. Potential participants were required to answer screening questions to assess whether they met the eligibility criteria. Participants who met the eligibility criteria were redirected to the informed consent web page. After providing their consent by clicking *Start*, participants were able to begin the full survey, which included detailed instructions on how to complete the survey and the operational definitions of the terms used in the survey.

An incentive for participation was provided in the form of entry to a gift card draw for each week that the survey was open, an approach found to be successful in encouraging participation among nursing groups [42] and in increasing the odds of response [43]. Participants had the opportunity to enter prize draws for electronic gift certificates for the duration of the data collection period ($15 CAD weekly for each week the survey was open and $150 CAD at the end of the study). The prize incentive was of a small enough monetary value to ensure that escalating incentive amounts did not unduly influence responses or coerce participants [44]. Data were collected from January 1, 2018, to June 30, 2018.

Data Collection

Web-Based Survey Development

We developed a web-based survey that consisted of existing scales, demographic questions, and researcher-developed questions using the tailored design method described by Dillman et al [45] and best practice recommendations on developing and conducting web-based surveys [46]. The 80-item web-based survey included five sections that addressed (1) the nature of the use of mHealth applications in practice, (2) nurses' perspectives regarding their use of mHealth applications at work, (3) the characteristics (eg, job title) of leaders responsible for implementing mHealth applications, (4) previous experience with mHealth applications and other mobile technologies, and (5) nurses' individual characteristics. The survey was pretested by nurses who met the inclusion criteria for potential respondents but were not involved in any other aspect of the study as per guidance [45]. Pretesting focused on the clarity and readability of content, accessibility, presentation and aesthetics, respondent burden, and ease in using and navigating the web survey, as well as other web survey–related considerations [45,47]. Revisions that involved the correction of typos and grammatical errors were carried out to develop the final version of the study survey, which was then uploaded to the university-provided Qualtrics survey software (which stores data on Canadian servers) for web-based distribution.

Variables and Instruments

The survey included an adapted version of the system-use measure developed by Doll and Torkzadeh [48,49], the Implementation Leadership Scale (ILS) developed by Aarons et al [26], variables from the TAM3 [9] and UTAUT [8], nurse demographic characteristics, and researcher-developed questions on the nature of the use of mHealth applications in nursing (eg, the functions of mHealth applications that were used).

Outcome Variables

The outcome variables were nurses' intention to use mHealth applications and their actual use of mHealth applications. Intention to use refers to nurses' plan to use mHealth applications as part of their clinical practice. The intention to use a technology is often considered a precursor or proxy for actual technology use behaviors; it was considered as the latter in this study. The measure for intention to use comprised 3 items adapted from the TAM3 developed by Venkatesh and Bala [9]. To mitigate the limitations of using only intention to use as the measure of nurses' use of mHealth applications, actual use was also captured. We used the measure of system use developed by Doll and Torkzadeh [48] as adapted by Maillet [49], which has been validated in the context of the Canadian health care system (Cronbach α=.93).

Predictor Variables

The key predictor variables in this study were implementation leadership characteristics as well as perceived usefulness and

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perceived ease of use of technology. Implementation leadership characteristics were measured using the staff version of the ILS [26]. The ILS asks respondents to reflect on the specific leadership behaviors of the *first-level* leader in charge of the implementation of mHealth applications, recognizing their key positioning to facilitate implementation [26,29]. To identify first-level leaders, participants were asked to identify the formal title of the person responsible for introducing mHealth and the formal title of the person responsible for maintaining ongoing mHealth use to support nursing practice (unit or department manager, charge nurse, clinical nurse educator, resource person outside of the unit or department, or other). Perceived usefulness refers to nurses' perceptions of how useful mHealth applications are in their work. The measure of perceived usefulness was adapted from the TAM3 developed by Venkatesh and Bala [9]. Perceived ease of use refers to one's perception of how easy it is to use mHealth applications. The measure of perceived ease of use was adapted from the TAM3 developed by Venkatesh and Bala [9] and comprises a subset of 4 items from the early studies on the user acceptance of computer technology conducted by Davis et al [7].

Control Variables

Control variables included voluntariness (a technology characteristic), previous experience with technology (individual characteristic related to technology), and nurse demographic characteristics (age, gender, and education). Voluntariness refers to the degree to which the use of mHealth applications is either a mandatory component or a voluntary component of nurses' jobs. Three items, drawn from the study by Moore and Benbasat [50], were used to measure voluntariness. Previous experience was conceptualized in this study similar to previous studies, with experience representing the passage of time from the initial use of the technology up to the present [8,51]. Nurse demographic characteristics included age, gender, and education, reflecting individual characteristics identified in both the technology use literature and nurses' research use literature. Age in years was calculated from the participant's report of their year and month of birth. Although studies on nurses' use of research have found no association between age and nurses' research use [35,36], age has been identified in the technology use literature as influencing individuals' perceived ease of use, perceived usefulness, and attitudes toward technology, with older participants expressing less positive attitudes toward technology [8,9].

Information on gender was collected by asking respondents to identify as men, women, prefer not to say, or other. Previous research has found that gender roles and norms influence attitudes toward, and actual use of, technology [8,52]. Information on education was collected by asking participants to indicate the highest type of nursing degree that they had completed (RN diploma, bachelor of nursing degree, master of nursing degree, or PhD). For analyses, nursing education was dichotomized into two groups: (1) RN diploma or bachelor of nursing degree group and (2) nursing graduate degree or other advanced education group. This grouping was based on findings from the research use literature where having a graduate degree was associated with increased research use compared with having a diploma or a bachelor of nursing degree, with no differences found when comparing research use between nurses with bachelor of nursing degrees and those with diplomas [36].

All instruments were psychometrically evaluated. Principal component analyses for all scales produced component solutions consistent with previous studies [6,7,9,52-55], with the exception of the system-use measure developed by Doll and Torkzadeh [48], which extracted 2 components that explained 67.74% of the variance. These findings do not reflect the 5-dimension structure of actual use as proposed in the original scale developed by Doll and Torkzadeh [48]. However, the 2-component solution does reflect the findings of the scale as adapted and used among nurses by Maillet [49]. A summary of the component structure statistics for all scales used in each group of variables (outcome variables, predictor variables, and control variables) is outlined in Multimedia Appendix 1 [6-9,48,49,51-55].

Statistical Analyses

Power

An a priori sample size calculation to detect a small effect and achieve statistical power of 0.8, with $\alpha<.05$ for a hierarchical multiple regression, was computed; a minimum of 177 participants was required. A small effect size was used as a conservative estimate, given the lack of information on the potential effects of leadership behaviors on the uptake and use of mHealth applications. Responses from 288 participants were used in all regression analyses, which ensured sufficient statistical power.

Data Screening and Preparation

Data were extracted from the web-based Qualtrics software into a password-protected SPSS (version 26.0; IBM Corp) database, and the raw data were screened for missing, incorrect, and questionable response patterns as well as data entry errors [56]. A review of the responses to the question asking about the type of nursing registration revealed that 35 (9%) of the 388 participants did not meet the inclusion criteria because they were registered practical nurses (n=7, 20%), nurse practitioners (n=27, 77%), or registered midwives (n=1, 3%); these responses were excluded from analyses. Other cases were removed owing to missing ILS scores (65/388, 16.7%). Thus, of the initial 388 participants, after removal of these 100 (25.8%) cases, 288 (74.2%) remained for analysis. Descriptive statistics (frequencies, percentages, means, SDs, and ranges) were obtained for each study variable and used to assess whether the data met the assumptions required to perform hierarchical multiple regression analyses [57,58]. Upon the completion of the data screening steps, all assumptions to conduct hierarchical multiple regression analyses were deemed to have been met.

Hierarchical Multiple Regression and Moderation Analyses

Hierarchical multiple regression was used as the main method of data analysis. Diagnostics of the *intention to use* and *actual use* regression models were conducted to assess model assumptions; all assumptions were met. Diagnostic assessments included an examination of Q-Q plots and residuals scatterplots to inspect the normality of residuals and to visually identify

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potential outliers; standardized residuals, leverage values, Cook distance, and Mahalanobis distance to assess model fit with the data and identify potentially influential cases; Durbin-Watson statistic to assess independent errors (ie, independence of residual terms for any 2 observations); and intraclass correlations to assess the independence of observations, multicollinearity among independent variables (indicated by multicollinearity indices [variance inflation factor {<10} and tolerance {>0.1}]), homoscedasticity (by examining the scatterplot of the standardized errors [y-axis] against the standardized predicted Y [x-axis]), and skew, kurtosis, and normal distribution of residuals, as well as the absence of extreme multicollinearity in the model variables [56,59,60].

The creation of the regression model and the sequence in which variables were entered into the model were theoretically justified and as detailed in the development of the conceptual model [34] and guidance on the order of variable entry when conducting a hierarchical multiple regression analysis [56,59]. Known predictors were entered first, followed by the key predictors of interest. Separate sets of models were run for each of the 2 outcome variables: intention to use mHealth applications and actual use of mHealth applications. This order of model entry aimed to examine the unique effect of implementation leadership characteristics over and above the effect of control variables, perceived usefulness, and perceived ease of use (RQ1) and whether there were significant moderating effects of nurse demographic variables (RQ2) and voluntariness (RQ3) on implementation leadership.

To test for moderating effects, an interaction term was produced for each interaction of interest, which is the product of the proposed moderator variable and the key predictor variable it is thought to influence [61]. Six interaction terms were computed and used in the regression analyses for each of the 2 outcome variables: implementation leadership × age, implementation leadership × gender, implementation leadership × education, implementation leadership × previous experience with work mHealth applications, implementation leadership × previous experience with nonwork mobile technology use, and implementation leadership × voluntariness. Each interaction term was tested independently in the final model for each outcome variable. Nonsignificant interaction terms were dropped in the final models. As no differences in outcomes were found with comparisons of centered outcome variables (creation of a new variable by subtracting the variable mean so that the new mean is 0) and noncentered outcome variables (preserving the original variable values; the mean will not be 0), this study used noncentered outcome variables to preserve the original scale of the variable, as per the recommendations by Aiken et al [61].

Local effect sizes resulting from the addition of variables to the regression models were calculated for significant variables. A variation of Cohen f^2 as described by Selya et al [62] was calculated using the web-based Soper effect size calculator for hierarchical multiple regression analysis [63], which provides a measure of the effect size of the addition of variables to the regression models [64]. Effect sizes are reported as per guidance by the American Statistical Association [65] and recommendations by various authors [65-67]. Cohen f^2 is a standardized measure of 1 variable's local effect size in the context of a multivariate regression model (ie, the unique proportion of the variance accounted for by the variable of interest) [62,64].

Results

Participant Demographics

There were 388 responses to the survey. After removing cases that did not meet the inclusion criteria (35/388, 9%) or were missing ILS responses (65/388, 16.7%), the final sample out of 388 participants consisted of 288 (74.2%) RNs. Descriptive summaries of participant demographics are outlined in Tables 1 and 2. The proportion of men in the sample (16/288, 5.6%) reflects the proportion of men RNs found in the Canadian RN population in 2019 of 7.5% (range 4.6% [in Prince Edward Island] to 11.5% [in Quebec]) [68]. Most of the respondents were RNs working in large urban settings (163/288, 56.6%) and primarily in hospital (110/288, 38.2%) or community health (117/288, 40.6%) settings.

Although participants were asked to indicate their primary nursing job, they were permitted to provide multiple responses, which resulted in 470 total responses (Table 3). Six practice specialties made up the most commonly reported specialty areas of practice by respondents (331/470, 70.4%). In descending order of frequency, respondents practiced in community or public health, medical, geriatrics or care of older people, emergency care, home care, and surgical nursing, followed by smaller numbers reported for the remaining practice specialty areas.

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Table 1. Participant demographic characteristics (n=288).

Characteristics	Values
Age (years), mean (SD)	41.6 (11.9)
Age group (years), n (%)	
≤29	58 (20.1)
30-39	89 (30.9)
40-49	60 (20.8)
50-59	53 (18.4)
≥60	25 (8.7)
Gender, n (%)	
Women	272 (94.4)
Men	16 (5.6)
Highest educational qualification in nursing, n (%)	
RN[a] diploma	64 (22.2)
Bachelor of nursing degree	195 (67.7)
Master of nursing degree	21 (7.3)
PhD (nursing)	1 (0.3)
Other (eg, advanced practice and specialty diplomas)	7 (2.4)
Years since first obtaining RN license, mean (SD)	16.9 (12.6)

[a]RN: registered nurse.

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Table 2. Participant employment characteristics (n=288).

Characteristic	Participants, n (%)[a]
Canadian province[b] of employment	
British Columbia	33 (11.5)
Alberta	63 (21.9)
Saskatchewan	128 (44.4)
Manitoba	13 (4.5)
Ontario	5 (1.7)
New Brunswick	21 (7.3)
Newfoundland and Labrador	24 (8.3)
Type of population setting[c]	
Large urban population center	163 (56.6)
Medium population center	40 (13.9)
Small population center	36 (12.5)
Rural area	48 (16.7)
Organization type	
Hospital	110 (38.2)
Community health	117 (40.6)
Nursing home or other long-term care facility	31 (10.8)
Other	27 (9.4)

[a]The sums of the characteristics do not equal 288 owing to missing responses and the data are not reported here, as per the conventions of reporting missing data.

[b]The numbers of participant respondents per province do not reflect the distribution of nurses across Canada's 10 provinces and 3 territories.

[c]Large urban population center: >100,000 people (high population density), medium population center: between 30,000 and 99,999 people (high population density), small population center: between 1000 and 29,999 people (high population density), and rural area: all other areas outside of population centers (extracted from Population Centre and Rural Area Classification 2016 [69]).

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Table 3. Respondents' areas of practice (n=470[a]).

Practice specialty of primary nursing job	Respondents, n (%)
Community or public health	86 (18.3)
Medical	68 (14.5)
Geriatrics or care of older people	55 (11.7)
Emergency care	44 (9.4)
Home care	39 (8.3)
Surgical	39 (8.3)
Critical care	27 (5.7)
Maternal	21 (4.5)
End of life	21 (4.5)
Pediatrics	20 (4.3)
Psychiatry or mental health	18 (3.8)
Other	13 (2.8)
Clinical or health informatics	6 (1.3)
Occupational health	5 (1.1)
Primary care[b]	4 (0.9)
Administration[c]	3 (0.6)
Correctional	1 (0.2)

[a]Participants were asked to choose all that apply, resulting in a total frequency of 470.

[b]Primary care was a new category identified in the text responses to the "Other, please describe" option.

[c]Individuals who indicated administration also selected >1 practice specialty area and indicated their work setting to be in a primary care clinic.

Descriptive Statistics

Descriptive statistics of the outcome variables (intention to use and actual use), key predictor variables (implementation leadership characteristics, perceived usefulness, and perceived ease of use), and control variables (voluntariness, previous experience with work mHealth applications, and nonwork mobile technology use) are reported in Table 4. Histograms for the variables perceived usefulness, perceived ease of use, previous experience with work mHealth applications, and voluntariness were skewed; therefore, medians are reported for these variables (unlike means, medians are less sensitive to skewed distributions [59]).

Overall, scores for the outcome variables indicated relatively high intention to use mHealth and moderately high actual use of mHealth among respondents (Table 4). For key predictor variables, the respondent scores indicated moderate perceptions of implementation leadership characteristics related to mHealth implementation. The median scores for the known predictors perceived usefulness and perceived ease of use suggested that respondents moderately perceived mHealth use at work to be useful and easy to use. There was a median of 48.95 months or 4.08 years of experience with work mHealth applications and an average of 162.48 (SD 79.63) months or 13.54 (SD 6.64) years of experience with nonwork mobile technology use. The median score for voluntariness suggested that nurses did not tend to perceive the use of mHealth in their work as voluntary.

The strengths of relationships among the major study variables were assessed via bivariate correlations using Pearson r, point-biserial correlations (r_{pb}), and ϕ correlation analyses. None of the bivariate correlations among the independent variables or among the outcome variables were deemed highly correlated (ie, all r values were <0.8) [57,59,64]. A bivariate correlation matrix among all variables is outlined in Multimedia Appendix 2 [6,8,9,26,35,36,48-52,70,71]. On the basis of the results of the completed diagnostics, assumptions to perform regression analyses were met [59].

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Table 4. Description of model variables.

Characteristics	Values, mean (SD)	Values, median	Values, range
Outcome variables			
Intention to use	6.01 (1.13)	N/A[a]	2.00-7.00
Actual use	37.57 (12.66)	N/A	14.00-70.00
Key predictor variables			
Implementation leadership characteristics	2.13 (1.05)	N/A	0.00-4.00
Perceived usefulness	N/A	6.00	1.00-7.00
Perceived ease of use	N/A	5.25	1.00-7.00
Control variables[b]			
Previous experience with work mHealth[c] applications (months)	N/A	48.95	0.36-339.34
Previous experience with nonwork mobile technology use (months)	162.48 (79.63)	N/A	0.36-342.46
Voluntariness	N/A	2.33	1.00-7.00

[a]N/A: not applicable.

[b]The control variables age, gender, and education were described here.

[c]mHealth: mobile health.

Hierarchical Regression Findings

Intention to Use mHealth Applications

Regression results for the final models predicting intention to use mHealth applications are reported in Table 5.

Model 4 shows that implementation leadership characteristics were not found to have a significant primary effect on nurses' intention to use mHealth technologies (P=.12) after controlling for perceived usefulness, perceived ease of use (known key predictors), voluntariness of use (control variable), nurses' demographic characteristics, and previous experience with mHealth applications and other mobile technologies (control variables). Model 5, which included the interaction term implementation leadership × education, explained 47% of the variance in nurses' intention to use mHealth applications in their clinical practice ($F_{10,228}$=20.14; P<.001). The effect size attributable to the addition of implementation leadership characteristics to model 4 is Cohen f^2=0.01, and the effect size attributable to the addition of the implementation leadership × education interaction term to model 5 is Cohen f^2=0.02; both are considered small effect sizes [72].

In the intention to use mHealth applications models, perceived usefulness (β=.45; P<.001) and perceived ease of use (β=.34; P<.001) were found to be the strongest predictors of nurses' intention to use mHealth applications (sr_i^2=0.41). The addition of perceived usefulness and perceived ease of use accounted for 41% of the variance. A small to moderate effect size (Cohen f^2=0.13) can be attributed to the addition of perceived usefulness and perceived ease of use [72].

Voluntariness was not found to moderate the relationship between implementation leadership characteristics and intention to use (P=.17). Voluntariness (β=−.21; P<.001) was found to be negatively associated with nurses' intention to use mHealth applications in the final model. In other words, if nurses had an option regarding using mHealth applications in their work (ie, if use was voluntary), they had lower intention to use them.

The inclusion of the interaction term in the final model does not allow for the interpretation of the primary effects of implementation leadership on intention to use mHealth applications in the final model [56]. Only the implementation leadership × education interaction term [61] was statistically significant in the final model (β=−.21; P=.03) and was negatively associated with nurses' intention to use mHealth applications. This significant negative β coefficient and the plotted interaction (Figure 2) suggest that education moderated the effect of implementation leadership characteristics on nurses' intention to use mHealth applications.

The interaction plot in Figure 2 depicts simple regression lines that plot implementation leadership characteristics with intention to use mHealth applications for each education group (point-biserial correlation [r_{pb}] between implementation leadership characteristics and nurse education; r_{pb}=−0.16; P=.008). From this figure, it seems that perceptions of higher implementation leadership had a greater influence on the intention to use mHealth applications among nurses with an RN diploma or a bachelor of nursing degree than among those with a graduate degree or other advanced education. Moreover, lower levels of implementation leadership among nurses with graduate degrees were associated with higher intention to use mHealth applications compared with nurses with an RN diploma or a bachelor of nursing degree. However, at higher levels of implementation leadership, nurses with an RN diploma or bachelor of nursing degree showed higher levels of intention to use mHealth applications than those with a graduate degree or other advanced education, not controlling for other variables.

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Table 5. Final regression models predicting intention to use mobile health (mHealth) applications (n=238).

Model and variable	B (SE; 95% CI)	β	*P* value	R^2	ΔR^2
Model 1				0.004	0.004
Gender[a]	−0.10 (0.32; −0.733 to 0.534)	−.02	.76		
Education[b]	−0.12 (0.26; −0.620 to 0.386)	−.03	.65		
Age	−0.00 (0.001; −0.015 to 0.014)	−.01	.93		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.003 to 0.002)	−.05	.53		
Months of previous experience (nonwork mobile technology use)	0.00 (0.01; −0.002 to 0.002)	.02	.78		
Model 2				0.038	0.034
Gender	−0.22 (0.32; −0.849 to 0.410)	−.05	.49		
Education	0.01 (0.26; −0.495 to 0.512)	.00	.97		
Age	−0.01 (0.01; −0.020 to 0.009)	−.06	.45		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.003 to 0.002)	−.03	.64		
Months of previous experience (nonwork mobile technology use)	0.00 (0.001; −0.002 to 0.002)	−.00	.99		
Voluntariness	−0.11 (0.04; −0.177 to −0.033)	−.20	.01		
Model 3				0.451	0.414
Gender	0.10 (0.25; −0.380 to 0.585)	.02	.68		
Education	0.15 (0.19; −0.229 to 0.536)	.04	.43		
Age	0.00 (0.01; −0.011 to 0.012)	.01	.94		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.002 to 0.001)	−.03	.60		
Months of previous experience (nonwork mobile technology use)	0.00 (0.001; −0.001 to 0.001)	.00	.99		
Voluntariness	−0.09 (0.03; −0.145 to −0.035)	−.17	.001		
Perceived usefulness	0.36 (0.05; 0.260 to 0.451)	.42	<.001		
Perceived ease of use	0.29 (0.05; 0.185 to 0.386)	.33	<.001		
Model 4				0.457	0.006
Gender	0.07 (0.25; −0.410 to 0.554)	.02	.77		
Education	0.11 (0.20; −0.273 to 0.496)	.03	.57		
Age	0.00 (0.01; −0.010 to 0.013)	.02	.77		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.003 to 0.001)	−.03	.56		
Months of previous experience (nonwork mobile technology use)	0.00 (0.001; −0.001 to 0.002)	.01	.93		
Voluntariness	−0.11 (0.03; −0.176 to −0.051)	−.21	<.001		
Perceived usefulness	0.37 (0.05; 0.274 to 0.469)	.44	<.001		
Perceived ease of use	0.30 (0.05; 0.201 to 0.406)	.35	<.001		
Implementation leadership characteristics	−0.11 (0.07; −0.240 to 0.027)	−.10	.12		
Model 5[c]				0.469	0.012
Gender	0.07 (0.24; −0.410 to 0.546)	.01	.78		
Education	0.81 (0.36; 0.089 to 1.521)	.21	.03		
Age	0.00 (0.01; −0.009 to 0.014)	.03	.64		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.003 to 0.001)	−.04	.43		
Months of previous experience (nonwork mobile technology use)	0.00 (0.001; −0.001 to 0.002)	.01	.91		
Voluntariness	−0.11 (0.03; −0.174 to −0.051)	−.21	<.001		
Perceived usefulness	0.38 (0.05; 0.281 to 0.475)	.45	<.001		
Perceived ease of use	0.29 (0.05; 0.193 to 0.396)	.34	<.001		

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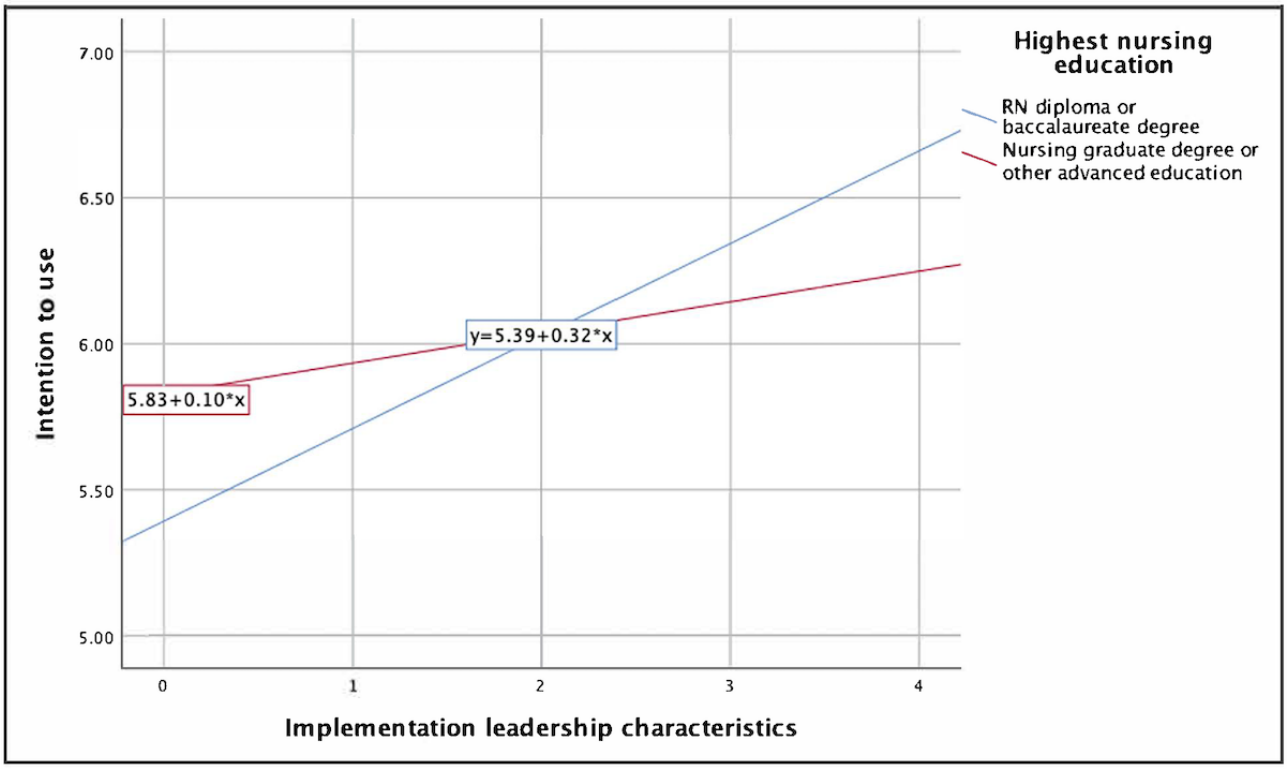
Model and variable	B (SE; 95% CI)	β	*P* value	R^2	ΔR^2
Implementation leadership characteristics	−0.07 (0.07; −0.206 to 0.066)	−.07	.31		
Implementation leadership × education	−0.43 (0.19; −0.811 to −0.054)	−.21	.03		

[a]0=man, 1=woman.

[b]0=registered nurse diploma or bachelor of nursing degree, 1=nursing graduate degree or other advanced education.

[c]$F_{10,228}$=20.14; *P*<.001.

Figure 2. The moderating effect of education on the relationship between implementation leadership characteristics and nurses' intention to use mobile health applications. RN: registered nurse.



Actual Use of mHealth Applications

Regression results for the final models predicting actual use of mHealth applications are reported in Table 6. Implementation leadership characteristics were found to have a significant influence on actual use of mHealth applications over and above control variables and other known predictors in models 4 (β=.22; *P*=.001) and 5 (β=.63; *P*=.002). The final model explained 40% of the variance in nurses' actual use of mHealth applications in their work ($F_{10,228}$=15.18; *P*<.001). A Cohen f^2 value of 0.20 was obtained, which represents a medium effect size attributable to the addition of the implementation leadership × age interaction term [72].

In model 2, gender was statistically significant (β=−.15; *P*=.02) along with voluntariness of use (β=−.38; *P*<.001). Voluntariness remained statistically significant in model 3 (β=−.35; *P*<.001), model 4 (β=−.25; *P*<.001), and model 5 (β=−.26; *P*<.001). Voluntariness was not found to moderate the relationship between implementation leadership characteristics and actual use. The addition of perceived usefulness was statistically significant in model 3 (β=.49; *P*<.001), and its addition to the model (along with perceived ease of use) had a moderate effect size (Cohen f^2=0.33). Perceived usefulness was also significant in model 4 (β=.45; *P*<.001) and model 5 (β=.47; *P*<.001). Perceived usefulness was the strongest predictor of nurses' actual use of mHealth applications (sr_i^2=0.21) in model 3.

The inclusion of the interaction term in the final model does not allow for the interpretation of the primary effects of implementation leadership on actual use of mHealth applications in the final model [56]. Only the implementation leadership × age interaction term was found to be statistically significant (β=−.53; *P*=.03) and had the second largest β coefficient in the final model. This significant negative β coefficient and the plotted interaction in Figure 3 suggest that age moderates the effect of implementation leadership on nurses' actual use of mHealth applications, with implementation leadership having a greater influence on the 3 youngest groups of nurses: those aged ≤29 years (*r*=0.49; *P*<.001), those aged 30 to 39 years (*r*=0.50; *P*<.001), and those aged 40 to 49 years (*r*=0.44; *P*<.001). A potential explanation of the nonsignificant effect of implementation leadership characteristics on the actual use of mHealth applications for nurses aged ≥60 years is that they constituted the smallest group in this sample, increasing the likelihood of a type II error.

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Table 6. Final regression models predicting actual use of mobile health (mHealth) applications (n=238).

Model and variable	B (SE; 95% CI)	β	*P* value	R^2	ΔR^2
Model 1				0.02	0.02
Gender[a]	−0.38 (0.25; −0.870 to 0.116)	−.10	.13		
Education[b]	−0.05 (0.20; −0.446 to 0.338)	−.02	.79		
Age	−0.00 (0.01; −0.011 to 0.011)	.00	.99		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.003 to 0.001)	−.07	.32		
Months of previous experience (nonwork mobile technology use)	−0.00 (0.001; −0.002 to 0.001)	−.01	.85		
Model 2				0.15	0.13
Gender	−0.56 (0.24; −1.026 to −0.097)	−.15	.02		
Education	0.14 (0.19; −0.232 to 0.510)	.05	.46		
Age	−0.01 (0.01; −0.020 to 0.000)	−.10	.16		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.003 to 0.001)	−.05	.47		
Months of previous experience (nonwork mobile technology use)	−0.010 (0.001; −0.002 to 0.001)	−.05	.41		
Voluntariness	−0.16 (0.03; −0.2104to −0.108)	−.38	<.001		
Model 3				0.36	0.21
Gender	−0.31 (0.21; −0.721 to 0.096)	−.08	.13		
Education	0.22 (0.16; −0.109 to 0.539)	.07	.19		
Age	−0.01 (0.01; −0.017 to 0.002)	−.10	.13		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.002 to 0.001)	−.05	.40		
Months of previous experience (nonwork mobile technology use)	−0.00 (0.001; −0.002 to 0.001)	−.03	.62		
Voluntariness	−0.15 (0.02; −0.194 to −0.101)	−.35	<.001		
Perceived usefulness	0.32 (0.04; 0.241 to 0.404)	.49	<.001		
Perceived ease of use	−0.03 (0.04; −0.118 to 0.052)	−.05	.45		
Model 4				0.39	0.03
Gender	−0.26 (0.20; −0.661 to 0.142)	−.07	.20		
Education	0.29 (0.16; −0.032 to 0.608)	.10	.08		
Age	−0.01 (0.01; −0.019 to 0.000)	−.13	.05		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.002 to 0.001)	−.04	.47		
Months of previous experience (nonwork mobile technology use)	−0.00 (0.001; −0.002 to 0.001)	−.04	.50		
Voluntariness	−0.11 (0.03; −0.158 to −0.054)	−.25	<.001		
Perceived usefulness	0.30 (0.04; 0.214 to 0.376)	.45	<.001		
Perceived ease of use	−0.06 (0.04; −0.149 to 0.021)	−.09	.14		
Implementation leadership characteristics	0.19 (0.06; 0.075 to 0.297)	.22	.001		
Model 5[c]				0.40	0.01
Gender	−0.26 (0.20; −0.659 to 0.138)	−.07	.20		
Education	0.28 (0.16; −0.041 to 0.594)	.09	.09		
Age	−0.01 (0.01; −0.011 to 0.028)	−.11	.38		
Months of previous experience (work mHealth applications)	−0.00 (0.001; −0.002 to 0.001)	−.04	.45		
Months of previous experience (nonwork mobile technology use)	−0.00 (0.001; −0.002 to 0.001)	−.05	.41		
Voluntariness	−0.11 (0.03; −0.163 to −0.059)	−.26	<.001		
Perceived usefulness	0.31 (0.04; 0.225 to 0.388)	.47	<.001		
Perceived ease of use	−0.07 (0.04; −0.153 to 0.016)	−.10	.11		

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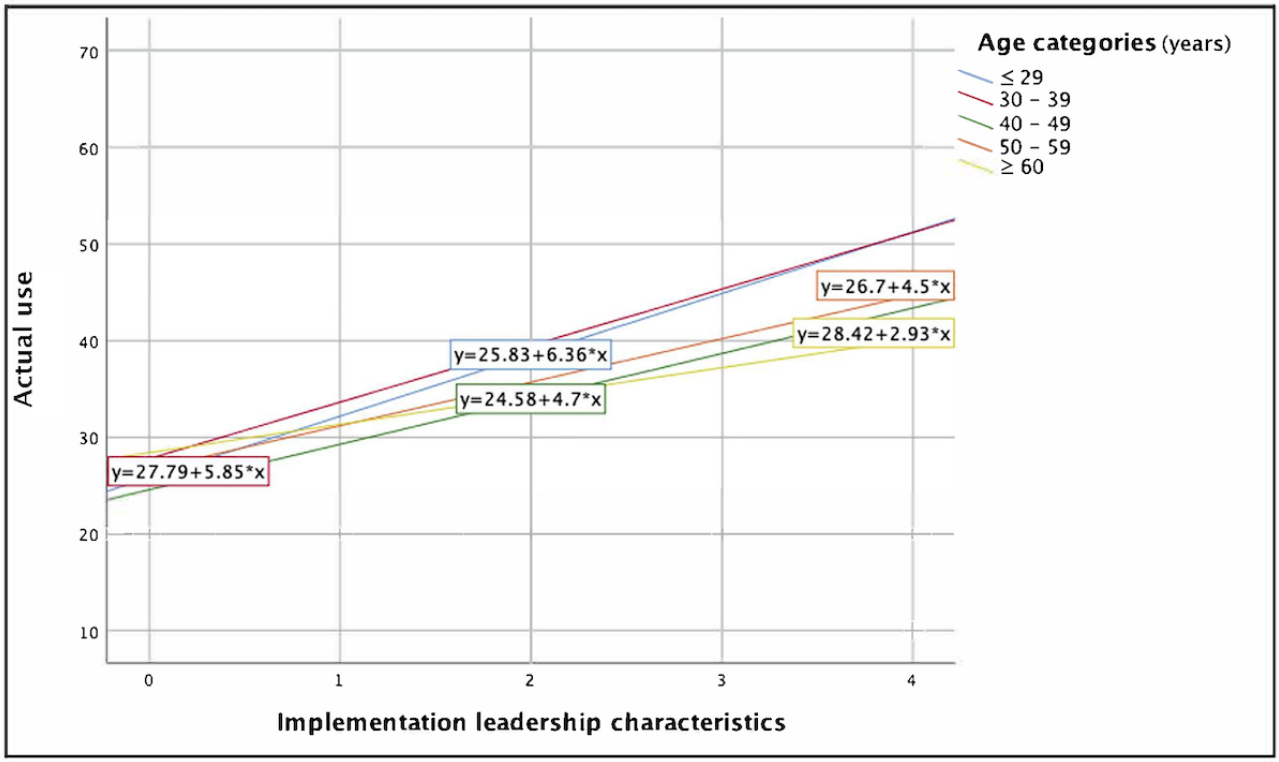
Model and variable	B (SE; 95% CI)	β	*P* value	R^2	ΔR^2
Implementation leadership characteristics	0.54 (0.17; 0.195 to 0.879)	.63	.002		
Implementation leadership × age	−0.01 (0.00; −0.017 to −0.001)	−.53	.03		

[a]0=man, 1=woman.

[b]0=registered nurse diploma or bachelor of nursing degree, 1=nursing graduate degree or other advanced education.

[c]$F_{10,228}$=15.18; P<.001.

Figure 3. The moderating effect of age on the relationship between implementation leadership characteristics and nurses' actual use of mobile health (mHealth) applications.



Discussion

Overview

This was a cross-sectional exploratory correlational study that was conducted to examine the effects of implementation leadership characteristics of first-level leaders, technology characteristics, and nurses' individual characteristics on nurses' intention to use and actual use of mHealth applications in clinical practice. To date, no other studies could be identified that have examined the role of implementation leadership in relation to the intention to use and actual use of mHealth applications in nursing, highlighting the novelty of this study.

There were a number of key findings with respect to intention to use and actual use of mHealth applications among nurses. Greater perceptions of the usefulness of mHealth applications were associated with greater intention to use and actual use of mHealth applications by nurses. Higher perceptions of implementation leadership characteristics were associated with greater intention to use mHealth applications among nurses, with greater influence of implementation leadership among nurses with RN diplomas or bachelor of nursing degrees than among those with graduate degrees or other advanced education. Implementation leadership also influenced nurses' actual use of mHealth applications, with implementation leadership characteristics having a greater effect on nurses aged 29 to 49 years than on those aged ≥50 years. Finally, voluntariness was found to not moderate implementation leadership. These findings are discussed in detail in the following subsections.

The Effects of Perceived Usefulness and Perceived Ease of Use

Perceived usefulness was found to be the strongest predictor of both nurses' intention to use and actual use of mHealth applications to support direct patient care. For intention to use, perceived ease of use was additionally found to be a significant predictor. The significant effects of perceived usefulness and perceived ease of use on nurses' intention to use mHealth applications were expected and in line with results that have been found elsewhere [52,73-75], with perceived usefulness being the strongest predictor of intention to use [9,76]. The large effect size for the addition of perceived usefulness and perceived ease of use suggests that these variables are of practical importance in influencing nurses' intention to use mHealth applications in their practice [77]. These findings concur with those in the systematic review by Gagnon et al [5] that found a

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similar significant importance of these variables on the use of mHealth applications, particularly of perceived usefulness. As such, these results provide support for the importance of evaluating nurses' assessments of the potential contributions and impacts to nurses' provision of direct patient care and workflows of any potential mHealth technologies by organizations before their deployment. Indeed, this provides further support for the need to involve nurses in early or all stages of the system life cycle [78] and the importance of person-centered design [79-81]. The moderate effect size of the addition of perceived usefulness provided support for the importance of assessing nurses' perceptions of perceived usefulness as a necessary part of the planning and implementation of mHealth applications, reflecting the findings of the importance of this variable in shaping the actual use of these technologies in other studies [5].

It was notable that perceived ease of use was a significant predictor of nurses' intention to use mHealth applications but not a significant predictor of nurses' actual use of mHealth applications. These findings are similar to the results of the study by Maillet et al [82], who examined nurses' use of electronic patient records and found perceived usefulness (captured by the concept of performance expectancy [3]) to have a positive and significant influence on nurses' actual use of electronic patient records, whereas perceived ease of use (captured by the concept of effort expectancy [3]) did not to have a significant influence. The authors also found that the link between perceived ease of use and facilitating conditions (which captures some aspects of implementation leadership characteristics) were among the strongest relationships identified [49,82]. Possible explanations for the different relationships between perceived ease of use and intention to use and between perceived ease of use and actual use may relate to discrepancies between behavioral intentions and actual behaviors or the how actual use behaviors are reported [9,83-88] (greater valuing of the usefulness of the mHealth tool may override the perceptions of ease of use [82]).

The Effects of Implementation Leadership on Actual Use of mHealth Applications

Implementation leadership had a strong significant direct effect on actual use of mHealth applications, which suggests that the skills of the person responsible for overseeing the use of mHealth applications are an important consideration when implementing mHealth applications for nurses providing direct patient care. On examination of the interaction variables, we found that age moderated the effects of implementation leadership on nurses' actual use of mHealth applications, where implementation leadership had a greater influence on increasing actual use of mHealth applications among younger nurses than among older nurses. One possible explanation for this finding may relate to the degree of expertise and self-efficacy that develop with increasing age and experience [89-91]. Older nurses may be more likely to have established ways of learning and acculturating to changes in their own practice. As such, they may be less influenced by the implementation leadership behaviors of first-level leaders who are promoting the use of mHealth applications. Another possible explanation for the greater influence of implementation leadership among younger nurses may be that the implementation leadership behaviors of first-level leaders are insufficient to mitigate the barriers that older nurses face in using mHealth applications in practice. Several studies have found that older nurses were more reluctant, less comfortable, and less likely to use HIT [92-94], and it is possible that first-level leaders' implementation leadership characteristics may be perceived as insufficient to support mHealth applications use by this group.

Finally, differences in the measurement of actual use may account for the contradictory findings in this study in comparison with the study by Venkatesh et al [51]. Venkatesh et al [51] used variety and frequency as a measure of actual use, whereas this study used the measure of actual use developed by Doll and Torkzadeh [48], which captures actual use as a multidimensional concept. The use of the measure of actual use developed by Doll and Torkzadeh [48] brings the focus into technology use from the perspective of providing value; Shachak et al [95] suggest that viewing use in the context of the value it adds allows for the linking of use behaviors to specific tasks. In comparison, measuring the frequency and type of use provides limited information and limits the interpretability of results; the question remains as to whether a high frequency of use translates into meaningful use or perhaps reflects challenges in use, which results in a greater amount of time spent using the technology.

Overall, the number of potential explanations for the moderating effect of age on implementation leadership spans a broad range of possibilities, which suggests that there remains a lack of clarity and underdevelopment related to the understanding of the role of age in influencing nurses' actual use of mHealth applications in practice. Similar to the study by Guo et al [96] that found seemingly contradictory effects of personalization and privacy in influencing the use of technologies that varied by age groups, it is likely that there are additional factors influencing the interaction between implementation leadership and age, and the subsequent effects on actual use warrant further exploration.

The Effects of Implementation Leadership on Intention to Use mHealth Applications

Implementation leadership had a weak, nonsignificant relationship with intention to use mHealth applications. However, testing for the effects of interaction variables revealed that education had a significant moderating effect on the relationship between implementation leadership characteristics and nurses' intention to use mHealth applications. This result suggests that implementation leadership characteristics were more influential in predicting nurses' intention to use mHealth applications among nurses with an RN diploma or a bachelor of nursing degree than among those with a nursing graduate degree or other advanced education. A possible explanation is the difference in the levels of autonomy in roles occupied by nurses with advanced degrees [97], thus attenuating the effects of implementation leadership on their use of mHealth applications. However, the proportion of participants with an RN diploma or a bachelor of nursing degree (259/288, 89.9%) compared with participants with a nursing graduate degree or other advanced education (29/288, 10.1%) represents a wide

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difference. In addition to the small effect size, cautious interpretation is required to understand the potential role of the interaction between nurses' level of education and implementation leadership on nurses' intention to use mHealth applications. Although we believe that it remains worth considering that implementation leadership behaviors may need to be tailored to support the different subgroups of nurses rather than taking a *one-size-fits-all* approach to the implementation of mHealth applications, further analyses of the relationships between the dimensions of implementation leadership and level of education are needed to better understand the nature and magnitude of the relationships.

The Effects of Voluntariness on the Use of mHealth Applications

Although it was hypothesized that voluntariness would moderate the effect of implementation leadership characteristics on the use of mHealth applications, it was found that voluntariness did not moderate the effect of implementation leadership characteristics on either intention to use or actual use of mHealth applications. However, standing alone, voluntariness was a significant negative predictor of both intention to use and actual use of mHealth applications, as has been found in some studies [52], including among other health care professionals [98]. These results suggest that when the use of mHealth applications was optional, nurses had lower intention to use and actual use of mHealth applications. There is mixed support for the importance of voluntariness in predicting intention to use mHealth applications and technology [52,99].

With regard to considering the effects of voluntariness on intention to use, a small effect size was found for the addition of voluntariness [64]. This small effect size limits the interpretation of this finding in terms of practical implications [77]. As such, the small effect of voluntariness on intention to use mHealth applications may provide some reassurance when interpreting these results in the context of health systems where the use of HIT systems is typically mandatory and does not allow for voluntariness of use to be considered.

However, when considering nurses' actual use of mHealth applications, a medium effect size was found for the addition of voluntariness, which suggests that there may be moderate practical implications when considering the effects of voluntariness on nurses' actual use of mHealth applications [77]. The practical implications of this finding can be interpreted in different ways. One message that can be gleaned from this finding is that making the use of mHealth applications mandatory in health care settings, which reflects the reality of HIT implementation currently, is necessary to optimize nurses' intention to use and actual use of mHealth applications. Indeed, this approach is the most common method used to conduct implementations of mHealth applications and HIT in health care systems. However, a challenge with this approach is the inability to understand the reasons behind why nurses elect to not adopt and use these *mandatory-to-use* technologies, which is the current status quo. Although individual-level characteristics undoubtedly play a role in shaping use behaviors, broader structural and contextual variables also play an important role.

Another important consideration is the overall inadequate understanding of the role of leadership in influencing technology use in mandatory settings. Indeed, there is little research on voluntary technology use (vs mandatory technology use) as related to HIT in health care systems; voluntariness is more typically examined in the context of enterprise systems in business [100]. One potential interpretation of the inverse relationships between voluntariness and the intention to use and actual use of mHealth applications is that, when given the option, nurses may choose to not use mHealth applications as a result of perceived insufficient support for the use of mHealth applications in practice or poorly designed technologies that do not support nursing practice and workflows [101-107]. Finally, it is important in the interpretation of these results to consider that although voluntariness reduced intention to use and actual use, actual use rates are low among all participants, regardless of whether the use of the technology is voluntary or mandatory.

Limitations

There are some limitations to this study. The first limitation relates to sampling procedures and the resulting composition of the study sample. Respondents were restricted to English-speaking participants, largely excluding French-speaking nurses in Canada. Another limitation is that the breakdown of respondents by province in this study is not representative of the broader Canadian nursing workforce. This was due to the large variability in recruitment success resulting from varied processes for research participant recruitment via RN registration bodies across Canada (Multimedia Appendix 3 [45]).

Another limitation relates to some of the study measures used. First, although the study focus is on first-level leaders, the wording used in the ILS scale is "mHealth applications leader." It is possible that the individuals that nurses view as being the "mHealth applications leader" may not always correspond to a first-level leader as we defined it in this paper, which has implications for nurses' ratings on the ILS. Next, we attempted to mitigate the limitations of the intention-to-use measure by adding a validated instrument to capture actual use. Nevertheless, collecting the system logs of actual use of mHealth applications would provide more accurate measures of the frequency and nature of the use of mHealth applications by nurses and provide additional insight into the potential meaningfulness of each measure of use of mHealth applications; for example, understanding the purpose for the use of mHealth applications as indicated by self-reports can provide insight into whether greater amounts of time spent using the system is a meaningful indicator of the successful use of mHealth applications or whether it shows problems with the mHealth applications. Finally, the use of a web-based survey is accompanied by some limitations. The web-based recruitment and survey approach with nonprobability sampling did not make it possible to estimate response rates and limited the ability to make explicit plans for mitigating low response rates. As such, the limitations of the sampling frame in terms of the ability to represent the national nursing population were anticipated. A related limitation of this study was the inability to pursue the means of recruitment beyond the web-based survey, given budgetary and time constraints. Although low response rates

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were observed among studies conducted in the 2000s, and the suggestion was made that there would be a limited increase in effectiveness in web-based surveys of health care providers in the future [108], more recent studies seem to suggest otherwise; for example, it has been shown that web surveys can achieve high numbers of responses in relatively short periods of time [105,109,110]. Furthermore, other studies that have compared web-based versus paper-and-pencil survey methods provide support for the general equivalency of the response rates that can be achieved with either method of data collection [111,112], as well as other comparable features such as potential for other types of biases [113].

Conclusions

Research in the realm of implementation leadership is moving beyond studying the presence or absence of leadership to studying which specific leadership behaviors are most important and for whom these leadership behaviors are important. A recent review of the concept of implementation leadership characteristics suggests that the concept continues to evolve; nevertheless, it holds potential promise for use in the context of nursing [114]. Along the same lines, a systematic review conducted by Gifford et al [115] focused on managerial leadership and sought to identify leadership behaviors that were associated with supporting research use among nurses. The findings from the review identified a range of leadership behaviors that included being change oriented, task oriented, and relation oriented, as well as being supportive and demonstrating commitment to research-based practices—behaviors that hold parallels with the dimensions of implementation leadership. The results from this study provide support for the attenuated effects of implementation leadership on both intention to use and actual use of mHealth applications in nursing and contribute to the body of work that aims to better understand and delineate what effective leadership behaviors to support the use of mHealth applications in nursing might look like.

Future research can build on the insights from this study by using qualitative approaches to develop deeper understandings of whether the functions and features of mHealth applications match with nurses' cognitive and information flows, nurses' workflows, and support for patient-centered care. Although this study provides detail regarding the nature of leadership in relation to mHealth implementation in nursing, further delineation of the concept of implementation leadership should be explored. In particular, a qualitative exploration of nurses' knowledge of the titles, roles, responsibilities, available resources, and constraints of the first-level leaders responsible for the implementation and ongoing use of mHealth in health care systems may provide important contextual information to aid in interpreting the relationships found between implementation leadership characteristics and nurses' mHealth use. Several other research directions can be explored related to the actual use of mHealth, including examining the relationships in the various dimensions of actual use, relationships between types and functionalities of mHealth and use, and relationships between intention to use and the dimensions of actual use, all of which can contribute to a more nuanced understanding of what a meaningful measure of actual use might be in the context of nursing.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Instrument psychometrics.
[DOCX File , 29 KB - nursing_v6i1e44435_app1.docx]

Multimedia Appendix 2
Variable details.
[DOCX File , 21 KB - nursing_v6i1e44435_app2.docx]

Multimedia Appendix 3
Recruitment details.
[DOCX File , 16 KB - nursing_v6i1e44435_app3.docx]

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Abbreviations

CHERRIES: Checklist for Reporting Results of Internet E-Surveys
HIT: health information technology
ILS: Implementation Leadership Scale
mHealth: mobile health
Nurse LEAD-IT mHealth: Nurse Leadership for Implementing Technologies-Mobile Health
RN: registered nurse
RQ: research question
TAM3: Technology Acceptance Model 3
UTAUT: Unified Theory of Acceptance and Use of Technology

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Original Paper

Underestimated Factors Regarding the Use of Technology in Daily Practice of Long-Term Care: Qualitative Study Among Health Care Professionals

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Abstract

Background: Increasing life expectancy is resulting in a growing demand for long-term care; however, there is a shortage of qualified health care professionals (HCPs) to deliver it. If used optimally, technology can provide a solution to this challenge. HCPs play an important role in the use of technology in long-term care. However, technology influences several core aspects of the work that HCPs do, and it is therefore important to have a good understanding of their viewpoint regarding the use of technology in daily practice of long-term care.

Objective: The aim of this study was to identify the factors that HCPs consider as relevant for using technology in daily practice of long-term care.

Methods: In this qualitative study, 11 focus groups were organized with 73 HCPs. The focus group discussions were guided by an innovative game, which was specifically developed for this study. The content of the game was categorized into 4 categories: health care technology and me; health care technology, the patient, and me; health care technology, the organization, and me; and facilitating conditions. The perspectives of HCPs about working with technology were discussed based on this game. The focus groups were recorded and transcribed, followed by an inductive thematic analysis using ATLAS.ti 9x (ATLAS.ti Scientific Software Development GmbH).

Results: Overall, 2 main domain summaries were developed from the data: *technology should improve the quality of care* and *acceptance and use of technology in care*. The first factor indicates the need for tailored and personalized care and balance between human contact and technology. The second factor addresses several aspects regarding working with technology such as trusting technology, learning to work with technology, and collaboration with colleagues.

Conclusions: HCPs are motivated to use technology in daily practice of long-term care when it adds value to the quality of care and there is sufficient trust, expertise, and collaboration with colleagues. Their perspectives need to be considered as they play a crucial part in the successful use of technology, transcending their role as an *actor* in implementation. On the basis of the findings from this study, we recommend *focusing on developing technology for situations where both efficiency and quality of care* can be improved; *redefining the roles of HCPs* and the impact of technology hereon; *involving HCPs in the design process of technology* to enable them to link it to their daily practice; and *creating ambassadors in care teams* who are enthusiastic about working with technology and can support and train their colleagues.

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KEYWORDS

health technology; eHealth; digital health; nurse; nurse assistant; health care professionals; implementation; adoption; acceptance; competencies

Introduction

Background

Health care is facing great challenges globally. On the one hand, there is increased life expectancy [1], resulting in increasing demand for care [2]. In contrast, there is shortage of qualified health care professionals (HCPs) to deliver this care [3]. In the Netherlands alone, it is expected that there will be demand for an additional 137,000 HCPs (mainly nurses and nurse assistants) by 2032 [4]. In addition, there is a shift in the location of care delivery, and people tend to live long in their own homes (ie, aging in place) [5]. This poses challenges for HCPs working in long-term care, who provide care for older people and people with mental or physical disabilities.

Technology is one of the solutions for bridging the gap between the increased demand for care and the number of available HCPs. Examples of such technologies in the long-term care setting are eHealth, robotics, electronic health records, virtual reality, and artificial intelligence. Their use is rapidly expanding, within both cure and care, and it is envisioned that they will influence the autonomy and independence of patients [6]. This increased use of technology has an impact on several aspects of the total health care system. Primarily, it transforms the way in which patients receive and experience care. Furthermore, it alters traditional financing flows, organizational aspects, and even a wide (political) system [7].

Technology also has an impact on HCPs, as they play an important role in its use [7,8]. Several studies focused on the attitude of HCPs regarding a specific type of health care technology [9,10]. Experience [11], enhanced patient care and safety [12-14], and easy-to-use technology that fits within existing workflows [14] lead to a more positive attitude of HCPs regarding technology. Badly designed and nonoptimal functioning of technology [12,13] contributes to negative attitude toward technology.

The focus on the adoption, use intentions, and behavior of a user regarding a specific technology is reflected in scientific studies [15,16]. Although this focus on adoption and acceptance is valuable, it remains as a narrow. The implementation of technology demands a broad look [17,18], as also seen in technology implementation models [7,19], including organizational variables and consequences of use in daily practice.

Particularly within this broad scope, it is important to have a good understanding of the viewpoint of HCPs regarding working with technology, as it potentially influences several core aspects of their work. First, the use of technology can have an impact on workflow [14,20,21] and workload [22-25] and can even contribute to or reduce clinician burnout [26]. In addition, the use of technology can lead to unintended consequences with possible negative outcomes [27]. Examples of unintended consequences include increased complexity, risk of no follow-up of care, and reduction in communication [22]. Furthermore, technology influences the interpersonal relation between HCPs and patients, leading to the loss of personalization [13]; however, it can also serve to improve communication [14,28,29].

Objective

Thus, although technology can be a solution for bridging the gap between the increased demand for care and the number of available HCPs, it influences several core aspects of the work of HCPs in long-term care. Although some studies focus on patterns of technology adoption by an individual HCP or a specific type of technology, we built upon literature [7,17,19] that emphasizes the need for a more overarching approach to understand how technology influences work in practice. Hence, the research question of this study was the following: which factors do HCPs consider as relevant for using technology in daily practice of long-term care?

Methods

Study Design

An inductive qualitative study based on the thematic analysis approach [30] was used because it is the most fitting method as a result of the limited evidence about factors that HCPs consider as relevant for using technology in daily practice of long-term care. Qualitative data were collected using focus groups, a research method suited for discovering perceptions and feelings about a specific topic and discussing them in a team setting [31]. We used a single-category focus group design, adding data until no new insights were gained [31].

Study Population

This study was conducted on a regional scale in the province of Gelderland in the Netherlands, where 15 long-term care organizations and education institutions worked together in a project focused on improving the digital skills of their employees. HCPs working in these long-term care organizations were invited to participate in this study. The main researcher contacted the care organizations regarding participation. Consequently, the care organizations used convenience sampling to invite participants and to compose a focus group of employees, whereby no detailed demographic data were collected. Some participants already worked together as a team. In general, participants included nurses and nurse assistants, with higher and secondary vocational education, working in a broad range of long-term care settings such as nursing homes for older people and people with mental or physical disabilities. Furthermore, all participants had at least some experience with technology in their work as HCPs.

In this study, 73 HCPs working at 6 different care organizations participated in 11 focus groups. The focus groups consisted of 4 to 11 participants, with most focus groups consisting of 5 to 8 participants, which is seen as the ideal size for this type of study [31].

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Data Collection

The focus group discussions were guided by a nondigital game, which was specifically developed for this study. Each focus group was led by a researcher who acted as a moderator to support the focused discussions. The researcher had no other involvement with the participants. The researcher guided the discussion and was specifically instructed to involve all participants in the discussion, which was also reflected in the design of the game. The focus group discussions had a duration of 60 to 90 minutes and were conducted at the workplace of the HCPs. Participants were able to recontact the researchers through an organization contact person if they wished to share additional views and experiences that had not been shared during the discussion.

Game Design

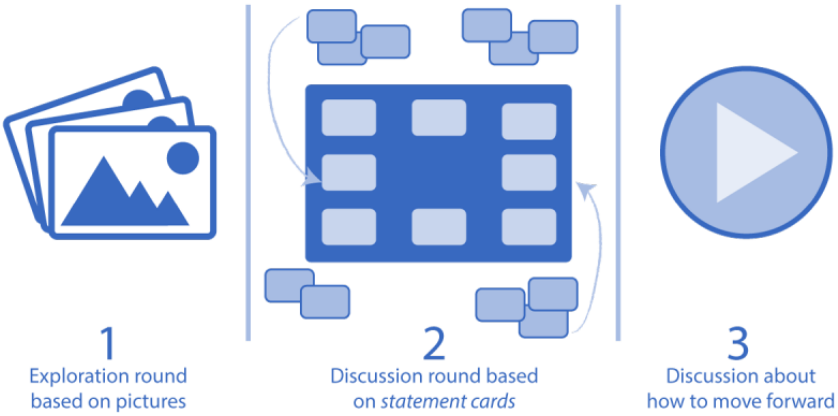
Overview

The aim of the game was to gain insight into the perspectives of HCPs about working with technology. The content of the game was iteratively formulated in close cooperation with HCPs and involved researchers during several meetings and brainstorms. The game was piloted in multiple trial sessions with both the HCPs and researchers involved, before data collection commenced (Figure 1):

Figure 1. Steps taken in creating the game.

The game consists of 3 rounds: an exploration round based on pictures, a discussion round based on statement cards, and a discussion about how to move forward (Figure 2).

Figure 2. Overview of the three rounds in the game.



Round 1

Participants were asked to choose a photo that reflected their view about health care technology. These photos are a standard collection used to evoke associations on a diverse range of topics. Examples included photos of a field of flowers, 2 hands holding each other, and the cockpit of a plane. Consequently, the researcher would accommodate a discussion about the associations and thoughts that the participants came up with in relation to the photos and their view about health care technology.

Round 2

The second round was guided by a set of statement cards (Multimedia Appendix 1). The participants were asked to choose 8 out of 37 cards that they found important in working with technology in long-term care. The content of the cards was divided into four categories: (1) health care technology and me; (2) health care technology, the patient, and me; (3) health care technology, the organization, and me; and (4) facilitating conditions. Every participant received a couple of cards ensuring that everyone was involved in this round of the game. During the process of selecting the cards, the researcher would accommodate a discussion between participants, thereby gaining insights into the motives and thoughts regarding working with technology in long-term care.

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Round 3

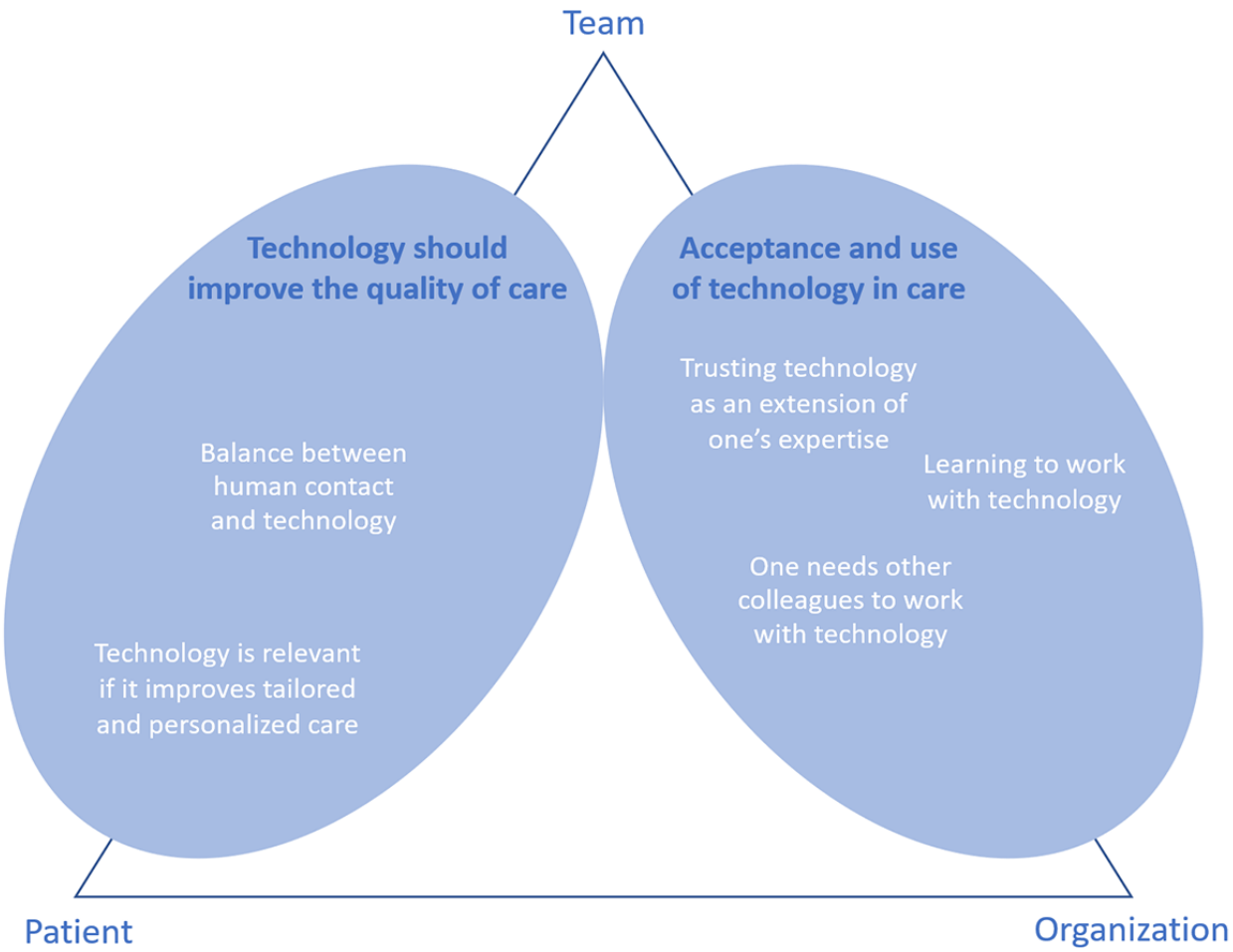
When participants finished their selection of 8 cards, the researcher would ask them what they would like to do or change in their work to accomplish the desired situation. This was done to gain a deep understanding of the opportunities and barriers seen by participants in working with technology in long-term care.

Data Analysis and Quality Measures

The focus groups were recorded, transcribed, and qualitatively analyzed by 3 researchers using ATLAS.ti 9x (ATLAS.ti Scientific Software Development GmbH). The pictures (round 1) and statement cards (round 2) served as a starting point for the discussions in the focus groups, and the recordings of the discussions were in turn used for qualitative analysis.

The thematic analysis consisted of 6 phases as described by Braun and Clarke [30]. First, the focus group discussions were transcribed by a research assistant, and transcripts were read and reread to get a first impression of the whole of the session. As a follow-up, initial codes were generated based on the transcript, followed by collating codes into potential themes. These steps were performed by the first author (SWMG), and 2 other researchers checked the process (MEMdO and HvO-M). After all the 11 focus group sessions were coded and potential themes identified (Multimedia Appendix 2), the 3 researchers jointly reviewed the themes, agreed upon relevant overarching domain summaries [32], and generated a thematic map of the analysis (Figure 3). Where necessary, all authors discussed the interpretations, thereby reaching consensus on the definition and naming of the domain summaries and themes. Consequently, a report was produced including, among other things, a selection of quotes that reflected the views of participants on each theme.

Figure 3. Overview of domain summaries, themes, and layers.



During the research process, several quality measures were pursued [33], such as recording the discussions to ensure proper reporting and involvement of multiple researchers in data collection and data analysis. To get a good understanding of the data, all the authors ensured that all insights were covered when discussing interpretations.

Ethical Considerations, Informed Consent, and Participation

No ethics approval was applied as this study was not subject to the Medical Research Involving Human Subjects Act, participants were not asked to act or to change behaviors, and the questions were not of a drastic nature. The researchers clarified the aim of the study at the start of the focus groups and notified the participants about the audio recording for data analysis. Participants were asked to verbally consent to their

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participation in this study, were guaranteed anonymity, and could contact the researchers through an organization contact person if they wished to share anything else at a later point. All confidential characteristics, such as names, were anonymized in the transcription process.

Results

Overview

On the basis of the thematic analyses, two domain summaries were developed from the data: (1) *technology should improve the quality of care* and (2) *acceptance and use of technology in care*. Both domain summaries consist of several themes; refer to Figure 3 for an overview.

An overarching notion that is recognized throughout the diverse themes was the impression that the use of technology is never an unambiguous task. HCPs see the use of technology as an interplay among patients, teams of HCPs, and the organization of care. These are not themes in themselves but rather aspects that can be seen as layers in gaining a better understanding of the themes. Figure 3 shows a visualization of an overview of domains and themes related to the layers. The domain *technology should improve the quality of care* is about the team of HCPs in relation to the patient, whereas *acceptance and use of technology in care* concerns the team of HCPs in relation to the organization of care. The domains, including themes and examples of quotes, are described in the following sections.

Technology Should Improve the Quality of Care

Overview

During the focus groups, participants emphasized that technology should be used to improve the quality of care. The themes *technology is relevant if it improves tailored and personalized care* and *balance between human contact and technology* were discussed in this regard. If technology did not have an added value for the quality of care or for their clients, HCPs were reluctant to use technology:

> *I believe that technology shouldn't replace the professional. It must add something. I am very open to it, and I like technical gadgets, but it should not be at the expense of quality of care.* [Focus group 2]

Technology Is Relevant if It Improves Tailored and Personalized Care

Participants indicated the importance of tailored and personalized care in relation to the use of technology. HCPs stated that the use of a specific technology is only relevant when it fits the needs of a patient:

> *You have to assess it per client, everyone has a different need for support. We have to discuss if and what technology could work for that specific person.* [Focus group 1]
>
> *Technology should serve the people we work for and not the other way around.* [Focus group 4]
>
> *It doesn't matter what you or I think about a technology, it is about the patient.* [Focus group 5]

Furthermore, participants indicated the difference among patients in relation to the use of technology. For instance, age differences or experience of working with technology were seen as important, as this determines what a patient can and is willing to do with technology. There were also some remarks about the safety aspect of the use of technology in health care:

> *Technology can also offer safety. For instance, we have a motion detector and if someone leaves the department we get a notification.* [Focus group 9]
>
> *Patients are becoming more independent...It gives them a safe feeling they can contact us through a messenger application.* [Focus group 8]

Balance Between Human Contact and Technology

The driving force for the participants to work as HCPs was to help people and to be of significance to them. Personal contact with their patients is an aspect that they love about their job, and technology alters this interpersonal contact. Both drivers of and barriers to this topic were mentioned. On the one hand, technology can be of added value to deliver personalized care and increase quality of care. In contrast, technology could hinder interpersonal contact between professionals and patients, making it more difficult to truly connect with patients:

> *The problem is that you don't really want this at all. I chose to work in healthcare, and I want to work with my hands. You don't want to be busy with these things [technology] at all, you want to work with the people themselves.* [Focus group 1]
>
> *Technology can be of added value for some people, but it also makes people lonelier. If you talk to a video screen, there is no one sitting next to you to drink a cup of coffee with. This feels troubling to me.* [Focus group 1]

In addition to their own involvement regarding the interpersonal aspects of technology, participants also indicated the influence of substitution of care by technology on the related personal aspects for the clients themselves:

> *In the future we will have less time on our hands. I do however find it a bit frightening what this will do to human contact. For instance, I don't see a robot putting an arm around someone in the near future.* [Focus group 7]
>
> *It is a bit troubling but also interesting to think of a robot washing people. I feel it is a bit inhumane.* [Focus group 7]

Acceptance and Use of Technology in Care

Participants also emphasized several aspects regarding working with technology in their job. Multiple aspects of *trusting technology* were discussed, and *learning to work with technology* and *collaboration with colleagues* were also topics of discussion.

Trusting Technology as an Extension of One's Expertise

A prerequisite for using technology in HCPs' work was trust; multiple aspects of this theme were discussed. First, working with new technology requires trust to rely on it. Participants

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stated that they were insecure about whether the technology would work when needed:

> *We blindly trust a piece of technology, but we are not sure if it can be trusted.* [Focus group 3]
>
> *Every time I arrive here, I am worried whether or not it will work.* [Focus group 4]
>
> *For me it is also the feeling of being safe, almost everything uses electricity. What if it breaks down, can we still get someone out of bed?* [Focus group 7]

Another aspect of trust was the lack of confidence in their ability to keep up with the speed of technology innovation. They were afraid of lagging behind if they did not comply with and master these skills. Being a qualified HCP requires new competencies, and not all professionals consciously choose to work with these types of skills:

> *I know I need to continuously keep up with new developments, but if I don't succeed I get nervous.* [Focus group 3]

The last aspect of trust was related to the open character of technology, for instance, in the use of portals for electronic patient records. They were fully aware of this aspect, as family members and informal caregivers can read and follow patient information. If they make a mistake, family members and informal caregivers can see this directly:

> *You have to think carefully what you report in a client file as family can read along in the new system.* [Focus group 1]

Learning to Work With Technology

If there is enough trust, it is important that HCPs know how to work with technology; participants discussed their preferences about learning how to work with technology. First, they indicated that they would like to know which technologies are available, both within and outside their organization. They need help to structure which technologies are relevant and which can add to the quality of care:

> *I would find it easy if there was a simple overview to see what is available. In my experience, there is so much information available that I get confused and I am more likely not to use it than I am to use it.* [Focus group 10]

Second, after HCPs had learned about the available technologies, they indicated the importance of addressing different learning preferences. Some participants want to experiment with technology themselves, whereas some need a colleague to instruct them and others want (written or oral) tutorials:

> *A manual or instruction video doesn't work for me, I have to see it, someone has to show it to me.* [Focus group 2]
>
> *I find it important to try it and to see if it works before we buy it and use it.* [Focus group 1]

Although they found it important, participants emphasized that it takes time to learn to work with technology. In contrast, they expressed that technology can be efficient and saves time if it is used correctly:

> *It takes time to learn, but in the end it can also save time.* [Focus group 2]
>
> *It is very important that you get time to learn [to work with technology], because in healthcare there is a high workload and then learning gets pushed aside fast.* [Focus group 11]
>
> *I spend a lot of time at the computer for work, which is a waste of time. Me and a colleague spent ten minutes working out how to turn on the screen.* [Focus group 4]

There were also many remarks regarding the (difference in) age of HCPs and the effect this has on learning to work with technology. For example, the difference between growing up in a digital or nondigital world and thereby gaining competencies to work with technology were discussed. Participants expected that young HCPs would have more skills in working with technology. Finally, some participants said that they were not interested in learning the skills needed for working with technology as they were approaching retirement:

> *Yes, age is important, it is about what you grew up with. But I also believe it can be learned, no matter how old you are. It is, however, more difficult when you are older.* [Focus group 1]
>
> *I have worked as a nurse for over 40 years. By the time I retire I will have mastered the skills needed.* [Focus group 1]
>
> *Technology can be of added value, but I can't keep up with it and that's fine with me at my age.* [Focus group 4]

One Needs Other Colleagues to Work With Technology

Participants indicated multiple aspects of collaboration during the use of technology in their work. Colleagues were seen both as an important source of information and as a source of support when needed:

> *I don't know everything, but I know I can always ask a colleague. Together we will find a way. I find it very important that we are there to support each other.* [Focus group 3]

Participants indicated the need for a team member who is able to support them with the use of technology, a so-called expert or ambassador. This person should not replace a technical or innovation department, but they could transfer knowledge from these departments in a more accessible way to the care team:

> *I prefer to have a colleague sitting next to me and explaining what I should do in a way that I can understand.* [Focus group 11]
>
> *I would like to have someone in my team that I can consult in case I have any questions. I prefer to ask questions instead of searching on the internet or folders.* [Focus group 9]

The information and communications technology (ICT) department colleagues were specifically mentioned. Participants perceived their help as supportive as they were able to solve problems quickly and effectively. However, HCPs also stated that some ICT professionals do not understand the context of

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health care and do not acknowledge the fact that not all HCPs are technical and thereby fail to give personal support to them adequately:

> *People working at the ICT department are technical people, they think I am stupid.* [Focus group 6]
>
> *If I call the ICT department they take over my pc and fix my problem. However, this is way too fast for me to understand.* [Focus group 11]

Finally, participants commented about the collaboration between colleagues at the board and strategic level and HCPs. They indicated the importance of fine-tuning between goals and plans made at the organizational level and the use of technology in practice:

> *It is about the way they make the plans; we need to participate. Now they develop plans from behind a desk without knowing how it works in practice.* [Focus group 9]
>
> *The colleagues who make the decisions are not aware of our situation. They should come and talk to us.* [Focus group 11]
>
> *For us it is not clear what the policy of our organization is regarding the use of technology, in terms of communication it could be a lot better.* [Focus group 9]

Discussion

Principal Findings

Our findings showed that HCPs are willing to use technology if it improves tailored and personalized care and when it is an extension of their expertise. Furthermore, the balance between human contact and the use of technology is of utmost importance to them. We also found that sufficient trust, expertise, and collaboration with colleagues in using technology in daily practice are important aspects of working with technology from an HCP perspective. A fit between technology, patient, team of HCPs, and the organization of care is important. This means that technology is context dependent and a one-size-fits-all approach is not successful.

Although a vast amount of research is being conducted focused on the adoption, use intentions, and behavior of a user regarding a specific technology [15,16], this study builds upon previous studies of others who took a broad system perspective about technology in health care consistent with technology implementation models [17,19]. This study adds the perspective of experienced HCPs about working with technology in long-term care to this broad scope. In this way, this study provides a detailed insight into the thoughts and motives of HCPs regarding working with technology in long-term care, transcending their role as an actor in using technology.

HCPs find it important that technology adds to the quality of care, an aspect that is also seen in several other studies where it sometimes was defined as the *enhancement of patient care and safety* [12-14]. In this study, HCPs indicated that technology should improve tailored and personalized care. Some overlap is recognized with the *performance expectancy* aspect in technology acceptance models, where it is originally defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" [15]. Improving tailored and personalized care, as indicated by HCPs in this study, could be seen as a form of gain in job performance; however, it is more focused on output quality than on effectiveness or productivity. This overlap was also found by Holtz and Krein [34], who explained productivity in terms of a high standard of care. Moore et al [35] found that using technology actually influenced the distribution of available nursing time. From a management perspective, it is conceivable that technology can be introduced to achieve great work efficiency, but as seen in the results of this study, it can also lead to an aversion to working with technology among HCPs, as technology, in this sense, does not necessarily add to the improvement of tailored and personalized care.

In relation to the quality of care, HCPs also indicate that they are searching for a good balance between human contact and the use of technology, referred to as balancing the human element with technology [36]. A possible explanation for this might be that HCPs find interactions with other people to be important [37], and using technology could lead to less contact, resulting in a negative attitude toward technology [9,13]. A recent systematic review of patients and HCPs' perspectives toward technology-assisted diabetes self-management education also concluded that technology should not replace or hinder human contact [38], with some studies also identifying situations where technology could benefit the process of communication [28,29].

Both these findings raise questions regarding the use of technology in relation to efficiency and quality of care. There is a shortage of qualified HCPs, and the use of technology could possibly help to overcome this challenge by working more efficiently. However, if HCPs maintain the current level of human contact and only use technology when it adds to the quality of care, it is questionable whether technology will actually form a solution. This means that the role of HCPs will probably change.

Consistent with previous studies [7,15,16], several aspects regarding working with technology (such as the role of the organization, influence of the involved patient, knowledge and skills needed to use technology, age, and social influence) were recognized. In this study, these aspects were discussed from the perspective of HCPs. We found that HCPs prefer a direct colleague who can support them with the use of technology (an ambassador). This is consistent with the work of Cain and Mittman [39], who identified the importance of opinion leaders in the diffusion of innovations within health care and others who acknowledge the benefits of clinical champions [40,41]. The preference for an ambassador can also be seen as a form of *social influence* [15]. This study adds indications to use this aspect proactively to stimulate the use of technology by HCPs by creating an ambassador in the team who is enthusiastic about working with technology. There was a strong preference for an ambassador with the same background as the HCP. A possible explanation for this might be found in the in-group and out-group theory [42], as social interactions within the in-group are "more predictable and understood." In practice, ICT

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colleagues are available to support with technical issues. However, HCPs indicate that these colleagues are not able to support adequately because they do not understand the context and situation of an HCP.

Although this study indicates several aspects regarding working with technology, these can (and probably will) change over time. The workforce is continuously evolving, and new generations are finding their way into health care. New HCPs, for instance, those belonging to generation Y (born between 1982 and 2005), are seen as more experienced in working with technology and are considered as having more skills to do so than earlier generations [43]. Furthermore, at this point, there is growing attention on the use of technology in the educational programs of HCPs [44]. In this way, some of the found issues may become less relevant in the course of time as increasing number of professionals become used to working with technology. However, it is important to take the distinction between the use of technology in personal life and in a professional way into account. Furthermore, not only is the workforce changing but technology, organizations, and society as a whole are also continuously evolving and transforming health care. Therefore, we also recommend providing support and training to the current workforce, especially because lifelong learning is considered to be important for practicing nurses [45] and the lack of knowledge and skills is seen as one of the barriers to implementation [25]. A recent scoping review indicated several subjects that should be part of nursing training to enable HCPs to effectively use technology [46] and integrate it into care delivery.

Strengths and Limitations

A strength of this study is the broad involvement of HCPs. The varied participants included nurses and nurse assistants on both higher and secondary vocational education levels. As the care organizations sampled their employees, no detailed demographic and other work-related data were collected on an individual level, and there is a lack of data about nonparticipation. Therefore, it is important to bear in mind that there is a possible selection bias, which could have influenced the results. However, this approach made it possible to get a complete and diverse idea about which factors are relevant to HCPs working in long-term care in a similar composition to their regular teams. The COVID-19 pandemic has accelerated the use of technology in health care [47]; some of our results may have changed owing to this fact, as data were collected before the pandemic (January 2019 to September 2019).

From a methodological perspective, it is worth noting that this study demonstrates the possibility of using a game as a research instrument to discuss thoughts and motives in a focus group setting. The game is a useful tool to stimulate discussion because it invited the participants to share their views in an accessible and playful manner. For further development of the game as a tool, it is recommended that attention should be given to the design in relation to possible information bias.

Implications for Practice

An essential follow-up to this study is the translation of the results into practice. On the basis of the findings of this study, it is recommended that the following aspects should be considered—*the development of technology for situations where both efficiency and quality of care can be improved*. An example of such technology is smart incontinence material [48], where a sensor feels whether a person needs to be changed. This prevents HCPs from having to regularly check the incontinence material, resulting in both efficiency (time saving) and quality of care (avoiding the need for unpleasant checks). Furthermore, it is recommended to *redefine the roles of HCPs* and the impact of technology on their role [49]. Working with technology implicates a renewal of tasks between humans and technology and thereby alters the traditional role of the HCP (ie, balance between human contact and technology). In addition, we recommend *involving HCPs in the design process of technology* to enable them to provide input into the design process and link it to their practice. HCPs can provide suggestions about how to improve technology features [24]. Technical guidelines should be followed, and the practical components of using that technology by HCPs, such as integrating into care pathways, should be incorporated to maximize the chance of successful implementation of technology [7].

Finally, we recommend *creating ambassadors in care teams* who are enthusiastic about working with technology, *supporting and training* the current workforce in working with technology, and incorporating it into educational programs for future HCPs.

Future Studies

The results obtained from this study should be further examined in the future using a quantitative design and a large sample of HCPs, thereby evaluating their completeness. It would be valuable to describe several case studies of care organizations that implement the suggestions and thereby develop scenarios for implementation. Every context is different, and by describing these case studies, more insight can be gathered about the influence of this aspect. Furthermore, technology, organizations, and society are continuously changing, and future studies should take this into account as this can influence the perspective of HCPs.

Conclusions

This paper presents underestimated factors regarding the use of technology in daily practice of long-term care from the perspectives of HCPs. HCPs want to use technology in long-term care when it adds value to the quality of care and there is sufficient trust, expertise, and collaboration with colleagues on using it in daily practice. The outcomes of this study clearly advocate taking the perspectives of HCPs into account as they are a crucial part in the successful use of technology, transcending their role as an *actor* in implementation.

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Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Statement cards used in the focus group.
[PDF File (Adobe PDF File), 56 KB - nursing_v6i1e41032_app1.pdf]

Multimedia Appendix 2
Code tree.
[PDF File (Adobe PDF File), 90 KB - nursing_v6i1e41032_app2.pdf]

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Abbreviations

HCP: health care professional
ICT: information and communications technology

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Original Paper

Sociotechnical Challenges of Digital Health in Nursing Practice During the COVID-19 Pandemic: National Study

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Abstract

Background: The COVID-19 pandemic has accelerated the use of digital health innovations, which has greatly impacted nursing practice. However, little is known about the use of digital health services by nurses and how this has changed during the pandemic.

Objective: This study explored the sociotechnical challenges that nurses encountered in using digital health services implemented during the pandemic and, accordingly, what digital health capabilities they expect from the emerging workforce.

Methods: Five groups of nurses, including chief nursing information officers, nurses, clinical educators, nurse representatives at digital health vendor companies, and nurse representatives in government bodies across Australia were interviewed. They were asked about their experience of digital health during the pandemic, their sociotechnical challenges, and their expectations of the digital health capabilities of emerging nurses to overcome these challenges. Interviews were deductively analyzed based on 8 sociotechnical themes, including technical challenges, nurse-technology interaction, clinical content management, training and human resources, communication and workflow, internal policies and guidelines, external factors, and effectiveness assessment of digital health for postpandemic use.

Results: Sixteen participants were interviewed. Human factors and clinical workflow challenges were highly mentioned. Nurses' lack of knowledge and involvement in digital health implementation and evaluation led to inefficient use of these technologies during the pandemic. They expected the emerging workforce to be digitally literate and actively engaged in digital health interventions beyond documentation, such as data analytics and decision-making.

Conclusions: Nurses should be involved in digital health interventions to efficiently use these technologies and provide safe and quality care. Collaborative efforts among policy makers, vendors, and clinical and academic industries can leverage digital health capabilities in the nursing workforce.

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KEYWORDS

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

Introduction

Background

Health care delivery has greatly changed with the growing adoption of digital health technologies. These changes have impacted nursing practice, as nurses are the largest group of health care providers, representing more than 59% of the world's health care workforce. The World Health Organization has recognized digital health as a critical catalyst to advance universal health coverage. Therefore, embedding digital health in nursing practice can significantly advance the services and

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improve health outcomes [1]. Digital health use in nursing practice has shown significant benefits at the personal and organizational levels, such as improved efficiency in service delivery [2], increased organizational support, and better communication between professionals and patients [3]. However, these are only possible if nurses are equipped with digital health skills and are actively involved in the design and implementation processes. At the frontline, nurses are the connection points between patients and digital health technologies. However, despite this vital communication role, the involvement of nurses in digital health is often low. The key challenges in the efficient use of digital health in nursing are the lack of basic skills and the lack of access to digital health technologies. Although digital health competencies for nurses have been developed by related national and international institutions [4-6], they are not yet formally integrated into nursing practice and education.

The COVID-19 pandemic has accelerated the use of digital health innovations, such as virtual consultations, remote patient monitoring, and digital transformation, associated with the speed of change in providing treatment and care during the pandemic [7]. Nurses were significantly impacted by digital transformation [8,9].

The need for digital health skills in nursing significantly increased after the COVID-19 outbreak [10]. Our previous study acknowledged the lack of global awareness about the skills required by nurses during nursing practice and education to efficiently act in digitally enabled care [11]. Australia's response to the COVID-19 pandemic included rapid implementation of digital health, namely telehealth, in both primary and acute care settings. In 2021, 950,700 telehealth visits were estimated to have been conducted for people aged 55 to 64 years across Australia [12]. The Australian Government provided principles for digital health to ensure continuous high-quality care [13]. However, at the time of conducting this study, it was unclear to what extent these principles were executed in nursing practice and what challenges nurses faced in using the rapidly deployed technologies.

Exploration of digital health use in nursing practice requires consideration that the design and performance of any organizational system can only be understood and improved if both "social" and "technical" aspects are brought together and treated as interdependent parts of a complex system [14]. Nowadays, health care organizations are profoundly affected by technological progress, and a flexible customized change model is required to fit the social network of the specific organization into which technology is being introduced [15].

Significance and Objective

Since the beginning of the pandemic, a large amount of literature has discussed its impact on nursing care, such as the interruption in workflow [16-19], the pressure and mental health issues among nurses [20-26], and the requirement of training [27,28]. Moreover, digital health implementations and their implications for nursing practice, such as telehealth adoption, informatics-related competencies, and the shift to virtual training for nursing students, have been studied [9,11,29]. However, one missing key theme is the processes in which interactions between nurses and technologies occur within the complex health care environment. There is limited clarity regarding the digital health technologies established during the pandemic, the communication between different tools and users, the workflow and processes that impact the data and information produced and the decisions made, the availability of human and financial resources and training to support the workflow, and the policies and regulations in place to inform efficient implementation and use of technologies, as outlined in our previous study [11]. It is essential to comprehend the human, technology, and process-related aspects of these interactions that impact the nursing practice, and it will be evident which competency requirements are needed to meet sociotechnical challenges.

Another missing aspect is knowing the sociotechnical challenges in the digital health pipeline from design to development, implementation, and evaluation, which can impact nursing practice [30]. With the pressure on nursing practice brought by the pandemic, there has been limited time to study nurses' engagement in the design and development of technologies, and even before the pandemic, digital health interventions were only studied at the implementation and utilization stages, with a lack of assessment of usability for integrating technologies into routine clinical care [31,32]. Therefore, there is a lack of user insights and feedback, and thus, it is difficult for developers to establish appropriate strategies for technology development that meet real-world nursing needs.

This study addresses the sociotechnical challenges in nursing practice associated with the digital health transformation during the COVID-19 pandemic, as well as nurses' expectations of digital health competencies in the emerging workforce for providing safe and quality patient care.

Methods

Study Design

The research team comprises digital health and nurse researchers. This national study follows the qualitative research principles suggested for digital health studies [33]. A semistructured interview protocol was developed and pretested with external experts, including academic, clinical, and policy-maker nurses, to refine the protocol before conducting the primary interviews. The protocol contained the following parts:

- Part 1: This part included 3 questions about nurses' roles and years of experience in their current setting and the types of digital health technologies they used during the COVID-19 pandemic, followed by 8 questions concerning 8 sociotechnical aspects, including technical issues related to the hardware, software, and network; nurse-computer interface; content management; training and human resources; communication and workflow; internal policies and guidelines; external factors; and effectiveness assessment for postpandemic use and integration.
- Part 2: This part included 4 questions about the expectations of new graduates regarding digital health competencies to overcome challenges and efficiently apply digital health in nursing practice. The questions were related to awareness,

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theoretical knowledge, practical skills, and competencies for digital health sustainability and integration into practice in the emerging nursing workforce.

Interviews enable researchers to explore a phenomenon in depth through the interviewee's experiences, opinions, and insights [34]. The research topic, study design, and interview protocol development were based on the findings and implications from our previous literature review [11]. The findings reported in the literature review were not necessarily based on nurses' experiences across the entire digital health pipeline or collected from different nurses involved in various stages of the pipeline. This interview study obtained information from various nurses involved in digital health within and outside health care settings regarding the sociotechnical challenges of digital health in nursing practice.

The ethics application and call for participation were undertaken from February to April 2022. The participant recruitment process, data collection, transcription, and analysis were conducted from May to December 2022.

Ethics Approval

This research received human ethics approval from Royal Melbourne Institute of Technology University (ID: 25054), and it is part of a larger translational project that will provide directions for the next stage.

Participant Recruitment

Nurses involved in digital health design, development, implementation, use, evaluation, regulation, and policy making were approached to participate in order to gain a comprehensive understanding of the sociotechnical issues related to the use of digital health in nursing practice. The participant groups included the following types of nurses across Australia:

- Nurses in clinical settings, including chief nursing information officers, clinical educators, and nurses within health care settings who had experienced the use of digital health initiatives for patient care. Participants in this group were labeled with code "C."
- Nurse representatives in digital health vendor companies that partnered with health care settings for digital health implementation. Participants in this group were labeled with code "V."
- Nurse representatives in the government who contributed to policy making for digital health implementation in health care settings. Participants in this group were labeled with code "P."

A call for participation was circulated through the researchers' professional networks in nursing and digital health communities in the country and on social media platforms. Moreover, a snowball sampling technique was used to recruit further participants. The aim was to include up to five participants from each of the 3 clinical nurse categories in the first group and up to three participants in the other 2 groups. Despite multiple calls for participants, no further individuals indicated a desire to participate. As we noted repetition and similarities in participant responses and included a cross-section of geographical locations and nursing contexts, we ceased recruitment. Generalization was not an aim of this research, but adequate data were obtained to answer the research questions through rich and nuanced responses.

Data Collection

Potential participants who expressed interest in participating were contacted to confirm that they met the study inclusion criteria. They were given a participant information sheet and a consent form to sign before the interview. One researcher arranged a date and time for the interview at each participant's convenience.

At each interview, the study purpose, study scope, research questions, and interview structure were briefly explained before asking the interview questions. To ensure consistency, 2 researchers conducted all the interviews via the Microsoft Teams platform (Microsoft Corp). Each interview took between 30 minutes and 1 hour. Interviews were audio recorded and transcribed verbatim.

Data Analysis

The interview transcripts were thematically coded and analyzed manually [35]. Thematic descriptions were coded deductively according to the parts of the interview protocol and analyzed in the following three core categories:

1. Types of digital health services implemented during the pandemic in primary and tertiary care settings.
2. Sociotechnical challenges identified in using digital health in nursing practice. The 8-dimensional sociotechnical model designed by Sitting and Singh [15] was selected to deductively analyze the interviews and explore the interactions between digital health technologies and nurses. This approach was applied to better understand the nurses' experiences 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 technical issues related to the hardware, software, and network; nurse-computer interface; content management; training and human resources; communication and workflow; internal policies and guidelines; external factors; and effectiveness assessment for postpandemic use and integration.
3. Competency requirements to efficiently apply digital health in nursing practice.

The findings were then reviewed by the research team and discussed in multiple meetings to reach an agreement on coding.

Results

Characteristics of Interview Participants

Sixteen individuals participated in the interview (Table 1). Most participants were in the clinical nursing group. They were distributed across 2 primary care settings and 10 hospitals nationwide.

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Table 1. Characteristics of the interview participants.

Participant group	Number	State	Participant ID
Chief nursing information officers	3	New South Wales and Victoria	C1, C2, and C3
Nurses	6	Queensland, New South Wales, Tasmania, and Victoria	C4, C5, C6, C7, C8, and C9
Clinical educators	3	Northern Territory and Victoria	C10, C11, and C12
Nurse representatives in digital health vendor companies	2	Queensland and South Australia	V1 and V2
Nurse representatives in government bodies	2	Queensland and Tasmania	P1 and P2

Types of Digital Health Services Implemented or Expanded During the Pandemic

The pandemic shifted face-to-face appointments to virtual appointments using various technologies. The digital health services mentioned by participants were virtual care, telehealth, telemonitoring, remote patient monitoring, and care at home. These services were either applied to monitor COVID-19 symptoms or to monitor other health conditions remotely. The technologies used in these services included various teleconference platforms, such as Zoom, Microsoft Teams, and Skype; mobile apps; wearable devices; and chatbots.

Health care systems had an urgent need for software systems that could help screen the high volume of patients before hospital admission. Telehealth services enhanced access to care across the country during the pandemic, as outlined by participants V1 and P2.

However, the newness of the technologies used in telehealth and the high load of data produced, which were not integrated with electronic medical records (EMRs), were challenging for nurses.

> *There is probably a cognitive load that started to increase, although those software systems might have improved the efficiency of looking at those the patient in different areas. It's starting to be difficult for some nurses to be able to follow and manage different software at the same time and most of the software is quite new, especially in those last two years, and did not yet integrate to the EMR.* [Participant V1]

There was a disproportionate balance in confronting the pandemic between health care settings that were digitally equipped and those that were not or were at the beginning of digital health adoption. For example, training of nurses was more challenging in settings that had not implemented digital health before, as mentioned by participant P2. In health care settings that had implemented digital health and EMRs for many years, more advanced applications were implemented during the pandemic to augment the existing systems. For example, participant C2 mentioned that mobile devices were provided for nurses to access EMRs from anywhere across the hospital.

Sociotechnical Challenges of Digital Health in Nursing Practice During the COVID-19 Pandemic

The interviewees addressed the sociotechnical challenges they experienced in digital health adoption and use during the pandemic. These challenges are outlined in Table 2.

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Table 2. Participants' perspectives on the sociotechnical challenges regarding digital health in nursing practice during the pandemic.

Sociotechnical aspects	Challenges (participant ID[a])
Technical challenges	• Lack of internet connectivity in distant areas (P1, P2, C7, and C8) • Interoperability challenges among various devices (P1, C2, and C12) • Inability to troubleshoot devices (C1, C7, and C8) • Difficulties in the infrastructure network (C1, C7, C10, and C12) • Difficulties in reporting errors (C4 and C6)
Nurse-technology interaction	• Challenging user interface for immediate clinical actions (P1 and C5) • Fear and demotivation in interacting and using a new technology due to lack of preparedness (V2) • Heavy load of digital documentation and nurse shortage (C3, C6, C8, and C9) • Interaction with various screens in telehealth consultations is overwhelming (C5, C7, and C11)
Content management	• Inability of digital health systems to store and analyze a large volume of collected data (C1 and C12) • Lack of time to manage the digital content for quality assurance (C12) • Lack of access to and use of patient-reported outcome measures to improve remote management (C11)
Training/human resources	• Lack of digital health literacy in the senior nursing workforce (P1, C4, C5, C8, and C9) • Lack of consistent and continuous formal training (P1, C3, C8, C9, and C11) • Lack of time for appropriate training (P1) • More cumbersome training in settings that were new to digital health (P2) • New technologies led to the emergence of new roles for nurses that required new skillsets (C1) • Lack of chief nursing informatics officer roles (P1) • Lack of the use of the informatics workforce in technology implementations (C3 and C4) • Lack of economists' perspectives in digital health business models (C4)
Communication and workflow	• Difficulties in data collection from siloed technologies that are not integrated into the electronic medical records (V1, C9, and C10) • Lack of effective communication among nurses and other stakeholders in using digital health (V1, C5, C6, C7, C10, and C11) • Lack of communication between managers and ward nurses to understand nurse-specific needs in using digital health (V2) • Lack of nurses' involvement in critical decision-making in digital health implementation (C3, C4, C7, and C10) • Interruptions in nurses' workflows due to lack of computers at the bedside (C4) • Difficulty in communication between nurses and patients in using mobile apps (C8) • Challenges in using interpreters in virtual appointments (C8)
Internal policies and guidelines	• Current legislations are not applicable nationwide (P1 and C7) • Lack of an organizational approach to identify the practice problems that can be solved by a particular technology (V1) • Lack of strategies on how to improve access to virtual care for communities with culturally and linguistically diverse backgrounds (C1)
External factors	• Lack of legislation to support data transfer between primary and acute care settings (P2) • Lack of involvement of external experts in using digital health technologies (C4)
Effectiveness assessment for postpandemic use and integration	• Lack of nurse' evaluation of the implemented digital health services (P1 and C12) • Lack of funding for continuous evaluation (P1) • Lack of workforce to know and conduct the evaluation (C1) • Lack of feedback and measurement of nurse performance in digital health systems (C12)

[a]The participant IDs are clarified in Table 1.

Technical Challenges

One of the major technical barriers was lack of internet connectivity in remote areas to enable data exchange and communication in virtual consultations. One of the policy makers (participant P1) and a chief nursing informatics officer (participant C1) mentioned that the current infrastructure was a large barrier to efficient communication.

> *We only have two fiber cables that run between us and the mainland, and interestingly both were cut through recently, so we had no IT on the island, which again shows our vulnerability in this space.* [Participant P1]

> *I think what lets us down sometimes is our infrastructure network in Australia. It lets us down significantly when we're trying to do virtual care and telehealth.* [Participant C1]

Additionally, participants from 2 groups of clinical nursing professionals (participants C1, C4, C6, C7, and C8) mentioned difficulties in troubleshooting and reporting errors.

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Interaction With Technologies

Most of the nursing workforce was not literate enough to use technologies efficiently under emergency circumstances. Moreover, there were challenges related to the design and functionality of digital health technologies, which were not responsive to emergency clinical demands and led to inappropriate use of clinical information.

> *Whatever the product happens to be, on a functional level, is this going to work day to day? No, because we've got 20 clicks to go through and five pages, and it's not workable or you've missed a key element of information that we absolutely need to capture. But there's no way for us to put that in a meaningful way.* [Participant P1]

Health care settings faced a nursing workforce shortage, while there was a high need for digital documentation of the large volume of collected data. Some participants (C3, C6, C8, and C9) reported that data were duplicated and repeatedly executed and stored in various places in the EMR.

> *The key changes around clinical information systems is that you should be documenting once and that documentation is pulled into various places rather than nurses being the workaround to capture that information.* [Participant C8]

Content Management

Various tools collected large amounts of data at the peak of the pandemic, which was overwhelming to nurses, as the current systems did not have the capacity to manage the data appropriately.

> *We had hundreds of patients needing care by nurses, and we and they were overwhelmed by the data that was coming through and the inability to be able to monitor all of the data in a safe way. And some of the challenges we had with our digital systems not being bespoke enough to manage that with the clinical decision support and the alerting in place.* [Participant C1]

Participant C12 was concerned that most of the nurses' time in using digital health tools was spent on documentation, which left no time for quality assessment or analysis and interpretation.

> *We'd spent much time at the end of our shift writing our notes, but we never looked at the content and the quality and that value, what value does it add? Why am I writing that?* [Participant C12]

Moreover, according to participant C11, the use of patient-reported outcomes was lacking, which, if collected efficiently, would help in having a more comprehensive picture of the patient status.

Training/Human Resources

The pandemic emphasized the need for continuous immediate training in digital health beyond the usual training cycles, which requires established plans to support the workforce for prompt changes.

> *Knowing that we have a workforce that can just continually keep pivoting as and when they need to, and they don't get changed fatigue because they're constantly having to relearn. And so this is where I think having dedicated rules in the health system are of benefit to support that work that's going through and can support across the workforce so that you don't feel vulnerable.* [Participant P1]

However, the same participant noticed that none of the digital health implementation failures was directly due to a lack of workforce competencies.

> *So I haven't heard that we've tried to implement something, and we haven't been able to do it because the end user hasn't had the skills to adopt it, and we've had to basically scrap it.* [Participant P1]

A clinical educator (participant C10) said that as most digital health initiatives implemented during the pandemic were still research-based projects, it was a waste of time to allow nurses to participate in such initiatives rather than clinical practice, due to staff shortages.

> *It jeopardizes our workforce supply. I called a number of times for project nurses to be called back to the clinical setting because I felt that it was not a good use of their time at this time.* [Participant C10]

Participant C9 was concerned that even some specialists are unfamiliar with the basics of IT and digital literacy. There was a worry about how these specialists will cope with the digital transformation. Participant P2 mentioned that most of the training for nurses on using digital health is conducted internally in health care settings and not through vendors or by following external digital health policies.

Owing to high demand for technologies and lack of time for providing real individual or group training, digital health vendors moved toward self-help training modules. They provided types of escalation sessions in which users can choose to have individual training (participant V1). This would help enhance autonomy at work and less reliance on the IT team.

In terms of the mode of training, participant C1 suggested the blended approach to respond to nurses with different need levels.

Participant C3 indicated that the health and nursing informatics teams were not actively involved in digital transformation during the COVID-19 pandemic owing to time pressure.

> *The team that led the work for COVID and the transformation in that space didn't leverage the informatics team. Primarily because it was just so fast-moving that it was done with our transformation team.* [Participant C3]

The emergence of new technologies defined new roles and responsibilities for nurses in virtual care and telehealth, such as a digital health coach who provides training to other nurses (participant C1). However, some health care settings did not have the infrastructure to adopt the technologies. Moreover, the nursing workforce might feel unsafe and demotivated when new technology is rolled out.

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> *Nurses won't be interested. They will not feel safe at work. They won't come to work. it's really hard. It's 12 months, if not more, to rebuild that relationship, to come in and train them and promise them that it will work.* [Participant V2]

Communication and Workflow

During the pandemic, there was a massive shift from paper-based workflow to digital forms and activities (participant C1). Health care systems increasingly relied on technologies to help in responding to the pandemic. Technology vendors said the newness of the tools, the high volume of data generated, and the lack of capability among the nursing workforce to use the tools efficiently were challenging.

> *There is no capability to actually have a contingency plan with those tools are failing because they don't have the workforce, they don't have the time to do it.* [Participant V1]

Nurses have the natural skill to communicate with other stakeholders to provide better care outcomes. However, they were not fully involved in digital health implementation due to a lack of analytical and critical approaches for the technical interface, as mentioned by participant V1. Moreover, based on the note by participant C5, it is difficult to communicate with the technical team when accessing virtual care services. There was also a lack of appropriate continuous communication between nurse managers and the nurses within different wards, which led to a different understanding of needs and challenges in using various technologies, as mentioned by participant V2.

The use of siloed technologies that were not integrated led to repeated tasks and duplication, which was time consuming, as mentioned by participant C9.

Internal and External Policies, Guidelines, and Legislation

Current policies did not keep pace with the fast changes of digital transformation, as highlighted by one of the policy makers.

> *Our existing legislation is not responsive to the technology pace. So I think this is something that we're still grappling with because the legislation doesn't change quickly.* [Participant P1]

One challenge for digital health vendors was that nurses often do not have a comprehensive organization-wide understanding of how a particular technology improves the workflow in different departments of a care setting.

> *Most of the time, a lot of nurses are interested in our platform and actually come to us to know more about it. The difficulty here is always about how those nurses can bring this perspective to their organization. Sometimes it's very difficult to understand what is the real problem on the floor. I think the real perspective from the nursing that is sometimes missing in a digital health space is for them to be able to bring to their executive like, these are the problems we need to be solving. And most of the discussions are very high level or very often projects are unsuccessful and not going forward because the executives lack the perspective of what's in it for the clinicians.* [Participant V1]

Another access challenge was raised in regard to virtual care services for people from culturally and linguistically diverse backgrounds. The lack of strategies and policies on how to design and implement virtual care to improve access to these services for this population was more noticeable during the pandemic.

> *They have very different cultural backgrounds and expectations on the way that healthcare is delivered. And I don't think we have fully unpacked what that looks like for those particular groups in our community.* [Participant C1]

Effectiveness Assessment for Postpandemic Use and Integration

Not all of the digital health technologies implemented during the pandemic were evaluated for sustainability and integration with workflow, as outlined by participant P1.

> *The formal evaluation hasn't happened, so there's no written evaluation of these services yet. But looking at the broader applicability to stretch it out beyond its original parameters has certainly taken off because of the success of how we've been able to run it currently.* [Participant P1]

The same participant emphasized that continuous evaluation and changes to IT infrastructure in health care settings are restricted due to financial impacts.

Some health care settings evaluated their virtual care services via the patient experience and patient outcome surveys in order to identify areas for improvement, as noted by participant P2. Moreover, participant C1 mentioned that the digital health technology evaluation requires a workforce to do research on it.

> *We need a workforce to do this and the barriers we have to do this are time and manpower. We don't have enough staff to be able to do the research that we need to do to evaluate this.* [Participant C1]

Competency Requirements for the Future Nursing Workforce

This part of the interview reported participants' expectations of new nursing graduates' digital health capabilities and their ability to use technologies efficiently (Table 3).

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Table 3. Participants' expectations of nursing graduates' digital health capabilities.

Participant group[a]	Expectations (participant ID[b])
Group C	• Students should learn about the rules and regulations of data security, privacy, and social media in using digital health. (C1 and C10) • Students should be taught about nursing digital health capabilities before coming into practice. • Use of academic electronic medical records should be a requirement in nursing programs. (C10) • Nursing students should learn about digital health systems in more detail than only data entry (eg, data exchange, security, and analytics). (C11 and C12) • Students should be taught about real-world digital health challenges in nursing in addition to theoretical concepts. (C11)
Group P	• There is a need for investment in a digitally enabled nursing workforce, as they are the only providers in remote areas of Australia. (P1 and P2)
Group V	• Universities can embed training content about analytics to foster critical thinking and curiosity among nurses about digital health technologies. (V1) • Universities can provide simulated learning experiments for various digital health scenarios. (V1) • The concept of a multidisciplinary approach should be embedded in digital health training to nursing students. They need to learn how to interact with internal and external stakeholders. (V1) • Universities should foster digital health training to be responsive to the new generation of technologies. (V2)

[a]Group C included nurses in clinical settings, including chief nursing information officers, clinical educators, and nurses within health care settings who had experienced the use of digital health initiatives for patient care; Group P included nurse representatives in the government who contributed to policy making for digital health implementation in health care settings; and Group V included nurse representatives in digital health vendor companies that partnered with health care settings for digital health implementation.

[b]The participant IDs are clarified in Table 1.

Clinical nurses and clinical educator groups acknowledged that they do not have enough digital health literacy. However, this will not be the case for most upcoming nursing professionals as they are naturally technology literate owing to their generation being raised with digital technologies. They highlighted the need for practical skills in simulated training so that the future workforce will be able to apply their digital health knowledge and skills in practice. It is critical to invest in a digitally enabled nursing workforce during undergraduate education. This was highlighted by participant P2.

> *An investment in enabling that particular profession to be digitally enabled is important because it assists in dealing with the geographic divide. It allows organizations to have confidence that there's access to health care in a timely manner. For example, improved responses to emergencies and quick access to clinical data for diagnosis. It also allows us to understand the level of service delivery needs of that population when there's a public health emergency and or a burden of chronic.* [Participant P2]

The nurse representatives in the digital health market had similar expectations to those of the clinical nurse group, emphasizing training of detailed content of digital health and improvement of practical skills. A multidisciplinary approach in using digital health was outlined by participant V1 as a critical training need for nursing students.

> *We're in a space where we need to bridge the gap between the different professions that we're not just talking to other health professionals, we're talking to scientists across a very wide variety of topics and be able to transfer, to actually communicate the patient experience to a mathematician that this translates later into a solution that will be applied to the patient.* [Participant V1]

Discussion

Principal Findings

The pandemic brought an unprecedented shift in digital health adoption. Health care organizations began to implement various technologies to help increase the speed of clinical workflows. However, the interview findings showed that most of the clinical nurse participants did not have comprehensive knowledge of the functionality of digital health tools and applications used in their health care settings. They were also not comprehensively involved in digital health implementation processes to fully understand the facilitators and obstacles to efficient use of the technologies. The lack of systematic policies and procedures for digital health evaluation not only makes nurses passive users of the technologies but also prohibits a thorough understanding of sociotechnical issues that need improvements within the nursing workflow [29]. The fast-growing digital health market requires prompt changes in policies to adopt the technologies in health care.

All of the participants indicated that the pandemic interrupted the move from face-to-face care to virtual care, and many staff did not have formal training to cope with these changes. Moreover, most clinical nurses said that they received training from a colleague who had learned it previously instead of receiving formal training. The interviews identified a lack of leadership roles like chief nursing information/informatics officers who can be actively involved in digital health implementation. These professionals can have a pivotal role in coordinating the team and providing necessary training.

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Nurses mainly used digital health technologies during the pandemic for virtual communication with patients and other professionals, remote monitoring of patients with either COVID-19 symptoms or chronic diseases, and training. A study by Isidori et al [9] found similar usage of digital health among nurses in a literature review with a 10-year timeframe that included studies conducted during the pandemic. Nurses experienced difficulties in nursing tasks and workflows when moving from one health care setting to another, where digital health maturity varies.

Gaps in the Nursing Workforce's Involvement in the Digital Health Pipeline

This study intended to explore the experiences of nurses involved in digital health design, development, implementation, use, evaluation, regulation, and policy making. The findings in Table 2 showed that the participants expressed sociotechnical challenges during the implementation and use of digital health technologies in nursing practice, with no indication of the design or development of such technologies requiring modification from their perspectives, which might not have been the core priorities for health care organizations during the pandemic. However, even before the pandemic, there was a lack of evaluation processes in health care settings, which, if conducted, would have revealed more detailed issues that can be considered by digital health technology vendors.

A study showed that devices designed and developed without nurses' inputs negatively impacted nursing workflow and patient safety [36]. The lack of appropriate leadership and internal and external policies on digital health evaluation in nursing practice to provide insights for design or development improvement was reported in this study as a major barrier to nurses' engagement in the effective use of these initiatives. Technology developers and implementers need to understand the complexity of care processes within the nursing practice. Nurses as end users have a vital role in facilitating a shared understanding. This highlights the need for the involvement of nurses in the design and development to capture their experiences and insights into how the technology will respond to their real-world practice needs [37]. This could be leveraged by a strong nursing leadership to shift the organizational culture and provide collaborative work to enable nurses to actively engage in the digital health pipeline and create a feedback loop to facilitate collaboration and provide opportunities to hear nurses' concerns regarding technology usability [38,39]. Design, development, and implementation of digital health without any input from nurses would lead to inefficient workload and burnout that might lead to unsafe care delivery [40].

In general, among the groups of interviewees, the group of clinical nurses expressed the slightest awareness and involvement of digital health interventions in their health care settings. Their knowledge was limited to the technologies used in their department and not in other nursing practices within their care settings. Nurses might have the knowledge needed to improve the application of digital health technologies, but this research showed that they are not involved in the evaluation. Owing to the lack of an assessment, there is no input to return to the vendor for redesigning or improving the development or co-design strategies with nurses [36].

Implications for Nursing Digital Health Competencies

The current nursing curricula lack comprehensive informatics and digital health content about all aspects of the digital health technology lifecycle, which prevents nurses from keeping up with the digital transformation [41,42]. This study showed that most of the clinical nursing groups perceived a lack of competency in digital health. The participants were asked about their expectations of digital health competencies ranging from basic skills, such as only awareness of digital health concepts or theoretical knowledge, to advanced skills, such as practical skills and evaluation. However, their responses were generic and without detailed specifications. Content beyond digital documentation was suggested to familiarize nurses further with the technical functionality and ability for interpretation. To ensure that the nurse workforce contributes to shaping the future of digital transformation, nursing education must embrace related content, and the nursing curricula should be updated to reflect contemporary nursing informatics practices [43].

Comparison With Prior Work

Several qualitative studies have been published since the beginning of the pandemic, and they explored the impact of digital health implementation on nursing practice [29,44-46]. Some studies have discussed telehealth and virtual care interventions in general with less focus on nurses. This study is the first of its kind in Australia to investigate the sociotechnical issues in the digital health pipeline that impact nursing performance, and it involved 5 groups of nurses across the country.

Limitations

The main limitation of this study was the lack of diversity in the geography of the participants from across the country. In addition, this research was conducted in the second year of a pandemic during a time of significant workforce shortage and high clinical demand. It is assumed that these factors influenced the ability to recruit nurse professionals for this study.

Conclusions

The rise of digital health adoption and use in health care settings through the proliferation of various technologies is an essential shift brought on by the pandemic. This interview study explored the level of involvement of nurses and the sociotechnical challenges they face in the digital health pipeline. There is a lack of knowledge, engagement, policies, leadership, and training that has led to various challenges in nursing digital health practice. Future work can dive deeper into the sociotechnical issues for different technologies to provide insights for co-designing tools with nurses, which can meet their needs and provide safe and quality care, and the curricula can be revised to increase digital health competencies in the emerging nursing workforce.

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Acknowledgments

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Data Availability

The data underlying this article cannot be shared publicly owing to the privacy concerns of the individuals who participated in the study.

Authors' Contributions

All authors have contributed substantially to the study's conception and design, and participant recruitment. KL and RA collected the data. KL, SP, RW, LZ, and KBH contributed to the data analysis. RA conducted the interpretation of the data and thematic synthesis of the results, and drafted the article. RW, SP, and LZ revised the manuscript critically for important intellectual content. RA revised and approved the final version and submitted it.

Conflicts of Interest

None declared.

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Abbreviations

EMR: electronic medical record

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Original Paper

Impact of an Electronic Medical Record–Connected Questionnaire on Efficient Nursing Documentation: Usability and Efficacy Study

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Abstract

Background: Documentation tasks comprise a large percentage of nurses' workloads. Nursing records were partially based on a report from the patient. However, it is not a verbatim transcription of the patient's complaints but a type of medical record. Therefore, to reduce the time spent on nursing documentation, it is necessary to assist in the appropriate conversion or citation of patient reports to professional records. However, few studies have been conducted on systems for capturing patient reports in electronic medical records. In addition, there have been no reports on whether such a system reduces the time spent on nursing documentation.

Objective: This study aims to develop a patient self-reporting system that appropriately converts data to nursing records and evaluate its effect on reducing the documenting burden for nurses.

Methods: An electronic medical record–connected questionnaire and a preadmission nursing questionnaire were administered. The questionnaire responses entered by the patients were quoted in the patient profile for inpatient assessment in the nursing system. To clarify its efficacy, this study examined whether the use of the electronic questionnaire system saved the nurses' time entering the patient profile admitted between August and December 2022. It also surveyed the usability of the electronic questionnaire between April and December 2022.

Results: A total of 3111 (78%) patients reported that they answered the electronic medical questionnaire by themselves. Of them, 2715 (88%) felt it was easy to use and 2604 (85%) were willing to use it again. The electronic questionnaire was used in 1326 of 2425 admission cases (use group). The input time for the patient profile was significantly shorter in the use group than in the no-use group ($P<.001$). Stratified analyses showed that in the internal medicine wards and in patients with dependent activities of daily living, nurses took 13%-18% (1.3 to 2 minutes) less time to enter patient profiles within the use group (both $P<.001$), even though there was no difference in the amount of information. By contrast, in the surgical wards and in the patients with independent activities of daily living, there was no difference in the time to entry ($P=.50$ and $P=.20$, respectively), but there was a greater amount of information in the use group.

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Conclusions: The study developed and implemented a system in which self-reported patient data were captured in the hospital information network and quoted in the nursing system. This system contributes to improving the efficiency of nurses' task recordings.

(JMIR Nursing 2023;6:e51303) doi:10.2196/51303

KEYWORDS

nursing system; electronic questionnaire; electronic medical record; medical informatics; EMR; medical records; EHR; health record; health records; nursing; documentation; documenting; usability; self-reported; patient data; questionnaires; data conversion; nursing record; nursing records; data capture; information system; information systems

Introduction

Nurses perform various tasks such as direct care of patients, patient-family relations, documentation, preparation of medications, and meetings, and documentation of electronic health records (EHRs) accounts for as much as 13%-25% of their total work time [1-3]. In general, nurses are required to create records and documents for each patient on the day of admission. Estimations of the contribution to a reduction in documentation time by EHR or computational order vary by study [4,5]. In recent years, there have been some reports on initiatives using new technologies, such as voice recognition; however, they are still in the prepractical stage or have only been demonstrated on a small scale [6,7]. In addition, all these reports are of devices on the provider's side and do not involve patients to reduce the recording time for nurses.

Nursing records contain extensive patient information. When patients are scheduled for inpatient care, they are asked to complete a paper questionnaire on a wide range of activities of daily living (ADL) and habitats. The nurse in charge, sometimes supplementing the patient's responses by interviewing in person, performs a comprehensive nursing assessment of the inpatient, which consists of ADL, instrumental activities of daily living, use of assistive devices and braces, dietary restrictions, appetite, weight change, bedsores, skin disorders, drinking habits, and smoking habits. These assessments are registered in the nursing system as part of the patient profile.

Any report on the status of a patient's health condition that comes directly from the patient without interpretation of the patient's response by a clinician or anyone else is called a patient-reported outcome (PRO) [8]. Questionnaires answered by the patients were also considered a type of PROs. In recent years, PROs have been increasingly collected using electronic devices and are now called as electronic PROs [9]. The integration of PROs into EHRs is difficult [10]; thus, there have been few attempts to integrate PROs into EHR [11-13]. In particular, in Japan, the situation is more difficult because electronic medical records (EMRs) in hospitals are usually on premise and external connectivity is considerably limited. Furthermore, extant reports have not clarified whether the integration can improve the workflow of health care providers. First, although they would be based on patient reports, nursing records are a type of clinical professional record. They are not a verbatim transcription of the patient's complaints. In other words, it is not sufficient to import PROs into the EHR. Appropriate mapping and conversion are required.

In this context, this study developed a novel system in which patient responses to electronic questionnaires are securely captured in the EHR and quoted in the forms of the nursing system in the EMR; it examined whether this system would reduce the time nurses spend completing patient profiles in the nursing system.

Methods

Overview

This study aimed to enable nurses to complete patient profiles with minimal recording work. An overview of this process is shown in Figure 1. The patient profile is one of the nursing records; it is a comprehensive nursing assessment of an inpatient consisting of 77 forms. Conventionally, patients are asked to complete paper-based questionnaires. Subsequently, the nurses interviewed the patients for more information. Finally, the nurse transcribed all data into a patient profile. Using our new method, the patient first responds to an EMR-connected questionnaire. The patient response data are stored on the EMR server and quoted in the corresponding forms of the patient profile in a predefined manner (Intelligent Quotation). Thus, nurses do not need to transcribe patient response data manually. Consequently, the nurse can complete the patient profile by interviewing the patient and completing the remaining parts of the form. The system was implemented using a preadmission nursing questionnaire. The details of this process are described below.

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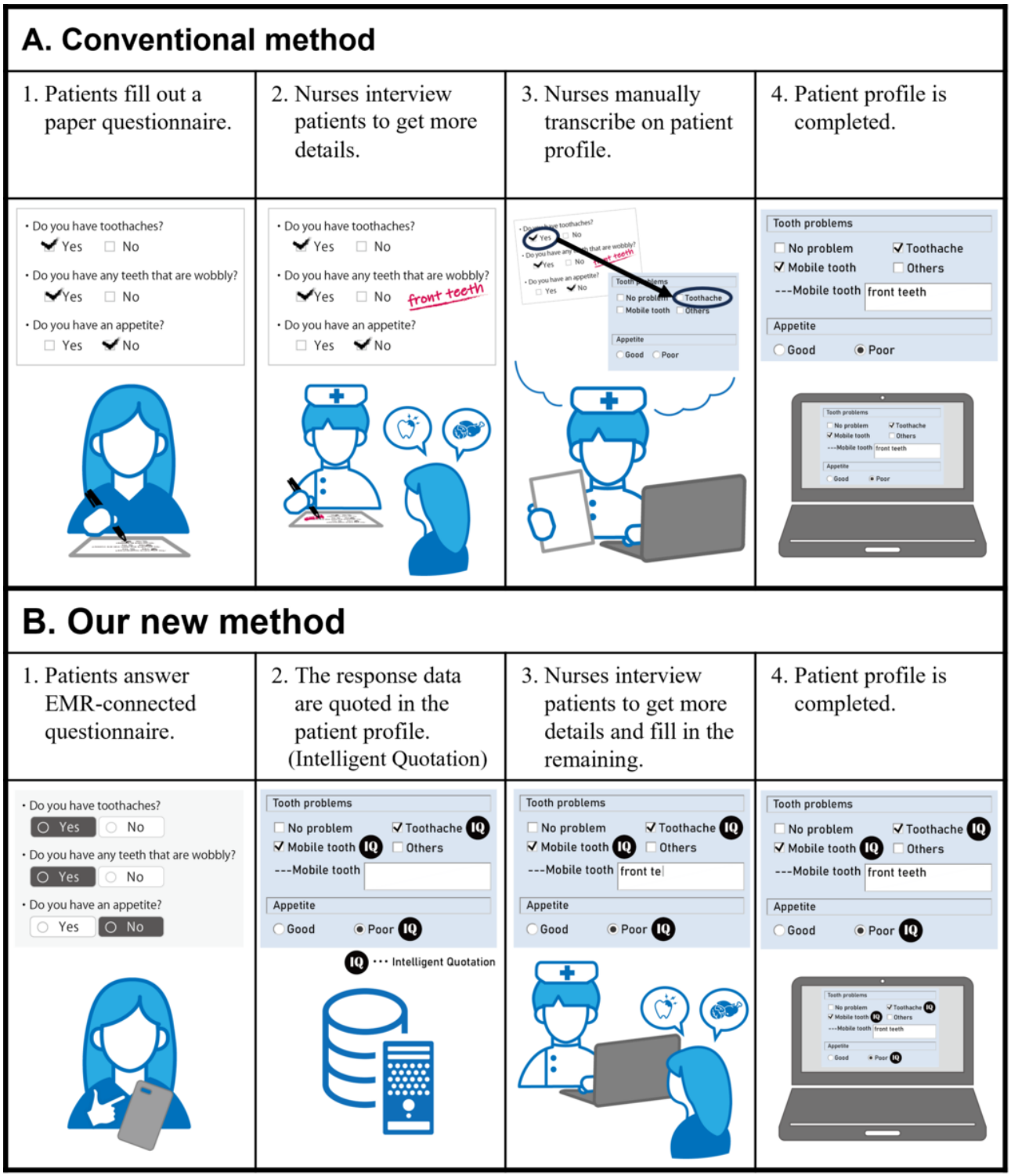
Figure 1. Overview. (A) Conventionally, the patient profile is typically completed as follows: (1) patients fill out a paper questionnaire, (2) nurses interview a patient for more information, (3) nurses manually transcribe the patient profile, and (4) the patient profile is completed. (B) In our new method, the patient profile is typically completed as follows: (1) patients answered an EMR-connected questionnaire, (2) the response data are mapped to the corresponding forms of the patient profile in a predefined manner, which is called Intelligent Quotation, (3) nurses interview the patient for more information and fill in the remaining, and (4) the patient profile is completed. The "IQ" icon indicates the items for which data are quoted from the EMR-connected questionnaire. EMR: electronic medical record.



EMR-Connected Questionnaire System

A web app, EMR-connected questionnaire, was developed and implemented (Figure 2), and patients can answer the questionnaire anywhere using tablets or smartphones. Generally, patients respond to a questionnaire using a hospital tablet connected to the hospital information system (HIS) network. The patient response data were directly transmitted to the HIS questionnaire server in the HIS network. Outside the HIS network, patients can answer the questionnaire via the internet using their smartphones or tablets (Outside-HIS use).

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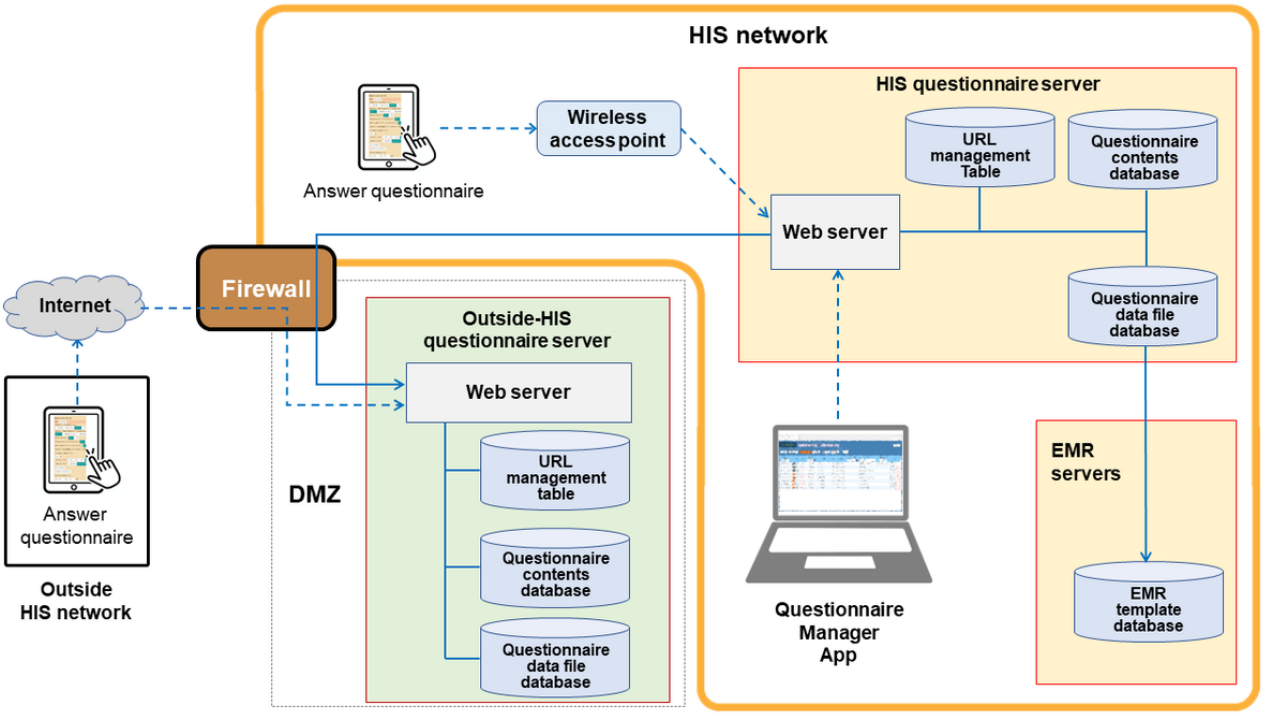
Figure 2. Overall view of EMR-connected questionnaire system. Patients answer electronic questionnaires inside and outside the HIS network, and the data are securely stored within the HIS network and in the EMR servers. EMR: electronic medical record; HIS: hospital information system.



The questionnaire contents were registered in advance using the HIS Questionnaire Server. A unique identifier and URL are generated each time a medical provider specifies the target patient and questionnaire to be used in the Questionnaire Manager App. They did not contain patients' identifying information. They were registered in the URL Management Table in the HIS Questionnaire Server. A QR code with an embedded URL was issued, and when it was scanned by a hospital tablet, the questionnaire content was displayed. The patients answered the questionnaire, and the response data were sent directly to the HIS Questionnaire Server. After the medical provider checks for completeness using the Questionnaire Manager App, the data are registered in the EMR Template Database.

The data flow of Outside-HIS use differs partially from that of HIS Use in ensuring a secure transmission function to acquire patient questionnaire responses. The questionnaire content was registered in advance using the HIS/Outside-HIS Questionnaire Server. As with HIS Use, an identifier and URL are generated each time a provider specifies the target patient and questionnaire to be used in the Questionnaire Manager App. The identifier and URL were written to the URL Management Table on the HIS and the Outside-HIS Questionnaire Servers. However, for privacy protection, patient information was not included in the URL Management Table on the Outside-HIS Questionnaire Server. A QR code with an embedded URL was issued and printed onto the patient. When a patient scans a QR code with their smartphone at home or elsewhere, the content is displayed. The patients answered the questionnaire, and their response data were transmitted through the firewall to the Outside-HIS Questionnaire Server. For security reasons, firewalls do not accept external connections. Response data from the Outside-HIS Questionnaire Server were transmitted into the HIS Questionnaire Server. Subsequently, the data file was removed from the Outside-HIS Questionnaire Server. Patient information was assigned by referring to a URL Management Table. The subsequent process was the same as that for HIS Use.

Through these processes, the patients' questionnaire response data were stored as XML in the EMR Template Database. The stored data can be further quoted for applications such as nursing systems and progress notes in the EMR [14].

Preadmission Nursing Questionnaire

The contents of the electronic medical questionnaire were created arbitrarily according to the intended use. The study had already implemented a system for the preadmission nursing questionnaire. One of the researchers of this study, a registered nurse, selected items from the patient profile, that were easy for patients to answer using electronic devices, converted them into patient-friendly wording, and drafted the questionnaire. Further discussions with the nursing staff led to brushing up on the preadmission nursing questionnaire. It consists of 15 questions regarding ADLs (seeing, hearing, walking, changing clothes, bathing, toileting, etc), weight change, dietary restrictions, drinking habits, and smoking habits. As the items in the questionnaire change depending on the answers, the patient may be asked to respond to another layer of detailed questions. Patients answered a minimum of 15 items and a maximum of 53. Most questions were single- or multiple choice questions. Some items, such as the amount of weight change, were answered by entering numbers on the screen using the keypad. The patients could answer the questionnaire in the hospital or at home as per their preference.

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Intelligent Quotation of Questionnaire Response Data in Patient Profiles

Hospital nurses performed a comprehensive nursing assessment of the inpatients based on Gordon's Functional Health Patterns [15]. The assessment is registered in the nursing system as a patient profile using single choice, multiple choice, or text-entry forms. The patient profile comprised 77 sections including health perception/health management, nutrition, elimination, physical activity and exercise, sleep and rest, cognition and perception, self-perception and self-concept, role and relationship, sexuality and reproduction, coping or stress tolerance, and values and beliefs (see Table S1 in Multimedia Appendix 1). Assessment items in each section were added depending on the patient.

As mentioned above, when a patient answers an electronic questionnaire, the data are stored in an EMR database. When the nurse creates a patient profile, the application is launched with the patient's response data already mapped to some of the corresponding templates of the forms that create the patient profile. In the mapping, the following well-designed methods were used to ensure that the patient self-reports were accurately reflected in the nursing records. Thus, nurses could fill in the remaining portions and, if necessary, correct the mapped data. In 20 of the 77 sections, the patient response data were quoted to a greater or lesser extent using the following techniques: from the perspective of Gordon's functional health patterns, quotes were set up in 5 of the 11 patterns: health perception or management, elimination, physical activities or exercise, nutrition or metabolism, and cognition or perception. No quotations were provided for the remaining 6 patterns: sleep and rest, self-perception and self-concept, role and relationships, sexuality and reproduction, coping or stress tolerance, or values and beliefs.

Converting to Medical Terminology and Aggregation of Information

The electronic questionnaire was patient oriented and contained redundant patient expressions. These were appropriately mapped to the corresponding medical terms in the nursing system (Textbox 1). The nursing system also gathered information by integrating the responses to several questions in the questionnaire (Figure 3).

Textbox 1. Expression in the electronic medical record-connected questionnaire and corresponding terminology in the patient profile on the nursing system. Redundant expressions for patients in the electronic medical record-connected questionnaire are converted to appropriate terminology in the patient profile on the nursing system.

Electronic medical record–connected questionnaire

- I can do it myself
- I can do it with someone's assistance
- I cannot do it myself
- Do you have trouble hearing in your daily life?
- Have leg weakness
- Told by a doctor not to put weight on either leg
- Spend most of my time on the bed

Patient profile in the nursing system

- Independent
- Needs help
- Unable
- Hearing impairment
- Lower extremity weakness
- Weight-bearing restriction
- Activity intolerance

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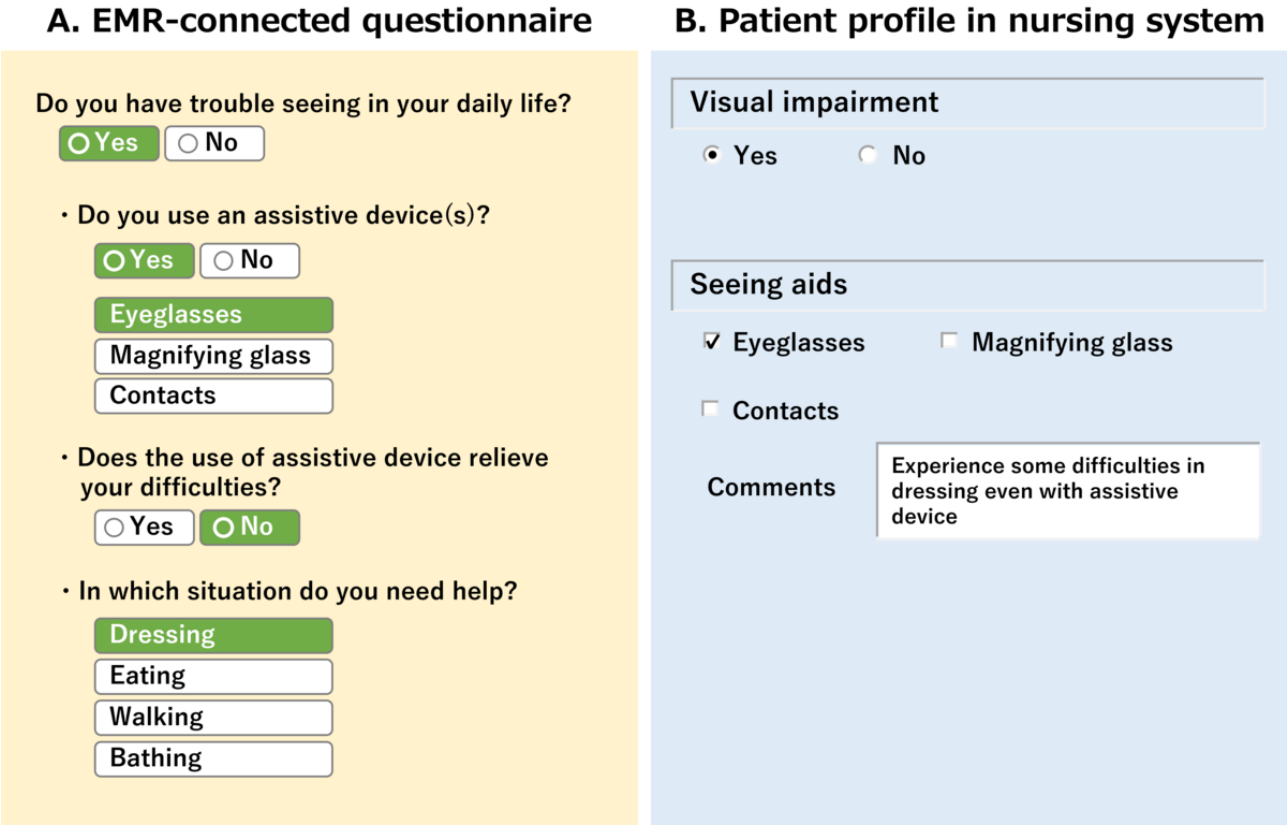
Figure 3. Gathering information. (A) In the EMR-connected Questionnaire, a patient answers the questions sequentially. (B) The response data are mapped to the corresponding items in the patient profile of the nursing system. Some responses are combined into one. "Comment" is also generated by integrating the answers to the two questions, whether and when they have difficulties even with assistive devices. EMR: electronic medical record.



Calculation

Patient responses to electronic questionnaires can be used to calculate the clinically relevant indicators in the nursing system. For example, smoking duration can be calculated from patients' answers regarding the age at which they started smoking and the age at which they quit smoking. The amount of alcohol intake per day and alcohol units (20 g of alcohol is defined as 1 unit in Japan) can also be calculated from the patients' answers regarding their drinking habits (Figure 4).

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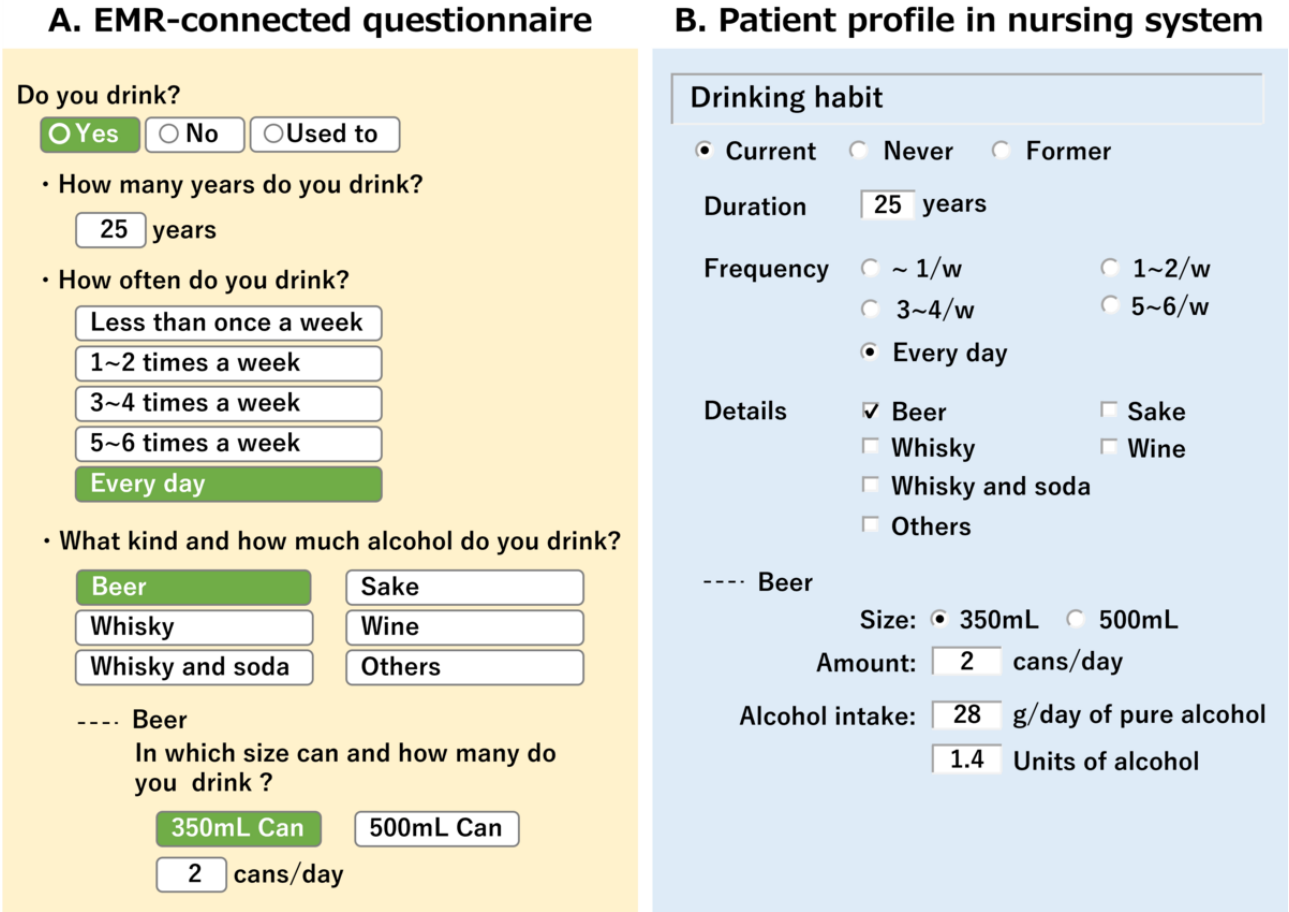
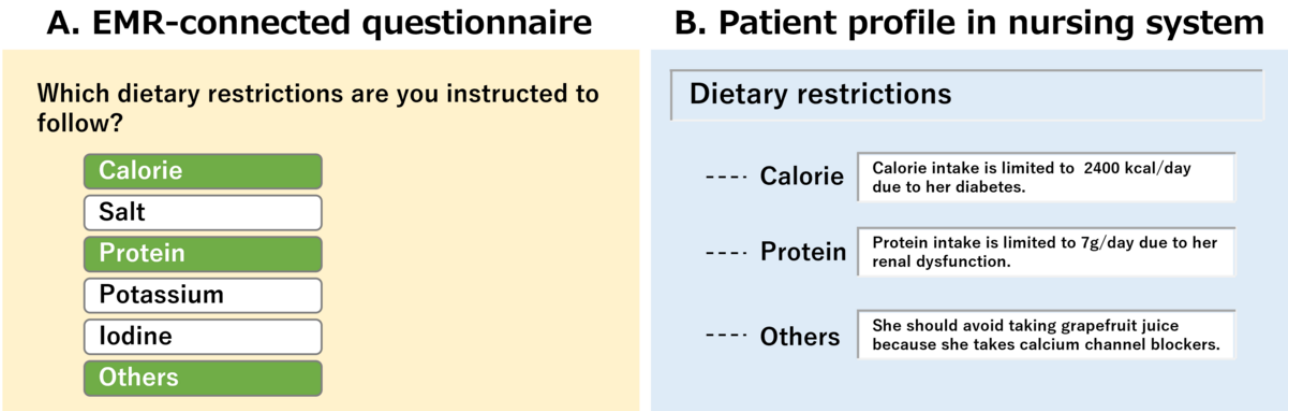
Figure 4. Calculation. (A) In the EMR-connected questionnaire, a patient answers the details about their drinking habits. (B) In the patient profile, the amount and units of alcohol intake are automatically calculated based on the patient's answer. For beer, pure alcohol is calculated by the equation: volume of can×number of cans×0.8×0.05. One unit of alcohol is equal to 20 g of pure alcohol. EMR: electronic medical record.



Combination of Quotation and Direct Interview

Given that electronic questionnaires were answered using tablets or smartphones, they were not suitable for patients to answer in detail using text input. For some assessment items, the patients first answered the electronic questionnaire's multiple choice questions, and the responses were quoted in the nursing system. However, further details are lacking in this regard. Therefore, the nurse conducted a focused interview to obtain details that should be registered in the patient profile (Figure 5). Thus, the patient profile was efficiently completed by combining the quotations of the questionnaire response data and the nurses' interviews.

Figure 5. Combination of quotation and direct interview. (A) In the EMR-connected questionnaire, a patient answers what dietary restriction they have. In this example, calorie, protein, and others are chosen. (B) In the patient profile, a textbox for manual typing appears according to the patient's response. In this example, text boxes for calories, protein, and others appeared. Details are filled in the boxes after nurses conduct a focused interview with the patient. EMR: electronic medical record.



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Usability Assessment

Usability was measured according to criteria defined by the ISO (International Organization for Standardization) 9241-11 standard [16]. A survey was administered to patients who completed an electronic medical questionnaire. The effectiveness was evaluated based on whether the patients answered the medical questions. Regarding satisfaction, the patients rated the ease of entry and their willingness to use the system again on a 5-point scale. Patient attributes such as age and sex were extracted from the EMR.

Contribution to Reduction of Input Time for Patient Profiles

The time nurses spent on the day of admission, as well as the following day entering the comprehensive inpatient assessment into the nursing system (input time), was calculated using the operation logs of the EMR system for cases with scheduled admissions from August to December 2022. Patients previously admitted to the hospital were excluded from the study. The total time was calculated when the nurse created the patient profile in several small steps. Nurses' EMR tasks are sometimes interrupted by other priority events, leading to task switching [17]. If a nurse was in the middle of entering the patient profile and left without saving it or logging out, the input time may have been overestimated. Therefore, input times 3 times greater than the mean by SD were considered outliers and excluded from the analysis. However, the study also conducted an analysis that did not exclude outliers and discussed them in the supplementary text. Patient attributes such as age and sex were extracted from the EMR.

Patients were divided into 2 groups according to whether they had completed a preadmission electronic questionnaire. Between the 2 groups, the number of single and multiple-choice questions and characteristics entered into the comprehensive inpatient assessment and the patient's profile, such as age, sex, cognitive impairment, and admission ward category, were analyzed. Cognitive impairment was collected from diagnosis procedure combination data [18]. Patient ADL on admission and prolonged hospitalization were also included in the analysis as indicators of case complexity. The bedriddenness rank is a reliable ADL scale scored by medical professionals [19]. It consists of 4 major categories: J, A, B, and C (J being independent and A, B, and C indicating less independence in that order). In this study, category J was defined as independent ADL and the others were dependent ADL. A prolonged hospital stay was defined as a case in which its hospital stay exceeded period 2, that is, the average hospital stay under the diagnosis procedure combination code [18]. Moreover, "years working in nursing" and "EMR use duration > 3 years" were also analyzed.

Ethical Considerations

This study conformed to the ethical guidelines outlined in the Declaration of Helsinki. The study protocol was approved by the Ethical Review Board at Osaka University Hospital (20247). All patients in the effectiveness and satisfaction assessments were given an adequate explanation and provided their informed consent electronically. In the efficacy assessment, individual consent was waived with the permission of the ethics committee; however, participants were given the right to veto consent by opting out.

Statistical Analysis

R (version 4.2.2; R Foundation) was used for the statistical analysis. Continuous variables were expressed as medians and quartiles, and categorical variables were expressed as frequencies and proportions (%). The Wilcoxon rank-sum test was used to test continuous variables, and the Pearson chi-square test was used to test categorical variables. The Cochran-Armitage test was used to test the trends of the proportions.

Results

Usability Assessment

Responses were obtained from 4083 patients scheduled for hospitalization between April and December 2022 who agreed to participate in a usability survey. They had a median age of 60 years; 2073 (51%) were men, and 3613 (92%) were daily users of smartphones, tablets, or personal computers. Of all patients, 3111 (78%) completed the electronic medical questionnaire by themselves. Factors associated with patients requiring assistance completing the questionnaire were not being comfortable using digital devices (P<.001) and patient's age (responses by proxy aged <20 years and in their 20s, 30s, 40s, 50s, 60s, 70s, and ≥80 years were n=407, 80%; n=18, 10%; n=9, 4%; n=15, 3%; n=27, 4%; n=55, 8%; n=187, 20%; and n=183, 49%, respectively; P<.001). When patients did not respond, their parents responded on their behalf for patients younger than 20 years and their children for those older than 70 years. Proxy respondents consisted of parents (n=398, 98%) for patients younger than 20 years and children (n=231, 62%) and spouses (n=79, 21%) for those older than 70 years. Of the patients who answered the electronic questionnaire themselves, 2715 (88%) gave a score of 4 or 5 for ease of entry, and 2604 (85%) gave a score of 4 or 5 for their willingness to use it in the future (Table 1). Factors associated with patients who reported an ease of entry score of 3 or less were being an older adult (P<.001) and not being habituated to using digital devices (P<.001).

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Table 1. Surveys on ease of entry and willingness to use again for patients who answered the questionnaire themselves[a].

Score	Ease of entry, n (%)	Willing to use it again, n (%)
5	2020 (66)	1982 (65)
4	695 (23)	622 (20)
3	304 (9.9)	348 (11)
2	21 (1)	60 (2)
1	32 (1)	31 (1)

[a]5 is the highest score and 1 is the lowest score.

Contribution to the Reduction of Input Time for Patient Profiles

Of the 2425 cases, 57 were excluded from the analysis because the input time was an outlier. Of the remaining 2368 cases, 1287 were in the use group and 1081 were in the no-use group; the use group had a shorter input time, more multiple choice questions, and more text-entry questions with more characters entered than the no-use group (Table 2). There was no difference in age, sex, prolonged hospital stay, or cognitive impairment between the 2 groups, but there was a difference in the admission ward and patient ADL. Subsequently, a stratified analysis was performed according to the admission ward and patient ADL. In the analysis by admission wards (Table 3), there was no difference in the number of questions or characters in the patient profile between the 2 groups in the internal medicine ward. Nonetheless, the use group took less time (2 minutes, 18%) to complete the profile than the no-use group. By contrast, in the surgical wards, there was no difference in the input time between the 2 groups, but the number of questions and characters in the patient profiles created by the use group was greater than those in the no-use group. In the analysis by patient ADL (Table 4), there was no difference in the input time in the patient with independent ADL, but the number of questions and the number of characters in the patient profiles created by the use group was greater. Conversely, in the patient with dependent ADL, the use group took comparatively less time (1.3 minutes, 13%) to complete the patient profile. An analysis using all measurements without excluding outliers in the input time was also performed, and the results were similar (Tables S2-S4 in Multimedia Appendix 1).

Table 2. Time required for nurses to enter patient data in the nursing system.

Characteristic	Use group (n=1287)	No-use group (n=1081)	*P* value
Patient age (year), median (IQR)	58 (41-73)	56 (33-73)	.14
Patient sex (male), n (%)	592 (46)	489 (45)	.71
Independent ADL[a], n (%)	885 (84)	703 (74)	<.001
Prolonged hospital stay, n (%)	666 (54)	527 (52)	.37
Cognitive impairment, n (%)	89 (6.9)	82 (7.6)	.54
Single-choice items registered, median (IQR)	56 (50-63)	56 (50-63)	.25
Multiple choice items registered, median (IQR)	16 (12-20)	15 (11-19)	.03
Sum of characters entered, median (IQR)	237 (152-353)	208 (139-299)	<.001
Input time (minutes), median (IQR)	9.4 (6.2-15.0)	10.1 (6.6-16.7)	.007
Ward, n (%)			<.001
Internal medicine	593 (46)	266 (25)	N/A[b]
Surgery	694 (54)	815 (75)	N/A
Years working in nursing, median (IQR)	4.7 (2.4-12.4)	4.6 (2.2-10.6)	.26
EMR[c] use duration > 3 years, n (%)	834 (65)	690 (64)	.62

[a]ADL: activities of daily living.

[b]N/A: not available.

[c]EMR: electronic medical record.

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Table 3. Time required for nurses to enter patient data in the nursing system stratified by the patient wards.

Characteristic	Use group	No-use group	*P* value
Internal medicine, median (IQR)			
Single-choice items registered	55 (49-63)	54 (49-63)	.78
Multiple choice items registered	15 (12-19)	15 (11-19)	.49
Sum of characters entered	222 (144-331)	216 (122-332)	.27
Input time (minutes)	8.9 (6.0-14.6)	10.9 (7.1-19.0)	<.001
Surgery, median (IQR)			
Single-choice items registered	56 (50-64)	57 (51-64)	.47
Multiple choice items registered	16 (12-20)	15 (11-19)	.01
Sum of characters entered	253 (163-368)	208 (143-288)	<.001
Input time (minutes)	9.7 (6.4-15.5)	10.0 (6.6-16.2)	.50

Table 4. Time required for nurses to enter patient data in the nursing system stratified by the patients' activities of daily living.

Characteristic	Use group	No-use group	*P* value
Independent ADL[a], median (IQR)			
Single-choice items registered	56 (50-63)	56 (51-64)	.33
Multiple-choice items registered	16 (12-20)	15 (11-19)	.01
Sum of characters entered	243 (160-353)	201 (138-272)	<.001
Input time (minutes)	9.5 (6.4-15.0)	10.0 (6.5-16.5)	.20
Dependent ADL, median (IQR)			
Single-choice items registered	54 (48-61)	54 (48-62)	.53
Multiple-choice items registered	14 (10-19)	15 (10-19)	.89
Sum of characters entered	232 (135-337)	234 (131-361)	.82
Input time (minutes)	9.1 (5.8-13.0)	10.4 (6.6-18.0)	.006

[a]ADL: activities of daily living.

Discussion

Principal Results

This study developed an EMR-connected questionnaire system in which patients could answer electronic questionnaires inside and outside the HIS network, and the questionnaire response data were transmitted securely to the EMR servers. It also developed an intelligent quotation of the response data in the nursing system. Furthermore, most importantly, it demonstrated that these systems could reduce documentation time for nurses.

Nursing records include various patient assessments, vital signs, and nursing care records. This study focused on patient assessments at the time of admission. Overall, the study showed that quoting responses to electronic questionnaires reduced input time (Table 2). However, the content and volume of patient assessments may vary depending on diseases and patient ADL. Therefore, stratified analyses were performed. In the analyses of the internal medicine ward and patients with dependent ADL, there was no difference in the amount of information in the patient profiles generated by the 2 groups, that is, the number of items filled and the sum of characters entered in the text. The input time was 1.3-2 minutes shorter in the use group. Thus, if the volume of patient profiles created is the same, a quotation from the electronic questionnaire response in the patient profile would save 13%-18% (1.3-2 minutes) of the time. In terms of nurses' overall recording time, a reduction of 1 or 2 minutes may not be considered a significant impact. However, when this system is expanded to other nursing assessments, time savings can be expected. In the analyses of surgical wards and patients with independent ADL, there was no difference in input time, but the number of characters entered was significantly higher in the use group. This means that the quoting from the electronic questionnaire response resulted in a more complete description of the patient profile, despite the same amount of time. It has been reported that the time spent using electronic medical records is positively correlated with health care provider burnout [20-22]. Consequently, reducing the time spent documenting is meaningful. In addition, insufficient time for documentation is reported to be an independent predictor of burnout among nurses [23]. In light of this, it is significant for patients and nurses that more comprehensive descriptions were completed in the same amount of time, as observed in the surgical wards and in the patients with independent ADL in this study.

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In terms of the nurses' workflow, there may be differences between the use and no-use groups. In the no-use group, that is, the conventional method using paper questionnaires, the nurse typically receives the patient's completed questionnaire, additionally interviews the patient and adds what they heard to the questionnaire. Finally, the patient profile was launched on the EMR terminal, and all information was transcribed simultaneously. Conversely, in the use group, which used the EMR-connected questionnaire, nurses typically reviewed the patient profile that had already been partially filled out by quotation at the bedside while simultaneously conducting additional interviews with the patient and entering the spot. The input time measured in this study was the total time the patient profile was run on the EMR terminal. Additionally, the time spent interviewing patients while running the patient profile was included. Consequently, the difference in input time between the 2 groups might have been underestimated, although the workflow may not have been constant for individual nurses in either group.

Until now, there is a dearth of information regarding whether the integration of PROs and EHRs improves the efficacy of hospital operations. A randomized trial reported that collecting PROs in clinical studies using the EHR portal saves researchers time compared to collecting them by telephone [24]; however, it was a small-scale study and not conducted in the setting of general clinical practice. To the best of our knowledge, this is the first study to demonstrate, in a daily clinical setting and on a large scale, that importing PROs into an HIS network and quoting the data in a nursing system could reduce documentation time.

Among the sections comprising the patient profile, quotations from the EMR-connected questionnaire were frequently set up for those corresponding to the nutrition and metabolism, elimination, cognition or perception, and physical activity or exercise of Gordon's functional health pattern. These sections included assessments of the patient's activities, mobility in daily living, and sensory perception, such as vision or hearing. These matters were easy for the patient to answer in the electronic questionnaire, as they could answer whether they could do it. By contrast, quotations were not included in sections related to self-perception or self-concept. These sections focused on patients' understanding of their feeling and attitudes toward the self. As patients do not usually have the opportunity to think about these matters, it was considered appropriate to assess them through direct conversations between the patient and nurse rather than through an electronic questionnaire. In addition, no quotes from the electronic interviews were set up in the form of roles or relationships. These sections focus on the details of the patient's family and the patient's involvement with them. These matters were considered difficult to ask in an electronic questionnaire because private information could often be included in the answers.

The series of systems in this study was realized using 2 chief technologies. The first is intelligent quotations. The PRO itself, which is not subject to interpretation by others, is important. However, transcribing PROs verbatim, whether in nursing records or progress notes, does not constitute medical records. Medical professionals must understand, interpret, classify, and supplement a patient's report from a professional perspective before classifying it as a medical record. Intelligent quotations make it possible to use data between documents of different natures, ranging from patient-oriented questionnaires to nursing records. Intelligent quotations will also play an important role in incorporating real-world data and patient-generated health data into medical and nursing records. This is because the necessary clinical indicators in the EMR often differ from the raw data provided by the patient, as in this study, in which the amount of alcohol consumed and alcohol units were calculated from the type and number of alcoholic beverages reported by the patient.

The other technology is the EMR-connected questionnaire system. It focused on ensuring the protection of patients' data and security from access outside the hospital, which is a known concern in PRO and EHR integration [25]. The unique identifier and URL generated did not contain any personal information. The Outside-HIS Questionnaire server did not include any personally identifiable information. The patient questionnaire data were obtained from the HIS Questionnaire server in the HIS network and mapped to the hospital patient ID with the generated unique identifier. This allows the patient questionnaire data generated outside the network to be securely integrated into the EMR.

At present, the data captured in the HIS network are stored in XML format. In the future, interoperability can be ensured by adopting standards, such as the Health Level Seven Fast Healthcare Interoperability Resources.

This EMR-connected questionnaire system not only improves nurses' workflow and enhances nursing records but can also be used for nursing research in the future. Data can be efficiently collected on outpatients before and after nursing intervention and analyzed with EMR data.

Limitations

The study has several limitations. It was a retrospective single-center study. The patients were not randomly assigned to use an electronic questionnaire or a traditional paper questionnaire. This may limit the generalizability of the findings. Nevertheless, the system allows patients to securely use the electronic questionnaire from both inside and outside the HIS network. The findings of this study can contribute to reducing nurses' recording time.

Conclusions

The study developed and implemented a system in which self-reported patient data were captured in EMR and quoted in the nursing system. This study highlights that this system contributed to reducing nurses' recording time and enhanced the content of records. The system is expected to improve nurses' work efficiency and aid in clinical research without increasing patients' burden.

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Acknowledgments

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Authors' Contributions

KK and SK contributed to the data collection, analysis, and manuscript preparation. RK, YM, and TT designed the study. SM, JY, and DT contributed to the system development and implementation. KO, SW, KS, and SI contributed to the data interpretation. All authors reviewed, revised, and approved the final manuscript.

Conflicts of Interest

JY reported being an employee of MKS Inc. DT reported being a board member of MKS Inc. YM reported being a stockholder of MKS Inc. and receiving patent royalties from MKS Inc. No other disclosures were reported.

Multimedia Appendix 1
Supplement tables for correspondence between Gordon's functional health pattern and the patient profile in the nursing system, and input tme analyses without excluding outliers.
[DOCX File , 43 KB - nursing_v6i1e51303_app1.docx]

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Abbreviations

ADL: activities of daily living
EHR: electronic health record
EMR: electronic medical record
HIS: hospital information system
ISO: International Organization for Standardization
PRO: patient-reported outcome

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Original Paper

Using Continuous Glucose Monitoring and Data Sharing to Encourage Collaboration Among Older Adults With Type 1 Diabetes and Their Care Partners: Qualitative Descriptive Study

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Abstract

Background: Persons with diabetes use continuous glucose monitoring (CGM) to self-manage their diabetes. Care partners (CPs) frequently become involved in supporting persons with diabetes in the management of their diabetes. However, persons with diabetes and CP dyads may require more communication and problem-solving skills regarding how to share and respond to CGM data.

Objective: The purpose of this study was to describe the experiences of persons with diabetes and CPs who participated in the Share “plus” intervention, which addresses dyadic communication strategies, problem-solving, and action planning to promote sharing of CGM data among the dyad.

Methods: Ten dyads participated in the Share “plus” telehealth intervention. Participants were interviewed during and after the Share “plus” intervention. Thematic analysis was used to analyze interview data.

Results: During postsession interviews, dyads described feeling a sense of shared responsibility yet viewed the persons with diabetes as ultimately responsible for the disease. Additionally, dyads shared that communication patterns improved and were able to recognize the negative aspects of previously established communication patterns. Dyads reported communication focused on hypoglycemia episodes while also differing in the frequency they reviewed CGM data and set alerts. Overall, dyads expressed positive reactions to the Share “plus” intervention.

Conclusions: Share “plus” was helpful in promoting positive CGM-related communication among dyads and encouraged more CP support. CPs play an important role in supporting older adults with type 1 diabetes. Communication strategies help support dyad involvement in CGM data sharing and self-management among persons with diabetes.

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KEYWORDS

type 1 diabetes; continuous glucose monitoring; care partner; communication; data sharing; caregiver; caregiving; diabetes; diabetic; type 1; glucose; dyad; communication; older adult; elder; telehealth; collaboration; insulin; endocrinology; endocrine; self-efficacy; health education; insulin pump; tele; telehealth; hypoglycemia; hyperglycemia

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Introduction

Background

The prevalence of type 1 diabetes (T1D) is estimated to affect up to 22 million individuals worldwide, with 1.6 million being aged 60 years or older [1]. The life expectancy of people with T1D has increased up to an additional 15 years, resulting in a higher incidence of older adults living with the disease [2,3]. Older adults living with T1D often experience age-related changes including increasing hypoglycemia accompanied by hypoglycemia unawareness [4]. Severe hypoglycemia in older adults can lead to loss of consciousness, seizures, falls, and other complications such as myocardial infarction [5-7]. However, technology such as continuous glucose monitoring (CGM) has recently been shown to be effective in reducing hypoglycemia and hyperglycemia in older adults with T1D [8,9]. Thus, the American Diabetes Association supports CGM in older adults with diabetes [10], which has become increasingly available to older adults after Medicare began covering this technology in 2017 [11].

Care partners (CP; eg, spouse, adult child, and friend) often want to be involved with the person with diabetes. Newer CGM apps that allow for glucose data sharing have the potential to facilitate the involvement of CPs in supporting persons with diabetes. Data sharing apps allow CGM readings and predictive hypo- and hyperglycemia alerts to be displayed on a CP's smartphone or smartwatch via allowance from the primary user, free with a compatible CGM device. In the Diabetes Attitudes and Wishes Study, persons with diabetes reported a desire for family members to be more involved in their diabetes [12]. However, in the second Diabetes Attitudes and Wishes Study for family members living with a person with diabetes, family members reported they frequently lacked an understanding of how best to be involved while feeling burdened and distressed about diabetes and were worried about hypoglycemia [13].

Although CGM with data sharing holds promise for involving CPs in diabetes management, there are barriers to data sharing. These include the persons with diabetes not wanting to include others in their care, communication challenges between the person with diabetes and their CP and difficulties setting up the data sharing mobile apps. The challenges in communication often reflect persons with diabetes and the CPs' different expectations regarding family involvement [14]. Persons with diabetes frequently regard diabetes as "their own illness," whereas spouses view the illness as more shared [15,16]. Yet, when a person with diabetes and their spouse share the same appraisal that diabetes is "shared," collaboration and support are more frequent [16,17]. When the spouse sees the illness as shared, there is an increase in self-care in persons with diabetes, likely by increasing their perceptions of greater emotional support and decreasing critical communication [17,18]. However, older adults are more likely to perceive diabetes as a shared condition than middle-aged adults [17]. Recent evidence from a couples-based intervention for those with type 2 diabetes [19] found that improving collaboration and communication supported quality of life benefits, as the intervention resulted in lower persons with diabetes and partner distress and higher relationship satisfaction. For those with moderately elevated glycated hemoglobin, the couples' intervention led to improved glycemic levels.

In response to these barriers, we developed a multifaceted diabetes care and education intervention for older adults and their CPs. The SHARE "plus" intervention was delivered by telehealth and consists of a dyadic appraisal of diabetes, communication strategies, problem-solving strategies, and action planning. An assessment of the overall feasibility of the SHARE "plus" intervention is described elsewhere [20]. However, the rich interaction between dyads and the Diabetes Care and Education Specialist (DCES) represented a key component of the Share "plus" intervention. The purpose of this manuscript is to present findings from the dyadic conversations during the Share "plus" intervention and post intervention in an attempt to highlight the importance of supporting dyad communication during interventions targeting diabetes management.

Dyadic Coping Model

The Dyadic Coping Model (DCM; Figure 1) posits that for persons with a chronic illness, dyadic coping can hold benefits for health outcomes, relationships, and the individual. Dyadic coping occurs when one individual perceives a stressor (in this case, diabetes) as "our" problem versus "my" or "your" problem and activates a process of collaborative coping to address stressors associated with diabetes [21]. Additionally, positive relationship quality and satisfaction between the persons with diabetes and CP can enhance self-management behaviors [22], and visibility of support [23]. However, collaborative involvement of the CP may be detrimental when the person with diabetes views diabetes as only their illness to deal with and does not consider its effects on the CP. In this study, the DCM was used in the development of dyadic education sessions focused on promoting the value of a CP's collaborative involvement in the glucose monitoring of a person with diabetes via CGM and addressing the importance of supportive and unsupportive behaviors. Moreover, the DCM-guided organization of codes into categories during analysis.

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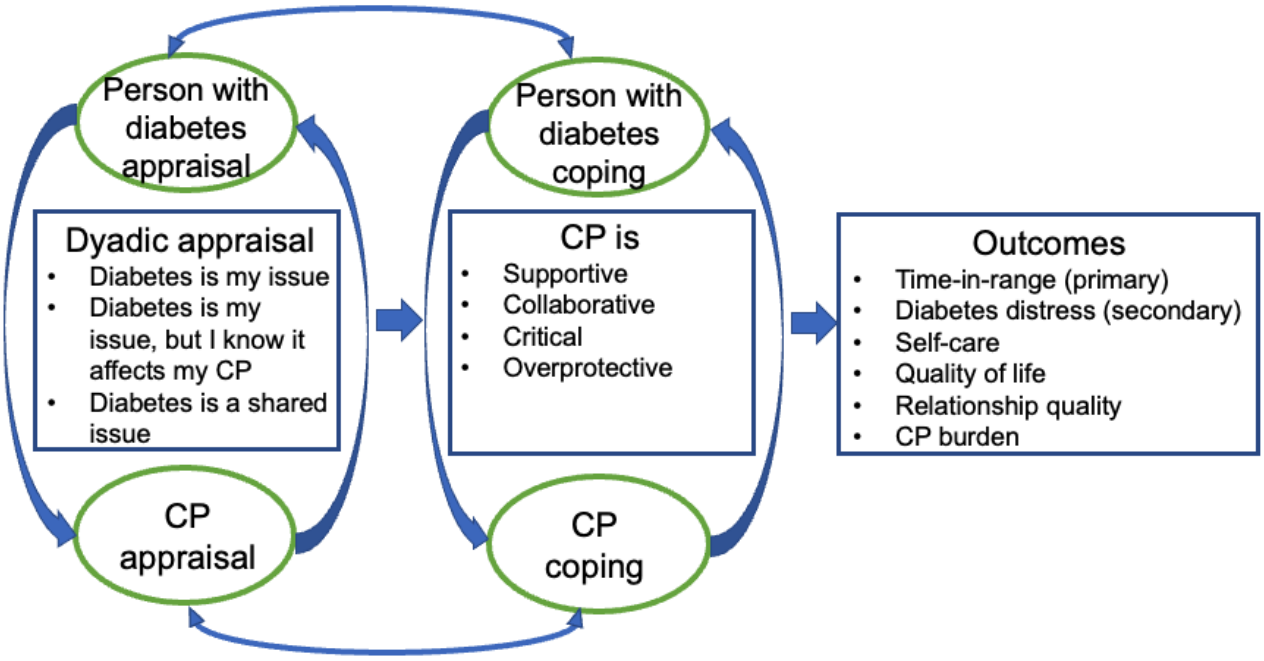
Figure 1. Dyadic coping process affected by Share "plus" intervention. CP: care partner.



Methods

Overview

This paper reports qualitative aspects from dyadic educational sessions as part of a larger intervention, the Share "plus" [20]. The Share "plus" intervention provides training to dyads in CGM communication and problem-solving and results in an action plan. Share "plus" includes evidence-based communication strategies, such as motivational interviewing questions, problem-solving, self-efficacy enhancement strategies, and action planning [10,24-26]. Full description of the Share "plus" intervention and results are reported elsewhere [27]. In this paper, we highlight participants' experiences with the dyad intervention sessions with a DCES and postintervention feedback shared during follow-up interviews.

Participants

Participants were recruited from an academic endocrinology specialty clinic and through social media flyers. Eligibility criteria included persons with diabetes who (1) aged ≥60 years, (2) diagnosed with T1D, (3) naïve to personal CGM use with the Dexcom Follow app, (4) glycated hemoglobin 6%-12% within the last 6 months, (5) able to read and write English, (6) own a smartphone compatible with the Dexcom G6 CGM, and (7) have a CP willing to participate. Persons with diabetes with or without an insulin pump were included. The Montreal Cognitive Assessment (MoCA) was used to screen participants [28]. The MoCA was performed as the incidence of dementia in persons with diabetes is more than 2 times that of people without diabetes [29]. Thus, we wanted to avoid the inclusion of individuals with moderate to severe dementia, as these individuals might lack the ability to participate in sessions targeting communication patterns. Persons with diabetes were excluded if they had (1) a MoCA score of <18, (2) a life expectancy estimated at <1 year, (3) unstable recent cardiovascular disease, significant malignancy, or other conditions resulting in physical decline, (4) a history of visual impairment that would hinder performing study procedures. Inclusion criteria for CPs were anyone identified by the persons with diabetes and (1) willing to use the Follow App, (2) willing to attend Share "plus" intervention education sessions, (3) were aged ≥18 years of age, (4) did not self-report cognitive impairment, and (5) owned a smartphone compatible with Dexcom Follow app. This study was conducted by telehealth with dyads in their own homes.

Data Collection: DCES-Led Dyad Sessions

The DCES used evidence-based communication strategies, such as motivational interviewing questions, problem-solving, self-efficacy enhancement, and action planning. Motivational interviewing questions were used to help the dyads identify and strengthen their personal motivation for data sharing in a supportive conversation. For example, persons with diabetes were asked, "On a scale of 1-10 how would you rate your confidence in your ability to share your glucose numbers with your partner" and then "tell me a little bit about why you did not choose a higher score?" CPs were then asked the same questions. Several self-efficacy enhancing strategies were also used such as role modeling to describe the experiences of other persons with diabetes and CP's that were similar. For example, dyads were asked how comfortable they felt about data sharing. Examples were provided about how other persons with diabetes have described the benefits of sharing their diabetes, such as an increased sense of teamwork, support, quality of life, and decreased diabetes-related burden. The barriers to sharing glucose levels were also identified (eg, glucose levels are private, persons with diabetes do not want to be judged). Verbal persuasion was used to provide education about effective and noneffective communication strategies. Past performance (eg,

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Mastery Experience) was also used to develop collaboration and knowledge. For example, if a person with diabetes reported that they viewed diabetes as their own illness, the dyad was asked to talk about something that they think of as shared such as planning a trip. Problem-solving action plan strategies included actions to take for hyper- and hypoglycemia and other CGM-related settings. Dyads were also asked to review problems that came up from the previous diabetes care and education session and generate solutions and options that might work moving forward. Last, several steps were taken to develop an action plan around agreed-upon communication strategies and CGM with data sharing settings and actions to take for hypo- and hyperglycemia (see Table 1).

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Table 1. Overview of Share "plus" session topics and objectives.

Session and topic	Approach	Objective
One		
Shared appraisal	• Persons with diabetes and CP[a] were asked to align themselves with 1 of 3 statements regarding their feelings about diabetes and its effects on their CP • Persons with diabetes and CP rated their confidence on a scale of 1-10 regarding the sharing of blood glucose	To determine comfort level with data sharing for the persons with diabetes and their CP
Communication	• Persons with diabetes were asked how they would feel about sharing their low and high glucose levels • Discussed helpful and unhelpful language	To explore supportive and unsupportive conversation strategies
Problem-solving	• Discussed problem-solving steps: identify the problem, find solutions, and take action (when needed) • Identified concerns and willingness to problem solve the cause of low and high glucose levels.	To explore problem-solving of out-of-range glucose levels
Action planning	• Identified alarm settings for persons with diabetes and CP • Agreed on how CP would contact the persons with diabetes for out-of-range blood glucose (call, text, etc) • Confirmed supportive language for out-of-range glucose levels	To set clear expectations around data sharing
Two		
Communication	• Reviewed problems with data sharing • Assessed if communication strategies were used • Interventionist chose 1 or 2 communication strategies to discuss after listening to problems with data sharing	To further develop communication strategies
Problem-solving	• Reviewed helpful and unhelpful interactions • Discussed frustrations with CGM[b] setting • Discussed CGM clarity data and impact of food on glucose levels	To explore glucose patterns and develop glucose management skills regarding the sharing of blood glucose levels and food choices
Action planning	• Agree on communication preferences around glucose levels and food choices and timing • Confirmed problem-solving strategies around glucose levels • Encourage routine discussions of glucose trends	To set communication preferences and to identify goals for dyadic problem solving of glucose levels
Three		
Communication	• Reviewed problems with data sharing and communication between the dyad • Assessed if communication strategies were used	To develop dyadic communication strategies
Problem-solving	• Discussed CGM clarity data and effects of lifestyle (exercise, stress, illness) on glucose levels	To explore new problems about healthy eating and to develop glucose pattern management skills around exercise and stress
Action planning	• Agree on communication preferences around glucose levels and lifestyle behaviors • Confirmed problem-solving strategies around glucose levels • Encourage routine discussions of glucose trends with dyad using positive communication and effective diabetes management strategies	To set communication preferences around stress and exercise; to identify goals for dyadic problem solving of glucose levels

[a]CP: care partner.

[b]CGM: continuous glucose monitoring.

Postsession Individual Interviews

Immediately after completing the 12-week Share "plus" sessions, dyads were invited to participate in individual interviews. Interview questions addressed dyad experiences and feedback regarding the Share "plus" sessions. Dyads were interviewed separately on Zoom (Zoom Technologies), by a trained research assistant and focused on using CGM, the Follow App (Dexcom), and the Share "plus" sessions.

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Rigor

Trustworthiness criteria from Lincoln and Guba [27] guided the rigor of this study [30]. A semistructured interview guide was used during the DCES dyad sessions and the postintervention interviews. DCES dyad sessions and interviews were recorded, transcribed verbatim, and verified for accuracy. AAB and NAA (lead authors) led the analysis as they have extensive background and experience in qualitative research. Team meetings were held where AAB, AG, DS, and NAA discussed and shared thoughts, reactions, and perceptions that emerged during data collection and analysis. Team members engaged in reflexivity throughout the analysis process, discussing previous experiences and personal perceptions that emerged during coding and theme development. A written record was maintained and comprised codes, definitions, decisions, memos, field notes, and team communication during the data collection and analysis processes. Team meetings were scheduled with the larger research team for feedback and input into the developed codes and themes. All participants of the Share "plus" intervention participated in the DCES dyad sessions and were invited to participate in the postintervention interviews. All but one dyad agreed to participate in the postintervention interviews.

Ethics Approval

This study was approved by the University of Utah's institutional review board (00114642). Informed consent was obtained and participants were informed of their right to opt out at any point of the study. Gift cards were given at the beginning of the study and at day 10 and at the end of the study for US $30 at each time point totaling US $90 for the person with diabetes and US $90 for the care partner.

Analysis

Thematic analysis was used to develop major themes representative of the participants' experiences during the DCES dyad sessions and postintervention interviews [31,32]. Coding followed 2 phases [33]. Phase 1 used inductive, open coding of the first 3 diabetic dyad sessions and the postintervention interviews and focused on describing behaviors outlined by participants. From this phase, a codebook was developed (see Table 2). During phase 2 of the analysis, team members AAB, DS, and AG (used the codebook to code the preceding sessions and Interview data. New codes continued to emerge and were added to the codebook. Codes were then organized into themes representing participants' views of the key aspects of the Share "plus" intervention and influenced by concepts of coping and appraisal from the DCM. Team members met weekly to review coding and theme development. Disagreements were discussed until consensus and themes were reached.

Table 2. Selected sample of codebook.

Codes	Illustrative quote	Corresponding theme
Alarm sharing	*Ok, alerts go off, he knows, like when I'm high or when I'm low* [persons with diabetes]	Sharing and monitoring glucose data
View of role	*Because we're married and we're together and I'm concerned over whatever happens with him* [CP[a]]	Shared responsibility
Illness appraisal	*It is my issue, but I know it affects others. Because it actually impacts sometimes what I can do, you know?...it's an inconvenience to me at times and becomes other people's inconvenience as well* [persons with diabetes]	Independent appraisal of roles within dyads

[a]CP: care partner.

Results

Overview

Ten dyads met the recruitment criteria, and 100% of them completed the 3 Share "plus" sessions. One dyad did not complete the postintervention interview because of time constraints but did complete the 3 sessions. Demographics of the participants with diabetes and their CPs are listed in Table 3. The participants with diabetes, on average, were 66 (SD 4.78) years of age, and CPs were slightly younger (mean 62.8, SD 11.82 years). The sample was 100% White, and the majority had college degrees. Only one dyad had a parent-child relationship. MoCA scores were evaluated for all participants with diabetes prior to enrolling in the study. All participants had a MoCA score ≥ 26 except 2 individuals; 1 person with diabetes scored 25 and the other scored 22.

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Table 3. Demographics for participants with diabetes and CPs (N=20).

Characteristics	Persons with diabetes (n=10; %)	CP[a] (n=10; %)
Age (years), mean (SD)	66.8 (4.78)	62.8 (11.82)
Sex, n (%)		
Female	5 (50)	6 (60)
Male	4 (40)	4 (40)
Prefer not to answer	1 (10)	0 (0)
White race, n (%)	10 (100)	10 (100)
Highest education, n (%)		
Associate degree or some college	0 (0)	1 (10)
Bachelor degree	3 (30)	2 (20)
Graduate degree	5 (50)	5 (50)
High school Graduate or general educational development	1 (10)	0 (0)
Vocational or technical school	1 (10)	2 (20)
Employment status, n (%)		
Disabled	0 (0)	1 (10)
Full-time	3 (30)	6 (60)
Part-time	0 (0)	2 (20)
Retired	7 (70)	1 (10)
Annual household income (US $)		
≤24,999	0 (0)	6 (60)
50,000 to 74,999	1 (10)	1 (10)
75,000 to 99,999	2 (20)	2 (20)
100,000 to 149,999	3 (30)	1 (10)
≥150,000	4 (40)	1 (10)
Declined to answer	1 (10)	4 (40)
Type 1 diabetes	10 (100)	__[b]
Diabetes duration (years), mean (SD)	24.9 (21.66)	N/A[c]
Relationship to persons with diabetes		
Child	N/A	1 (10)
Spouse	N/A	9 (90)

[a]CP: care partner.
[b]Not available.
[c]N/A: not applicable.

Results From DCES Dyad Session

Overview

Three themes developed representing experiences during the DCES dyad sessions include (1) independent appraisal of roles within dyads; (2) communication patterns; and (3) sharing and monitoring glucose data. During sessions with the DCES, the discussion focused on understanding the dyad's baseline view of the role of the CP in supporting persons with diabetes and communication patterns. Working together with the dyad, the DCES was able to develop and tailor management strategies including how alarms were set and how the persons with diabetes and CP engaged with the CGM and Follow app.

Independent Appraisal of Roles Within Dyads

During the initial session with the DCES dyads were asked to consider how they viewed responsibility for diabetes management. Most persons with diabetes demonstrated a core sense of independence. For example, 1 person with diabetes stated, "It is my issue, but I know it affects others" (person with diabetes #4, aged 65 years), which the CP echoed by stating, "I think it's like it's her issue in the sense that only she can actively manage her diabetes. But there are lots of people who care about her well-being." (CP #4, aged 67 years) While persons with

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diabetes expressed desire for self-control of management, CPs responses highlighted a desire to be in a supportive role.

The DCES also encouraged dyads to consider engaging in teamwork. Yet, when asked about teamwork, persons with diabetes echoed similar thoughts regarding independence. One person with diabetes stated, “Well, I guess because I’m the one with diabetes and she’s not. She just has to put up with me having diabetes and how it impacts our lives” (person with diabetes #3, aged 67 years). While the CP shared:

> *Regardless whether we’re together or apart, I still know basically how he’s doing and it affects me. I'm conscientious of what he should or shouldn’t be eating and watching what he does or how he's acting, especially if he is high or low, then it affects me in the middle of the night, the alarm goes off. And so if he's not sleeping, I'm not sleeping, and vice versa. So, I think it's very much a shared responsibility to make sure he's where he needs to be.* [CP #3, aged 60 years]

Overall, while the DCES introduced concepts of shared responsibility and teamwork, responses from persons with diabetes continued to center on the idea that disease management rested mainly with persons with diabetes, while CPs were more likely to be viewed as supportive partners only.

Communication Patterns

During sessions with the DCES, communication strategies were presented and reviewed. Initially, most dyads reported feeling they had previously established good communication patterns prior to participation in the Share “plus” intervention. One person with diabetes shared a commonly echoed sentiment, “We communicate pretty well. It's not going to change” (person with diabetes #2, aged 65 years). Dyads entered the Share “plus” intervention with strong feelings of having established good communication patterns. However, throughout the sessions, half of the dyads reported experiences with the use of unsupportive communication during hypoglycemic or hyperglycemic events. One person with diabetes shared, “I know I snap at him (CP) enough that he probably knows when you know when that happens” (persons with diabetes #5, aged 69 years).

Moreover, communication occurred primarily around hypoglycemic events. Dyads shared how hypoglycemic events were seen as more important, requiring communication. One person with diabetes shared:

> *The lows are a life, a life-threatening circumstance. The highs are not. But I would think so. Yeah, she's pretty much just minding your own business and keeping it to herself unless she feels that there’s a need to say something and the need would be a low alert, probably.* [Person with diabetes #7, aged 73 years]

Persons with diabetes recognized and appreciated CPs ability to communicate and support them during hypoglycemic events, while hyperglycemic events were seen as mainly the responsibility of the persons with diabetes. Dyads voiced concerns that there were limited options they could take when the persons with diabetes experienced hyperglycemia, which decreased communication around higher glucose trends. One CP shared:

> *I don't think we're educated enough to …actually come up with a solution to the problem. There’s just something that happens that we have no …way of dealing with it other than just waiting it out.* [CP #9, aged 70 years]

Communication patterns between dyads centered on reacting to hypoglycemia. While dyads often shared experiences with unsupportive communication, they overwhelmingly felt they had already established good communication patterns.

Sharing and Monitoring Glucose Data

Overall, persons with diabetes and CPs shared different approaches toward monitoring glucose trends at the start of the intervention. Persons with diabetes shared that they checked their levels multiple times throughout the day. One person with diabetes stated checking CGM data, “every hour or so” (person with diabetes #1, aged 67 years). In contrast, CPs reported a lower baseline engagement in monitoring glucose trends. One shared:

> *I don't really look at it that often...(persons with diabetes) is…quite capable on her own of, you know, monitoring your blood sugars and looking at that type of data.* [CP #7, aged 73 years]

Yet, when CPs actively engaged in glucose trends monitoring, they reported feeling increased peace. For example, one CP stated:

> *When I check, when I check my phone and for some reason there's no, no data available, I find that stressful. So then it's like, hey, how come mine's not working? So, yeah, we definitely rely on it and it gives us peace of mind.* [CP #2, aged 61 years]

Nonetheless, CP baseline engagement in glucose trend monitoring was mainly limited to alarm notification regarding hypoglycemic glucose trends. As part of the Share “plus” intervention, dyads were encouraged to discuss and set shared notification alerts regarding glucose levels. One person with diabetes shared:

> *(CP) doesn't involve herself with the highs…As I said, they're transient, the lows are more important to me. The lows are a life-threatening circumstance. The highs are not.* [Person with diabetes #4, aged 66 years]

While dyads set similar limits for hypoglycemic alerts, CPs set alerts for hyperglycemic trends at levels higher compared to the persons with diabetes in order to avoid or limit the alerts they received.

Results From Postsession Interviews

Overview

During the postintervention interviews, similar themes emerged, which included (1) shared responsibility; (2) communication patterns; and (3) sharing and monitoring glucose data. Overall, while dyads addressed positive and negative communication

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patterns with the DCES, during postintervention interviews, participants identified that a change occurred from viewing diabetes management as an independent appraisal to feeling a sense of shared responsibility among the dyad. In addition, dyads addressed the positive influence the Share "plus" intervention had on promoting positive communication habits and monitoring glucose trends that emerged as part of the Share "plus" sessions.

Shared Responsibility

In contrast to the initial session, dyads reported how the Share "plus" sessions helped increase their awareness and shared responsibility around diabetes management. One CP shared:

> *It was almost like just confirming everything that we've done and that we established, you know, as a partner, as a, you know, husband and wife. And so, I would totally recommend (SHARE "plus") for anybody. And I think if someone's not married and they have diabetes… that they should find that accountability partner and share that with that person… Because I think everybody should have the partnership to help them with (diabetes).* [CP #1, aged 60 years]

Dyads shared how an increased sense of partnership emerged as they interacted with the DCES and each other. One person with diabetes shared:

> *I think going through this class it kind of opened me up to the fact that because we're a partner, we're a team on this and it's just something we're facing together, it kind of made me think, "Okay" yeah." I still primarily see it as because it's my body and my l'fe, it's primarily my issue, but it is a shared issue and I think the class kind of helped me open up to that a little bit more, so I think that's why the difference in the answer.* [Person with diabetes #3, aged 67 years]

CPs also described how they came to view the issue of shared responsibility through engagement with the diabetes educator session. For example, a CP stated, "Well, I just think being aware has made it really, really nice. We feel like we're more in touch" (CP #10, aged 81 years). Through working with the DCES, dyads described becoming more open to sharing responsibility within the dyad and addressed the positive impact on the dyad relationship.

Communication Patterns

Upon reflecting on involvement in the Share "plus" sessions, persons with diabetes reported conversations increased around strategies to promote better support and collaboration with their CPs. One person with diabetes shared, "well we've always communicated a lot, but we communicated more about my diabetes in general because of being involved in the study, which is good" (person with diabetes #8, aged 63 years). Another person with diabetes described increased CP involvement, which resulted in increased levels of support. He stated:

> *I think we are sharing the burden of managing the lows better than what we were before. I think it helped us both realize this is something we both need to stay on top of.* [Person with diabetes #3, aged 66 years]

Overall, dyads reported that communication occurred in reaction to the current disease state of persons with diabetes as well as proactively considering how to increase the involvement and support of CPs.

CPs described the communication benefits of the Share "plus" sessions as positive and reinforcing teamwork. One stated, "I don't know it's through this, or just because she's mentioned it, of being a little more patient and kinder when dealing with this" (CP #4, aged 67 years). Another shared:

> *I'm a scolder… Being demeaning anyway, so, yeah. I think the study was really helpful because it helped me realize that and it helped him realize that too that it is a partnership.* [CP #2, aged 60 years]

Yet, dyads also shared a few instances of continuing unsupportive communication. Unsupportive communication resulted from long-established communication patterns present between partners. For example, one CP stated, "The high one (alarm), the one I know was an actual high, I let my alarm on my phone nag him. He kept telling me, "Just turn it off. Turn it off." I said, "Nope" (CP #9, aged 71 years). Instead of engaging in communication regarding the hyperglycemic events in persons with diabetes, the CP relied on the alarm to alert and influence the behavior of persons with diabetes. Moreover, some CPs reported engaging in language that they knew was to be avoided, such as blaming. One CP shared:

> *I guess I got upset, "Look, you're falling, you know better than this. Why are you letting this fall?" ... I said "Why is this happening?" And I would assume that would be considered nagging, but, yeah.* [CP #4, aged 67 years]

As dyads experienced frustration, habitual and unsupportive communication patterns, such as blaming, emerged. In contrast to the session with the DCES, in the postinterviews, dyads were more likely to recognize and report communication strategies that were viewed as unhelpful. Dyads demonstrated increased awareness of communication patterns that were negative and that might hinder successful partnerships.

Sharing and Monitoring Glucose Data

Most dyads expressed an increased dyad awareness of glucose levels that occurred as a result of engaging in the sessions with the DCES. For example, one person with diabetes said:

> *I think (CP) feels good about being in the loop more than she was before, and it makes me feel better that she's aware, and (CP) can warn me or make sure I'm aware of where I am. So (Share "plus") has been a positive. Because I've had diabetes for a long time.* [Person with diabetes #10, aged 79 years]

Similarly, a CP described a feeling of closeness as a benefit of this awareness, "Well, I just think being aware has made it really, really nice. We feel like we're more in touch" (CP #10, aged 80 years). Another benefit was an increase in empathy, "I think I become a little more patient and understanding, that I can see where things are going" (CP #4, aged 67 years).

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Importantly, dyads described that awareness increased feelings of safety. One person with diabetes shared, “Well what worked well was that it gave her (CP) peace of mind to know that she could have a window on things so to speak. And that made me feel good” (person with diabetes #8, aged 63 years). A CP described a sense of relief that hypo- and hyperglycemia was being prevented, “I was more aware because of the alarms, and his (persons with diabetes) alarms. So, I could go in and look at him, and talk to him, and see where he actually was” (CP #9, aged 71 years).

DCES Session Feedback

During postsession interviews, dyads were asked to reflect on their experiences working with a DCES. Overwhelmingly, dyads shared positive experiences and addressed how regardless of their prior experiences and understanding about diabetes, they gained new information and felt supported. One CP shared:

> *(DCES) took the time to explain things. You know, if I had a question, you know’ she wasn't in a rush to kind of get through the next, whatever, learning module, or however it was structured. And you know, I think, you know, created an atmosphere where it was comfortable for persons with diabetes and I to both share, you know? And so, you know, it was a good, positive thing.* [CP #5, aged 69 years]

Persons with diabetes agreed, sharing:

> *(DCES)…knowledge base is huge, and she’s such a good teacher, and she can solve problems like nobody’s business. So, I mean, she can figure it out, and understands what’s going on, and she’s- and she listens, too.* [Person with diabetes #5, aged 68 years]

Overall, dyads shared how they gained new information and reported an increased sense of partnership. Moreover, dyads felt empowered and shared that communication, understanding regarding shared responsibility, and increased consideration of glucose trends were positively impacted by engaging in counseling sessions.

Discussion

Principal Findings

In this study, dyads identified how working with a DCES addressed a missing aspect of their current health care management. Most reported how they felt more empowered as the DCES took time to provide education, address problems and questions regarding aspects such as diet or medications, and overall supported skill development in communication. Additionally, perceptions regarding independent appraisal changed to dyads reporting feeling a shared responsibility for management.

Importantly, a key change in communication patterns emerged. Initially, dyads reported high initial confidence in their communication skills. Persons with diabetes asserted their ability to self-manage their diabetes, and CPs reported they were confident in relying on the self-management of persons with diabetes. However, during the DCES sessions, participants recognized their communication patterns and were able to identify patterns of negative behaviors and discussed during postsession interviews how they sought to change long-established communication patterns. Learning how to work together on supportive and unsupportive communication promoted a sense of teamwork for several of the dyads despite their long-term relationship and management of diabetes.

Overall, dyads shared how despite experiencing T1D for several years, they were supported by the education received during the diabetes education sessions. This finding may be related to the long duration of T1D in this sample of older adults and a lack of referrals to diabetes care and education. The standard of care for referring persons with diabetes for diabetes care and education is at diagnosis, annually, or when not meeting treatment targets, when complicating factors develop (medical, physical, and psychosocial), and when transitions in life and care occur [34]. Despite this standard of care, less than 5% of Medicare beneficiaries with diabetes and 6.8% of privately insured persons with diabetes have participated in diabetes self-management education and support services [35,36].

Prior research considering patient education programs in diabetes have established that programs that promote self-reflection, identification of risk factors, and action planning may positively influence perceptions of self-efficacy and support health behavior changes [37-39]. This was echoed in our study as the initial feedback from persons with diabetes highlighted feelings of independent appraisal, which evolved during the sessions into feelings of having a shared responsibility among the dyad. However, the influence of patient education programs encouraging persons with diabetes and their CPs to engage in CGM data sharing has not been previously considered. This is the first study to assess the experiences of dyadic participants in a telehealth patient education intervention to support CGM data sharing communication.

During the Share “plus” intervention sessions, dyads demonstrated increased appreciation for diabetes management collaboration. At first, dyads often shared beliefs that persons with diabetes retained ultimate responsibility for the management of their diabetes and that CP’s role was to provide supportive actions. However, as dyads progressed through the sessions and provided poststudy feedback, it became clear that most realized how the CP could be more involved in diabetes management, without taking over. At the end of the 12-week study, dyads reported a sense of teamwork and a shared sense of responsibility. These results are consistent with the DCM that guided the Share “plus” intervention in that changes in dyadic appraisal accompanied strategies of collaboration.

The involvement of CPs in diabetes management is especially important as persons with diabetes grow older because of the many diabetes age-related changes such as hypoglycemia unawareness and deleterious effects of hyperglycemia causing hospitalization [40]. Both hypoglycemia and hyperglycemia can also cause multiple complications including myocardial infarction, cerebral vascular accidents, seizures, and falls [41]. Especially concerning is the relationship between hypo- and hyperglycemia and dementia [42]. A proactive care model is needed for older adults with diabetes that includes support from an engaged CP or several CPs before complications such as

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cognitive impairment occur. Involving CP's earlier in diabetes management may serve to provide early detection of cognitive changes and prevent life-threatening diabetes management mistakes.

Persons with diabetes who receive training in data tracking and in the use of CGM have demonstrated improved outcomes [43-45]. However, there have been few studies examining CGM with data sharing in older adults [27,46]. Moreover, family members report wanting to be more involved in care of persons with diabetes but often lack knowledge about specific diabetes management strategies or how to prevent hypo- or hyperglycemia [47,48]. Thus, family members report feeling burdened and distressed about diabetes. Recent evidence from a couples-based intervention for those with type 2 diabetes found that improving collaboration and communication resulted in lower persons with diabetes and CP distress and higher relationship satisfaction [15,49].

Limitations

The limitations of this study include the lack of a diverse dyad sample. Moreover, further consideration of nonspousal CP relationships is necessary to explore the unique needs of other types of CP relationships. It is possible that this sample was biased as persons with diabetes and CP's with poor relationships may not have volunteered for this study. Additionally, the findings are limited by the small sample size and the lack of racial or ethnic diversity. Further study is needed with a larger more diverse sample of dyads. Additionally, further study is needed regarding the quantitative understanding of the dyad relationship quality before and after the intervention in a larger sample.

Conclusions

In conclusion, persons with diabetes and their CPs experienced improved communication skills and glucose management strategies after participating in the Share "plus" program. Families are often not included when addressing data-sharing with T1D despite the American Diabetes Association recommendation that CPs be involved in the care of older adults with diabetes [10]. Additionally, there has been limited training for diabetes care teams on how to provide educational or clinic visits with CPs. The Share "plus" intervention contributes to behavioral science by providing an educational curriculum to improve dyadic communication and support using CGM with data sharing. Care models are needed that actively engage persons with diabetes and CP in strategies that promote communication and problem-solving as well as CGM data sharing.

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Authors' Contributions

AAB and NAA wrote the manuscript. MLL, CAB, CJ, and NAA contributed to the study design. AAB, DS, AG, and NAA participated in data analysis and discussions. AAB, MLL, CAB, EGG, DS, AG, CJ, and NAA edited the manuscript. All authors have reviewed and approved the final manuscript for publication.

Conflicts of Interest

None declared.

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Abbreviations

CGM: continuous glucose monitoring
CP: care partner
DCES: Diabetes Care and Education Specialist

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DCM: Dyadic Coping Model
MoCA: Montreal Cognitive Assessment
T1D: type 1 diabetes

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Original Paper

An Augmented Reality Mobile App (Easypod AR) as a Complementary Tool in the Nurse-Led Integrated Support of Patients Receiving Recombinant Human Growth Hormone: Usability and Validation Study

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Abstract

Background: Children with growth hormone deficiency face the prospect of long-term recombinant human growth hormone (r-hGH) treatment requiring daily injections. Adherence to treatment is important, especially at treatment initiation, to achieve positive health outcomes. Historically, telenursing services embedded in patient support programs (PSPs) have been a valid approach to support r-hGH treatment initiation and patient education and facilitate adherence by identifying and optimizing appropriate injection techniques. The development of mobile phones with augmented reality (AR) capabilities offers nurses new tools to support patient education.

Objective: To investigate experiences among nurses of a new mobile phone app developed to support patient training with a phone-based PSP for r-hGH treatment.

Methods: In 2020, the Easypod AR mobile app was launched to support nurse-driven telehealth education for patients initiating r-hGH therapy with the Easypod electromechanical auto-injector device. Nurses who were part of PSPs in countries where the Easypod AR app had been launched or where training was provided as part of an anticipated future launch of the app were invited to participate in an online survey based on the Mobile App Rating Scale to capture their feedback after using the app.

Results: In total, 23 nurses completed the online questionnaire. They positively rated the quality of the app across multiple dimensions. The highest mean scores were 4.0 for engagement (ie, adaptation to the target group; SD 0.74), 4.1 (SD 0.79) for functionality (navigation) and 4.1 (SD 0.67) for aesthetics (graphics). Responses indicated the potential positive impact of such a tool on enhancing patient education, patient support, and communication between patients and PSP nurses. Some participants also suggested enhancements to the app, including gamification techniques that they felt have the potential to support the formation of positive treatment behaviors and habits.

Conclusions: This study highlights the potential for new digital health solutions to reinforce PSP nurse services, including patient education. Future studies could explore possible correlations between any behavioral and clinical benefits that patients may derive from the use of such apps and how they may contribute to support improved patient experiences and treatment outcomes.

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KEYWORDS

augmented reality; growth hormone; growth hormone deficiency; mobile app; mobile health; nurse; patient support program; telehealth; telemedicine; treatment

Introduction

Growth hormone deficiency (GHD), in which the pituitary gland fails to produce a sufficient amount of growth hormone (GH) during childhood, affects between 1 in 3500 and 1 in 4000 children in the United Kingdom [1]. It exposes children to the prospect of long-term recombinant human GH (r-hGH) treatment that requires daily injections over several years [2]. This can lead to challenges with adherence to therapy [3] and often puts a substantial social and emotional burden on patients and their families, affecting both well-being and quality of life [4]. Furthermore, suboptimal adherence to therapy is inevitably also associated with less favorable clinical outcomes and higher health care costs [2].

Successfully achieving full height potential with r-hGH therapy depends on maintenance of optimal dosing schedules, adherence to therapy, and early treatment initiation [2,5]. Indeed, a systematic review by Graham et al [6] reported that up to 71% of children with GHD and their families were nonadherent to their r-hGH therapy as prescribed, with key modifiable factors including a lack of knowledge and understanding of their condition and treatment, discomfort and pain associated with injections, and the quality of the health care professional (HCP)-patient relationship. Treatment adherence is one of the main drivers of health outcomes [7,8], and this is especially important at treatment initiation, when needle anxiety might be more prevalent [9] and sufficient competence is needed to ensure proper injection techniques are followed.

The need for frequent injections over a long period of time in the treatment of GHD has driven the development of medical devices that facilitate the subcutaneous delivery of medication and thus have the potential to improve patients' adherence to therapy. In recent years, several devices have been developed for the administration of GH. So far, different types of GH injection devices have been introduced, such as needle syringes, injection pens, self-injection pens, and electronic devices. Despite advances in connected injection delivery devices and digital health, there is still room for improvement in the management of GH treatment. Studies carried out with patients, caregivers, doctors, and nurses experienced in the administration of GH indicate that an optimal device for the administration of GH should have the following characteristics: (1) reliability, (2) ease of use, (3) effective control via a good monitoring system, (4) absence of pain during injection; (5) safety in use and storage, and (6) a minimum number of steps before injection preparation [10,11]. In addition to the evolution of delivery devices, a wide range of digital solutions have been developed to support GH treatment [12-14].

Such medical devices require patient education, which is often delivered via patient support programs (PSPs) [15,16]. These are structured programs that offer services through patient or patient-caregiver interactions, and given the focus on patient education and adherence support, PSPs are often delivered by nurses. They are predominantly designed to support the education of patients who must follow complex treatment modalities that require the use of technology, and they may also be part of pharmacovigilance responsibilities under medical device regulations [17]. PSPs have been shown to help patients and their families from treatment initiation through the maintenance and transition period to adult care, if required [15], and they are often provided by manufacturers of specific drugs or medical devices according to the legislation of each country.

For many years, telenursing services embedded in PSPs have been a valid approach to support treatment initiation. Nurses involved in PSPs provide patient education to facilitate adherence by identifying and optimizing appropriate injection techniques. The emergence of more advanced mobile phone technology with augmented reality (AR) capabilities offers nurses new tools to support patient education.

Outside the GH therapy area, emerging research is showing the potential of using AR to complement pediatric patient education in areas such as diabetes [18], asthma [19], and chronic pain [20]. Also, a recent review of the use of AR in nurse training revealed that experiences of using such technology were positive overall [21]; however, the included studies mostly focused on AR applications in nurse education and did not address patient education. Overall, there is a lack of knowledge on how nurses involved in patient education perceive AR and other similar digital solutions and their potential to deliver effective patient education.

The evaluation of digital solutions and mobile apps to support patient education and self-management has been found to be a complex multidimensional process addressing different aspects, such as usability and engagement, that can be framed across multiple theoretical frameworks. To address the challenge of the quality evaluation of mobile health solutions and to evaluate the extent to which they are suitable for the target population, Stoyanov et al [22] created a new validated survey, the result of a systematic evaluation of previous research—the Mobile App Rating Scale (MARS).

Given the need for improvements in r-hGH treatment, this study aims to analyze emerging digital solutions and the opinions of nurses concerning the use of tools such as the Easypod AR mobile app to educate and support patients receiving GH treatment for growth disorders as part of a PSP.

Methods

Study Design

The presented study is a cross-sectional survey with a single evaluation time. Study participants comprised PSP nurses and HCPs who support patients and their families during the initiation of r-hGH treatment administered with the connected Easypod device.

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Participants

All participating PSP nurses worked as third-party providers who were managed by the respective local affiliates of the health care business of Merck KGaA (Darmstadt, Germany) and offered the Easypod AR mobile app to patients as part of their r-hGH treatment initiation and education. They were invited by email by EK to respond to an online survey. There was no other involvement or influence by local affiliates, and each PSP nurse was asked to provide their individual consent to the survey and to respond independently. The invited nurses were from countries where the Easypod AR mobile app was already integrated into the PSP nurse care routine, including Hong Kong, Taiwan, Germany, Singapore, the United Kingdom, Australia, and South Korea. PSP nurses in Argentina also participated, based on preparation and training they received when the app was launched there in 2022.

Data Collection

Participants anonymously accessed an online form where they evaluated and commented on their experience with the use of the Easypod AR mobile app in their work educating patients in receiving r-hGH treatment. The researchers did not collect the participants' contact details, as EK distributed the invitation to take part in the study to all eligible participants. The online questionnaire was based on the validated MARS questionnaire, which assesses, mostly using Likert scales (eg, 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, and 5=strongly agree) [23], whether an intervention is perceived as entertaining, interesting, customizable, and interactive [22]. It also addresses usability and perceived impact in terms of self-management. Regarding the *association* dimension (the self-management behaviors that the app is aiming to impact), and following MARS guidelines, we adapted the questionnaire for the administration of r-hGH using the connected Easypod device (Multimedia Appendix 1 provides more details on the adaptation of this dimension). We did not use the MARS *information* dimension since the quality of the information within the app was out of the scope of the study. Furthermore, we added a few additional questions on the subjective quality of the mobile app in the context of using it for patient support (eg, the impact of COVID-19 on using the app to support patient education). Finally, the survey included a qualitative feedback element to acquire additional context and understanding of the mobile app using questions such as "Please enter any feedback suggestions for the improvement of Easypod AR" and "Please enter any positive feedback about your experience with Easypod AR."

Data Analysis

The data were analyzed using simple descriptive statistics, and the qualitative feedback received is presented together with these data.

Ethics

This project follows the ethical and deontological principles marked by the principles of the Declaration of Helsinki and the Convention of the Council of Europe for the protection of human rights and the dignity of the human being regarding the applications of biology and medicine of Oviedo. Special care was taken with respect to informed consent of the PSP nurses, their voluntary participation, and their right to leave the study at any time. The project was approved by the Ethical Review Committee of the University of Valencia, Spain (1807083).

Saizen Digital Health Ecosystem

This study took place within the context of treatment with r-hGH (somatropin; Saizen, the health care business of Merck KGaA, Darmstadt, Germany) and the r-hGH digital health ecosystem, comprising the Easypod connected injection device, Easypod Connect for HCPs, the Growlink app for patients and caregivers, the integrated PSP nurses, and the TuiTek adherence support behavior coaching program. This evolving platform of digital health solutions connects HCPs with their patients and their caregivers to support optimal treatment adherence and deliver HCP insights to support clinical decision-making to achieve the best possible growth outcomes. Figure 1 illustrates how patients using the connected Easypod device work with PSP nurses within the context of the r-hGH digital health system.

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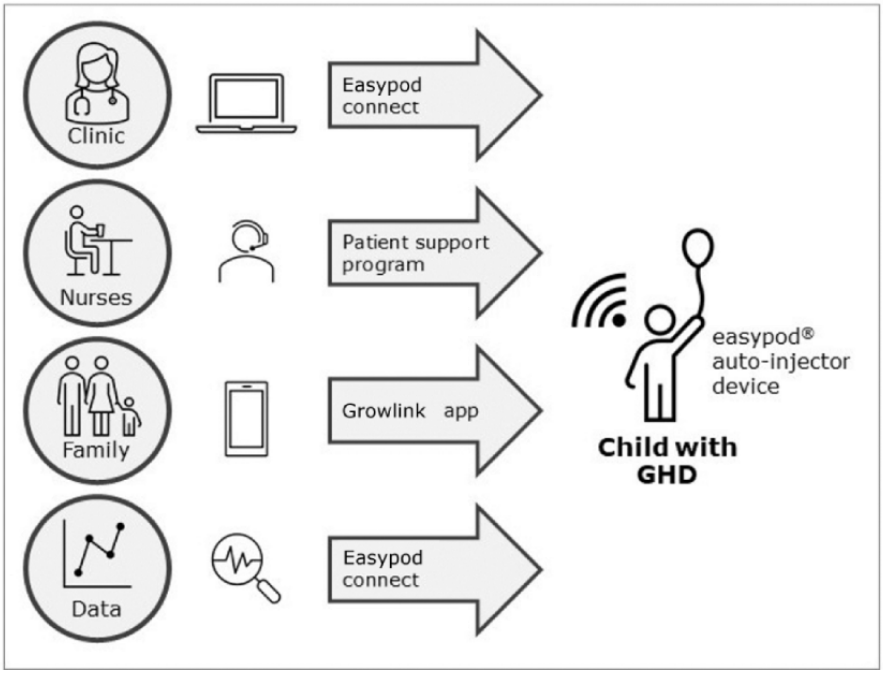
Figure 1. The Saizen digital health ecosystem. GHD: growth hormone deficiency.



Description of PSP

The participants in this study were r-hGH PSP nurses who worked for the services provided by the health care business of Merck KGaA, Darmstadt, Germany. These nurses provide support and training to patients receiving r-hGH. In addition, the prescribing HCPs had access to a remote dashboard to monitor patient adherence [24] to the Easypod device and facilitate communication between themselves and the patient and their caregiver [9]. Previous studies have shown high levels of adherence in patients using Easypod and also observed clinically significant changes in height and mean growth velocity [25].

Easypod AR App

The Easypod AR mobile app was specifically developed to help educate and support patients and their families using the connected Easypod device to administer r-hGH. It is a digital and interactive tool that contains the instructions for using the Easypod device to administer r-hGH (Figure 2). The tool aims to help patients better understand the steps of the injection process using AR technology to provide an immersive learning experience. The app is also intended to help HCPs resolve questions that patients or caregivers may have and provide support between visits.

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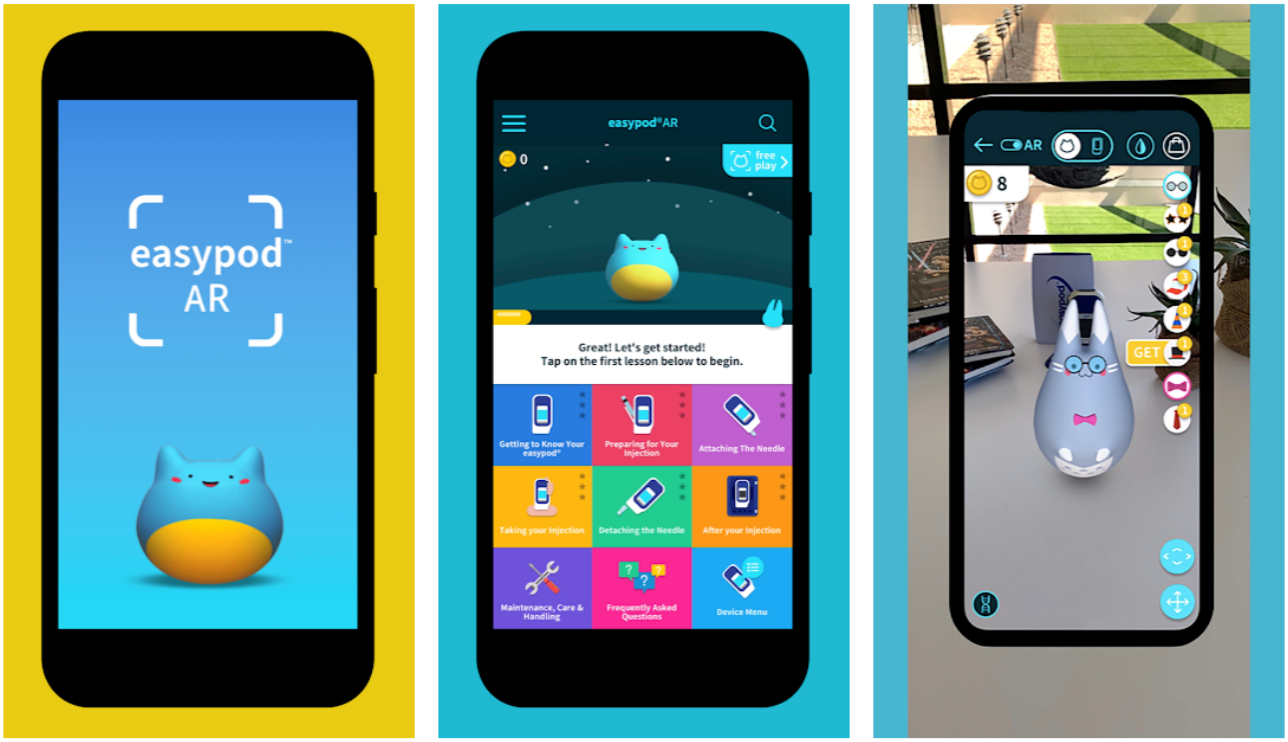
Figure 2. Screenshots of the Easypod AR mobile app.



Setting

The Easypod AR app was launched in 2020 and had over 1000 users as of December 2021 in the countries where the study was performed (Hong Kong, Taiwan, Germany, Singapore, the United Kingdom, Australia, and South Korea). The average amount of time that these users spent with the app per session (defined as one user opening the mobile app) varied by country but averaged between 8 and 14 minutes, which is a considerable duration for a mobile app [26] and may reflect patient engagement during treatment initiation and PSP-delivered training.

Results

In total, 23 nurses (of 24 to whom the email invitation was sent, ie, the total number of nurses who were part of PSPs in countries where the Easypod AR app had been launched or where training was provided as part of an anticipated future launch of the app) responded to the email invitation to participate in the study and completed the online questionnaire anonymously (Multimedia Appendix 2).

Engagement, Functionality, and Aesthetics

The nurses reported average positive results in all 5 subdimensions of *engagement* (*entertainment*, *interest*, *customization*, *interactivity*, and *adaptation* to the target group). All reported mean scores were ≥3.0 (Table 1; Multimedia Appendix 1 provides details of the specific rating scales for each dimension). The highest mean score reported for *engagement* (adaptation to the target group) was 4.0 (SD 0.74). The lowest score (3.3, SD 0.97) was reported for *entertainment*, which aligns with qualitative feedback that suggested adding more engagement features such as gamification elements.

Within the dimension *functionality*, the highest score (4.1, SD 0.79) was reported for *navigation*, while the lowest (3.8, SD 1.03) was reported for *performance*. The qualitative feedback provided by the nurses showed that in some devices, the app was slower than desired, which might reflect the use of mobile devices with fewer technical features; this might have compromised the performance of the app, which has substantial 3D visualizations and AR.

Within the dimension related to *aesthetics*, the average score was positive for all elements, but the highest score was reported for *graphics* (4.1, SD 0.67) and the lowest score reported for *visual appeal* (3.7, SD 0.81).

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Table 1. Scores per dimension from nurse participants (n=23). Multimedia Appendix 1 provides details of the specific rating scales for each dimension.

Dimensions/subdimensions	Scores, mean (SD)	Range
Engagement		
Entertainment	3.3 (0.97)	2-5
Interest	3.6 (0.72)	2-5
Customization	3.5 (0.85)	2-5
Interactivity	3.3 (1.10)	1-5
Target group	4.0 (0.74)	3-5
Functionality		
Performance	3.8 (1.03)	2-5
Ease of use	3.9 (0.73)	3-5
Navigation	4.1 (0.79)	3-5
Gestural design	4.0 (0.77)	2-5
Aesthetics		
Layout	4.0 (0.77)	2-5
Graphics	4.1 (0.67)	3-5
Visual appeal	3.7 (0.81)	2-5

Association With Self-management

The MARS questionnaire also includes a *perceived association* dimension, which in this case was related to the administration of r-hGH using the connected Easypod device. The perceived impact scaled positively across all subdimensions, notably exceeding in *knowledge*, *emotions*, and *help-seeking* (Table 2).

Table 2. Perceived impact of Easypod AR by nurses in relation to administration of r-hGH via Easypod (n=23).

	Respondents, n (%)		
	Disagree or strongly disagree	Neutral	Agree or strongly agree
Emotions[a]	2 (9)	6 (26)	15 (65)
Behavior change[b]	1 (4)	8 (35)	14 (61)
Help-seeking[c]	1 (4)	7 (30)	15 (65)
Intention to change[d]	2 (9)	8 (35)	13 (57)
Attitudes[e]	1 (4)	9 (39)	13 (57)
Knowledge[f]	0 (0)	7 (30)	16 (70)
Awareness[g]	0 (0)	8 (35)	15 (65)

[a]Emotions: “The use of Easypod AR is likely to decrease the fear and anxiety associated with using this treatment procedure.”

[b]Behavior change: “The use of Easypod AR is likely to increase the proper and safe administration of this treatment procedure.”

[c]Help-seeking: “The use of Easypod AR is likely to encourage further help-seeking for correct treatment procedure via the Patient Support Program.”

[d]Intention to change: “The use of Easypod AR is likely to increase intentions/motivation to follow the correct treatment procedure.”

[e]Attitudes: “The use of Easypod AR is likely to change attitudes toward using the device properly and in a safe way.”

[f]Knowledge: “The use of Easypod AR app is likely to increase knowledge/understanding of using the correct treatment procedure properly and safely.”

[g]Awareness: “The use of Easypod AR app is likely to increase awareness of the importance of addressing the treatment procedure properly and safely.”

Subjective Quality of Easypod AR

The subjective quality of the mobile app was high, with 70% (16 of 23) of the respondents saying that they would recommend it (Table 3). Also, the average rating was quite positive, with an average of 3.5 on a scale from 1 (worst) to 5 (best).

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Table 3. Subjective quality of the Easypod AR mobile app.

Score	Description	Respondents, n (%)
5	Definitely, I would recommend this app to everyone.	11 (48)
4	There are many people I would recommend this app to.	5 (22)
3	Maybe, there are several people whom I would recommend it to.	5 (22)
2	There are very few people I would recommend this app to.	2 (8)
1	Not at all, I would not recommend this app to anyone.	0 (0)

Subjective Feedback and COVID-19

Fourteen of 23 participants reported that they "especially liked" or "strongly liked" the potential to reduce fear of injections (eg, "Relieving anxiety about injections"). Also, one nurse reported that the app might be useful for training children and parents together (eg, "Easy to use, parents and children can engage training together").

As explained in the Methods, we included some questions about the impact of COVID-19, because the introduction of Easypod AR occurred at the same time as the global pandemic. Indeed, of the participating nurses, 12 answered that yes, they believed such a mobile solution could improve patient education in the context of such a public health situation.

Discussion

Principal Findings

This study investigated the experiences of nurses who used a mobile app to support patient training and education within a PSP that was mostly virtual (phone-based). The results are quite encouraging in terms of the positive feedback received from the nurses; these results are aligned with previous studies on the use of AR in nursing care [21] and pediatric patient education [18-20]. Furthermore, the average rating of the app was quite positive when compared with examples used in MARS testing [22]. The results also showed areas for improvement in terms of technical aspects that might also be related to the heterogeneity of setups (eg, different smartphone capabilities and internet connections). Qualitative feedback suggested adding gamification elements, which have the potential to support adherence to r-hGH therapy [27]. Our study adds to the previous literature due to its international nature, with nurses participating from different countries who all worked in specialized care (pediatric endocrinology) using telehealth. Importantly, this shows the potential of AR-based approaches to support patient education across different health care systems.

International recommendations state that nursing involvement is needed in the development and application of artificial intelligence–based technologies in nursing [28]. However, research indicates that nurses are traditionally not sufficiently involved in the development of these technologies [29]. This study also shows the potential of involving nurses in the evaluation and assessment of digital health solutions that can, in fact, help increase digital health literacy [30] among those HCPs who are involved in patient education and are consequently also able to advise patients on mobile health solutions. This is especially important in growth-related disorders, where there have been concerns about the quality of some available mobile apps [12].

Limitations

Our study has some limitations. The use of a survey (MARS) has many inherent limitations (eg, a lack of detailed qualitative feedback). Also, here, a modified version of the survey was used; in particular, we did not address the *information* dimension in the standard MARS survey, as it was not pertinent to the research objective, and we added a few complementary questions (eg, impact of the COVID-19 pandemic). Furthermore, our study did not address the objective impact on patient education outcomes (eg, reducing errors or promoting adherence), as this would have required a separate study design. Therefore, future research is needed to explore the patient's perspective.

Our study addresses the acceptability of an AR-based mobile solution to support nurse-led patient education from the nurses' perspective, but we did not address the quantifiable impact in nursing practice. Although there is evidence supporting the use of AR in nursing [21], few studies have looked into how this mobile solution impacts clinical encounters. An example outside of the domain of pediatric endocrinology is Sisom (from the Norwegian phrase "Si det Som det er," meaning "Tell it how it is"), a computer-based animated tool that analyzed the impact of a mobile solution in communication between pediatric oncology patients and nurses [31,32]. Future research using an experimental study design could investigate how mobile solutions impact the quality of nursing encounters in patient education for r-hGH therapy.

Conclusions

The Easypod AR mobile app was well-received by nurses involved in the training of patients with GHD for the administration of r-hGH, especially with regard to nurses' perceptions about the potential to improve patient education, improve self-management, relieve anxiety about injections, and encourage patients and their families to seek further support from PSPs.

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Acknowledgments

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Data Availability

All data generated or analyzed during this study are included in this published article or the Multimedia Appendices 1 and 2.

Authors' Contributions

RMB and EK designed the study, analyzed the data, and interpreted the results. BM and LMP critically reviewed the data and contributed to writing the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

BM is an employee of Ares Trading SA, Eysins, an affiliate of Merck KGaA, Darmstadt, Germany. EK is an employee of the health care business of Merck KGaA, Darmstadt, Germany, and holds shares in the company.

Multimedia Appendix 1
Adapted MARS survey.
[PDF File (Adobe PDF File), 1634 KB - nursing_v6i1e44355_app1.pdf]

Multimedia Appendix 2
Survey data.
[XLSX File (Microsoft Excel File), 23 KB - nursing_v6i1e44355_app2.xlsx]

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Abbreviations

AR: augmented reality
GH: growth hormone
GHD: growth hormone deficiency
HCP: health care professional
MARS: Mobile App Rating Scale
PSP: patient support program
r-hGH: recombinant human growth hormone

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Original Paper

Nurses' Work Concerns and Disenchantment During the COVID-19 Pandemic: Machine Learning Analysis of Web-Based Discussions

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Abstract

Background: Web-based forums provide a space for communities of interest to exchange ideas and experiences. Nurse professionals used these forums during the COVID-19 pandemic to share their experiences and concerns.

Objective: The objective of this study was to examine the nurse-generated content to capture the evolution of nurses' work concerns during the COVID-19 pandemic.

Methods: We analyzed 14,060 posts related to the COVID-19 pandemic from March 2020 to April 2021. The data analysis stage included unsupervised machine learning and thematic qualitative analysis. We used an unsupervised machine learning approach, latent Dirichlet allocation, to identify salient topics in the collected posts. A human-in-the-loop analysis complemented the machine learning approach, categorizing topics into themes and subthemes. We developed insights into nurses' evolving perspectives based on temporal changes.

Results: We identified themes for biweekly periods and grouped them into 20 major themes based on the work concern inventory framework. Dominant work concerns varied throughout the study period. A detailed analysis of the patterns in how themes evolved over time enabled us to create narratives of work concerns.

Conclusions: The analysis demonstrates that professional web-based forums capture nuanced details about nurses' work concerns and workplace stressors during the COVID-19 pandemic. Monitoring and assessment of web-based discussions could provide useful data for health care organizations to understand how their primary caregivers are affected by external pressures and internal managerial decisions and design more effective responses and planning during crises.

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KEYWORDS

text mining; machine learning; blog data; COVID-19; pandemic; work concerns; stressors; natural language processing

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Introduction

Background

The COVID-19 pandemic presented substantial challenges to health care systems overwhelmed by patients with COVID-19, creating stress on the care delivery system. For months, health professionals faced anxiety because of heavy workloads and risk of infection [1]. Overstressed nurses are now considering leaving a job that many thought to be their calling. In a survey of 6568 nurses by the American Association of Critical-Care Nurses, two-thirds of the respondents said that the coronavirus pandemic had prompted them to consider leaving the profession [2]. The ripple effects of disasters such as the pandemic may persist long after the crisis period [3].

The COVID-19 global outbreak placed health care systems under unprecedented stressors and has been a challenging time for those who work on the front lines of health care. Stress is caused by the experience of anticipating or encountering adversity in one's goal-related efforts [4]. Facing prolonged and excessive stress may lead to nurse burnout, a state of emotional, physical, and mental exhaustion. Health providers' experiences of burnout have been discussed in recent studies [1,5], demonstrating that it can affect not only nurses' quality of life but also patient care. Hence, it is important to understand the work concerns and stressors behind nurse burnout during the COVID-19 pandemic.

A study on the H1N1 outbreak [6] showed that Twitter data could be used for real-time infodemiological studies, providing a source of opinions for health authorities to respond to public concerns. The availability of large volumes of user-generated content provides an opportunity for organizations to analyze the content and derive insight. In the health care context, these data can be used to capture patients' concerns and worries or the satisfaction of staff, which can then be used to improve care [7] and working conditions. For example, user-generated content can help improve cancer care by analyzing the discussions in cancer-related communities [8] and identify mental illnesses such as depression using Instagram images taken by users during the COVID-19 pandemic [9]. Web-based content analysis is also used to determine how mask guidelines differ across nations and regions [10].

Prior Work

There is a lack of literature on interventions for supporting health care workers during disease outbreaks. To investigate this important consideration, recent studies have used surveys to identify nurses' stressors during the COVID-19 pandemic [11] and have shown that nursing care has been influenced by fear and isolation, making it hard to maintain the humanization of health care [12]. Survey results [11] identified 6 themes: infection-self, illness or death–others, workplace, personal protective equipment (PPE) or supplies, unknowns, and opinions or politics. Interestingly, some of the stress factors were under the control of health care organizations (HCOs). For instance, HCOs did not provide the proper equipment or put in place policies to ensure the safety and effectiveness of their staff. Many staff members felt betrayed without adequate PPE early in the pandemic and when facing furloughs and layoffs. Caught in firefighting mode, HCOs failed to sense and respond to concerns raised by clinical providers.

Questionnaire surveys can be used to investigate people's attitudes, opinions, or knowledge related to COVID-19 [13]. However, this method limits the number of participants to a given time and location [14], which can be a constraint when addressing a global pandemic spanning an extended period [15]. Collecting and analyzing a large number of practitioner comments from social media can be an effective way to investigate and understand how the pandemic affects clinicians and their work over time. The large volume of comments across several months from different states allows us to analyze and identify topics and themes related to a complex phenomenon such as COVID-19 and its impact on health care systems longitudinally [16]. Such analysis is beneficial for health care administrators to develop effective strategies [17].

Manually analyzing large bodies of unstructured text can be resource-intensive [18]. Natural language processing (NLP), a subfield of machine learning (ML) focused on representation and interpretation of words, has been widely used to uncover useful information from large bodies of text while allowing for the validation of findings through replication [19]. Recently, NLP has been used to analyze concerns and discussions about COVID-19 from Weibo and Twitter at the early stages of the pandemic.

Although the NLP area is broad, a particular problem is the categorization of large bodies of text in an unsupervised fashion, or topic analysis. Topic modeling (TM) is an unsupervised ML application of NLP that has been used to infer patterns and group similar text or documents without needing a priori topic labels [20]. A common algorithm for TM is latent Dirichlet allocation (LDA). For example, it has been used to investigate Twitter data in real time during a natural disaster [21], analyze text comments in the health care industry [22,23], identify and understand sentiments within patient experience after total shoulder arthroplasty [24], and study health effects associated with electronic cigarette use from user-generated content from web-based forums [25].

During the COVID-19 pandemic, LDA was also used to analyze scientific publications [26] and elicit themes and emotions that measure the general public's response to the pandemic [9,10,27]. As the pandemic evolved, further studies concentrated on symptom identification based on longitudinal data from Reddit [16] and patient web-based forums [28]. Health misinformation and conspiracies were also valuable investigation topics during this pandemic [29]. Most of these studies focused on data from patients or the general population. Fewer studies looked at the discussion and concerns from a nursing perspective. We identified 2 studies have investigated nurse burnout during the pandemic [30,31], but such studies are based on survey questionnaires that were cross-sectional in nature and only covered nurses' willingness to care for patients in a risky environment and mental health problems at the early stages of the COVID-19 pandemic. A notable exception [32] used sentiment analysis and TM to examine posts made by nurses on social media from March 2020 to November 2020. This study focused on the detection of negative and positive emotions

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and sentiments of fear, frustration, exhaustion, and loneliness among nurses. Their analysis also showed how these topics changed over time.

Our study considered data drawn from nurses who served on the front lines of the pandemic. We analyzed nurses' comments during a 14-month period to identify a comprehensive set of nursing-centric issues such as concerns about family and home impact, risk identification, work concern inventory, and nurse burnout. The data were retrieved from a web-based professional health care forum with open discussion among primarily US-based colleagues during a 14-month period to identify how work concerns evolved during the COVID-19 pandemic. To extract meaning from the forum threads, we adopted NLP techniques. We used LDA on a biweekly basis to understand temporal changes in topics.

Study Objectives and Approach

In this study, we aimed to (1) identify themes emerging from nurse discussions related to workplace stressors during a major crisis such as a pandemic and (2) identify the salience of stressors and see the evolution of these stressors over time.

Web-based content provides an opportunity to explore and learn from events such as the COVID-19 pandemic by leveraging NLP to analyze large volumes of comments in a systematic way and investigate meaningful topics and themes. We adopted the perspective that work stressors are related to the experience of anticipating or encountering adversity in one's goal-related efforts [4]. We guided our classification of nurses' concerns into higher-order constructs (ie, themes) by considering the self-selected goals provided by the work concern inventory framework [33].

We complemented this framework in 2 ways. First, we adapted the framework to a health care context, where a key source of stress are interactions with patients. Concern for patients is an example of positive stress [4], the stress experienced when a person adapts positively to a challenge, and is associated with goal-oriented behavior but can also lead to role conflict, which is when the attainment of one goal hinders the fulfillment of others. Second, we considered the specific context of a pandemic in which work overload and risk management become priority concerns. The value of a goal is determined by its instrumentality in achieving other valued objectives. The goal of risk management is the preservation of the physical and human assets of the organization for the successful continuation of its operations, making self-preservation contribute to business continuity. To effectively manage pandemic-associated risks will require risk identification, risk analysis, and risk mitigation [34].

Methods

Overview

This study provides a year in review from the perspective of nurses working in the front lines in the United States by analyzing the data retrieved from a nurse forum that aims to unite and empower >1 million nurses across 60 nursing specialties by providing a venue for discussion (allnurses.com). AllNurses is a social media platform for nurses to share their working concerns and experiences [35] and has been previously used for data collection and analysis [36]. In this study, we collected data over a 13-month period from a specific part of the nursing forum, *COVID, Disaster, Pandemic* [37]. This part addresses "current news, experiences, and discussions on how the disaster may impact both nurses' working and personal lives" [37].

In this forum, nurses voice concerns, share personal stories, and communicate with others regarding the COVID-19 pandemic since its outbreak, providing valuable data for investigation. We collected posts from March 2020, the onset of the pandemic in the United States, to April 2021, when the Centers for Disease Control and Prevention (CDC) eased face mask guidelines for vaccinated people and a sense of normalcy returned to health care [38]. A total of 1 year of data provided relevant insights into the perspectives of health care workers [39]. We performed a longitudinal analysis of the data to identify relevant themes related to our framework in the conversations among nurses.

Data Analysis

The data analysis stage included unsupervised ML and thematic qualitative analysis [40,41]. The unit of analysis was individual forum threads that were temporally windowed biweekly. A thread may contain posts by multiple users, and these posts are typically aligned to the name of the thread (eg, "Refusing Care of a COVID-19 Patient Due to Inappropriate PPE" posted on March 19, 2020) [42]. ML algorithms were used to segment topics and themes first, and then, following a qualitative approach, we manually reviewed a portion of the comments based on different themes to validate and explain the findings provided by the algorithms [43]. Figure 1 shows an overview of the methods used in this study.

For data extraction, a scraper engine was written using Java (Sun Microsystems) with the HtmlUnit (version 2.44.0; Gargoyle Software) package to extract data from allnurses.com for all posts within the *COVID, Disaster, Pandemic* thread. Figure 2 shows example data from the forum posts. The data set has the URL for the post, the post time, the post itself, and the thread text and thread post time. There can be many posts under the same thread, where many posts in the User_Response_Post column are part of the same thread, as shown in the Thread_Post_Text column.

We decided to perform 2 analyses: one that considered a monthly window (all posts within a month) and another that considered a biweekly window. At lower levels of granularity (ie, weekly or daily), the data set became sparse during important time frames. We created a collection of posts that served as the corpus for analysis (ie, biweekly posts).

For text processing, we then used the Natural Language Toolkit (version 3.6.5; Team NLTK) library [44] to remove stop words, split paragraphs into sentences, and then further split sentences into words (tokenize) and generate ordered combinations of words (bigrams and trigrams). Preprocessing methods play an important role in preparing data for insights and typically comprise the first step in the text-mining process [45]. The Natural Language Toolkit library includes a dictionary of common English stop words to remove (eg, *the*, *in*, *a*, and *an*)

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and allows for lemmatization of the corpus to reduce the dimensionality of the data set. The lemma of a word includes its base form plus inflected forms [40,45] where we considered part-of-speech nouns, adjectives, verbs, and adverbs. We also considered unigrams (eg, *nurse*), bigrams (eg, *COVID-19*), and trigrams (eg, *personal protection equipment*) as part of our feature set.

Figure 1. Method overview.

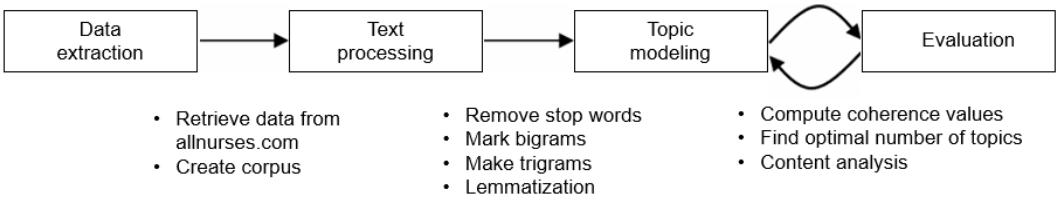

Figure 2. Example of forum post data.

	ResponseID	Thread_URL	User_Response_Time	User_Response_Post	Thread_Post_Text	Thread_Post_Time
526	15612.0	https://allnurses.com/covid-vaccine-given-way-...	2021-03-16 01:34:18	Definitely weird and I'm not sure how that hap...	My husband was able to get his COVID vaccine t...	2021-03-12 02:42:40
527	15613.0	https://allnurses.com/covid-vaccine-given-way-...	2021-03-16 05:21:05	1inch below the acromion fossa and z track ha...	My husband was able to get his COVID vaccine t...	2021-03-12 02:42:40
528	15614.0	https://allnurses.com/covid-vaccine-given-way-...	2021-03-18 02:20:28	I wish that method had been used. I uploaded...	My husband was able to get his COVID vaccine t...	2021-03-12 02:42:40
529	15615.0	https://allnurses.com/covid-vaccine-given-way-...	2021-03-19 19:11:52	oh my god what that's insane...	My husband was able to get his COVID vaccine t...	2021-03-12 02:42:40
530	15616.0	https://allnurses.com/covid-vaccine-given-way-...	2021-03-21 03:44:00	My thoughts exactly...	My husband was able to get his COVID vaccine t...	2021-03-12 02:42:40

After preprocessing the data, we used TM techniques to help identify relationships among the text. We used the LDA method, which has been widely applied in NLP, social media analysis, and information retrieval [41]. LDA is an unsupervised probabilistic method that performs topic extraction by uncovering hidden structures (semantics) from a large corpus [46], where each document can be represented as a probabilistic distribution over latent topics [41]. This adds value to large document collections by discovering interpretable, low-dimensional subspaces present in the data [47]. For its implementation, we used MALLET (version 2.08), a Java-based wrapper package for Python, to perform statistical NLP, clustering, and TM [48] and Gensim (version 3.8.3; RARE Technologies Ltd) [49], an open-source Python library for TM, to build the topic models [41].

Topic models with higher topic coherence are more interpretable (ie, words in a coherent topic have higher mutual information and, thus, are assumed to be related). Low-quality topics may be composed of highly unrelated words that cannot be fit into another topic [50] or topics that are too abstract (eg, a topic capturing the fact that nurses are discussing *COVID-19*). To select the optimal number of topics, the number of topics was bounded (n=1-16), and we chose the topic counts that gave the highest coherence score. These were further qualitatively analyzed for content, where it was found that topics too few in number tended toward being too abstract and topics too high in number tended toward having insufficient posts to produce coherent topics. Although, quantitatively, the highest performers were 2 and 4 topics, having 2 topics was found to be too abstract to be useful; therefore, having 4 topics was selected for use in the study. In Figure 3A, we present a biweekly analysis result, where having 4 topics yielded a coherence score of 0.36. Figure 3B shows an example of the 4 topics generated using MALLET. This process was repeated for biweekly and monthly levels of analysis.

TM was complemented with content analysis using an interpretive social science approach. TM removes the need for open and selective coding and theoretical sampling, enabling the analyst to condense a large corpus of narrative texts, and it becomes the analyst's task to interpret and make sense of TM, contextualizing the topics [51].

The interpretative analysis was implemented by adapting the steps of the well-established model for thematic analysis [52]. In total, 2 researchers were designated as annotators and familiarized themselves with the data by exhaustively reading the top 10 posts in each biweekly topic generated by TM (ranked based on coherence scores). Working independently, they gave the topics theme names to ensure that the names fit the content of the posts. The researchers compared selected theme names for the labeled topics, which achieved an interannotator agreement of 68%. The 32% in conflict was due to failure to identify low-coherence themes (3%) or to interpretative disagreement, such as where one researcher favored a more abstract label (ie, *Family work balance*) whereas the other favored a more specific label (ie, *Use or abuse of leave of absence policies*). After the first round, the level of agreement reached 94%. For the remaining 6%, the underlying posts were examined together to resolve the disagreements, which left no unresolved annotations. Finally, a cluster of themes was agreed upon by the researchers, and themes were condensed into higher-order constructs; for instance, *vaccine trials* and *vaccine side-effects* were condensed into *COVID-19 vaccine*.

The grouping into higher-order themes was guided by the work concern inventory framework [33], which provides a broad view of personal self-selected goals: (1) specific job tasks, (2) coworkers, (3) supervisor or manager, (4) subordinates, (5) learning new skills or development, (6) challenge, (7) variety, (8) hours or attendance, (9) help with or feedback on tasks, (10) working conditions, (11) pay or benefits, (12) autonomy or responsibility, (13) discrimination or fairness, (14) the company, and (15) future job situation. These goals determine the type of information that individuals perceive and attend to and the individual search for feedback and should be reflected in the web-based content. We complement the issues raised by this framework by detailing the specific concerns regarding the management of pandemic-associated risks [34].

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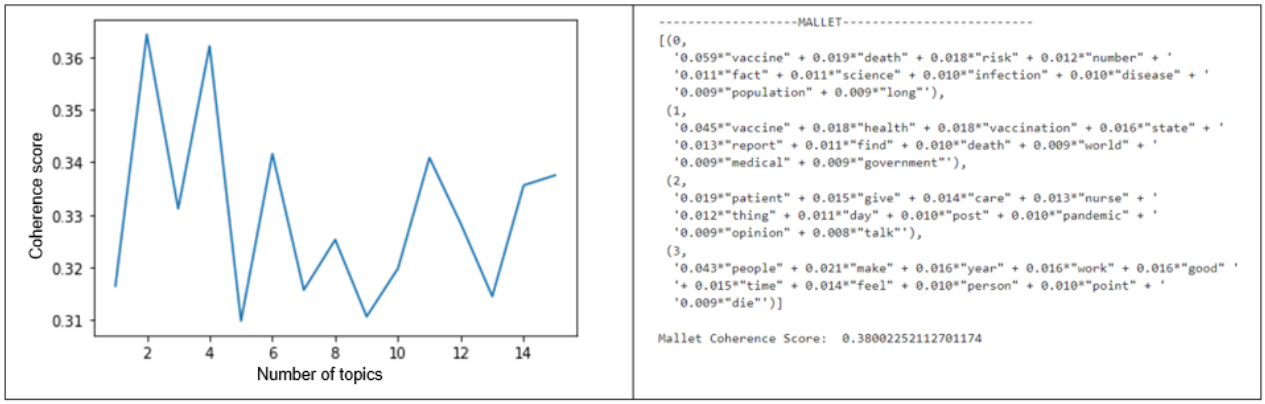
The last step in interpretative analysis involved generating higher-level narratives stitched together by themes and a sequence over time. A narrative is an account of a string of events occurring in space and time. These events do not unfold randomly but rather as an ordered series of events connected by the logic of cause and effect [53].

Figure 3. (A) Coherence score; (B) MALLET for topics.



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Ethical Considerations

This study was conducted primarily at Florida International University, where ethics review is not needed when a study uses "anonymous samples or data available from commercial or public repositories or registries" [54]. This study used data posted publicly on an internet-based nursing interest forum. As such, no consent or ethics board review is required.

Results

Overview

First, we present the themes and subthemes identified by the ML system and the human-in-the-loop classification process. Then, we show the temporal evolution of each theme. Third, we delve deeper into each theme and provide a narrative of each one by analyzing the conversations over time.

Descriptive Results

The topic analysis method identified 310 topics based on the analysis of text data from posts aggregated over 28 two-week periods from March 2020 to April 2021. The thematic analysis categorized the topics into distinct themes.

The team considered the identified topics, groups of words, and representative blog post samples in each topic; categorized the 310 topics into 58 subthemes; and then grouped these subthemes into 20 higher-order themes anchoring the theme identification in the work concern inventory [33]. For example, one topic included the unigrams *staff*, *care*, *nurse*, *nursing*, *shortage*, *number*, *find*, *provide*, *grad*, *leave*, which was categorized as a nurse shortage subtheme within the workload concern theme. Another topic included the unigrams *mask*, *room*, *wear*, *staff*, *flu*, *face*, *cough*, *time*, *pt*, *doctor*, which was categorized as mask use and PPE or risk-mitigation work concern. There were also topics with overlapping words (such as *mask*, *work*, and *home*). These were mapped into distinct themes based on the combination of words and analysis of the sentiment and meaning of the specific posts in the cluster. The final classification resulted in 20 themes, as shown in Table 1. Several topics were considered low-coherent based on the analysis of representative blog post samples (65/310, 21% of the initial topics) and were not further considered in the analysis.

Theme 1 refers to concerns about family and home impact. Nurses expressed concerns about infecting their family, leading to isolating behavior such as only talking to their children from >6 feet away with a mask. The tension with work concerns was evident, with some subthemes discussing leave of absence to resolve the tension.

A second set of themes relates to risk identification, risk-mitigation goals, and a set of work concerns related to work conditions. Themes 2 to 5 relate to risk identification: infection and fatality risk (theme 2), testing as risk identification (theme 3), virus information (theme 4), and specific nursing risk identification (theme 5). Themes 6 (PPE) and 7 (COVID-19 vaccine) refer to risk-mitigation concerns.

Themes 8 to 14 directly match items from the work concern inventory: specific job tasks, learning new skills and development, hours or attendance, working conditions, pay and benefits, autonomy and responsibility, and future job situation. These were labeled as patient care (theme 8), workload (theme 9), task completion and performance (theme 10), working conditions as safety concerns (theme 11), pay and benefits (theme 12), recognition and responsibilities (theme 13), and future job situation (theme 14).

Theme 15 refers to conversations about nurse burnout, an outcome of workplace stress. The nurses' conversations also revealed frustrations at a broader level: frustration with misinformation, frustration with government response, and frustration with people not complying with mask recommendations. Themes 16 to 20 refer to these macrolevel concerns with potential implications in the workplace, namely, theme 16 (mitigation strategies for public health), theme 17 (mandates and restrictions), theme 18 (political, economic, and social concerns), theme 19 (government response), and theme 20 (denial and misinformation).

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Table 1. Overview of main themes and subthemes (work concerns).

Broader theme number	Broader theme name	Subthemes[a] (58 in total)	Summary description
1	Family and home impact	• Personal choices: family vs work • Family and home impact • Anxiety and stress	• Concern with impact on family life and work-life balance
2	Infection and fatality risk	• Infection and transmission • Fatality risk • COVID-19 surge	• Risk factors for communicable disease and concerns over mortality rate factors and rate of spread
3	Testing as risk identification	• Testing policies • Testing efficacy	• Concerns with testing procedures, policies, and effectiveness
4	Virus information	• Virus mutation science • Transmission vector • COVID-19 effects • Information sharing	• Seek to understand the pathogenic evolution of COVID-19 and transmission vectors, including communication of findings
5	Nursing risk identification	• Nurse risk factors and exposure • Nurse privacy • Nurse self-protection • Hospital regulation	• Fear of being infected at work, risk factors, and exposure in the work environment
6	PPE[b] as risk mitigation	• PPE resource availability and control • PPE use effects	• Recommendations in the organizations regarding body protection, technology (material), management of shortage (priority allocation and reuse), and dealing with allergic and other adverse reactions to PPE use
7	COVID-19 vaccine as risk mitigation	• Personal choice to get vaccinated • Vaccine effectiveness • Vaccine science • Vaccine safety • Side effects of vaccine • Vaccine supply chain • Optimism after vaccine • Perception of vaccine risk and reward	• Personal choice to get vaccinated, vaccine effectiveness, vaccine safety, side effects of vaccine, and vaccine supply chain
8	Patient care	• Patient safety concerns • Support system for patients with COVID-19	• Concern with providing care and support to patient
9	Workload	• Staff reallocation • Capacity management: safety • Hospital capability to respond • Nurse shortage and understaffing • Nurse workload and choice of floor • Nurses leaving • Predicting stress on health system	• Nurse shortage and understaffing—anticipating demand for hospitalizations and need for adding capacity through human resources: nurse reallocation, step-up of noncritical nurses, and use of retired nurses
10	Task completion and performance	• PPE • Equipment • Practices and procedures • Vaccination and medication	• Mask quality, effectiveness, and PPE use • Ventilator early use and effectiveness vs other therapies and technical details on sensors and alarms • Workplace COVID-19 procedures, infection prevention, intubation practices, and avoiding sample contamination • Medication for patients with COVID-19 and vaccine administration information
11	Working conditions as safety concerns	• Work safety concerns • Supervisor or manager • Learning new skills • Coworkers • Patient conflict	• Increasing nurse-patient ratios, masks as protection in hospital, personal choices on work safety, and policies for transitioning patients • Employee obligation for safety and poor management response • Training for new jobs and training on critical care skills • COVID-19–positive health care workers being forced to work • Mask refusal: patient behavior

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Broader theme number	Broader theme name	Subthemes[a] (58 in total)	Summary description
12	Pay and benefits	• Omitted	• Pay for overtime, hazard pay for frontline workers, compensation as a measure of respect, travel nurses' compensation, and lower compensation and salary cuts
13	Recognition and responsibilities	• Nurse value • Nursing vs corporate interest • Nurses' union	• Alignment or mismatch between nursing values and established norms and between organizational values and expectations
14	Future job situation	• Future job situation	• Career development and certifications
15	Nurse burnout	• Nurse stress and burnout	• Nurse stress and burnout
16	Mitigation strategies for public health	• Omitted	• Social distancing, wearing masks in public, vaccination, and herd immunity
17	Mandates and restrictions	• Omitted	• Lockdown scope, travel bans, need for regulations, and fairness of mask mandates and other restrictions
18	Political, economic, and social concerns	• Omitted	• Political polarization, prevention vs open economy, responsibility to protect the vulnerable, and costs and benefits of travel bans
19	Government response	• Omitted	• Role of governments regarding sanitation, misinformation, giving voice to medical experts, and impact on the economy
20	Denial and misinformation	• Omitted	• Web-based spread of misinformation, unscientific thinking, and conspiracy theories

[a]Not all subthemes are displayed; they were omitted for some themes for brevity.

[b]PPE: personal protective equipment.

Temporal Analysis

Overview

TM allowed us to establish topics and themes and measure the prevalence of themes in each period and the change over time. The prevalence of a theme was assessed using the relative incidence rate, as shown in the following section. We built models on cross-sectional posts, namely, biweekly blog conversations, to produce high-quality topics that capture the subject within the context and period of that conversation. We then analyzed how aggregate themes evolved over time and the changes in dominant themes from period to period.

Themes Over Time

Table 2 shows the themes' monthly incidence rates from March 2020 to April 2021. The rate was calculated by dividing the number of topics within a specific theme in each month by the overall number of topics identified for that month across all themes.

During a specific period, certain goals will have more influence on action than others [33], and these goals drive the information that individuals seek and the theme of web-based conversations. During the first 4 months (March 2020-June 2020), 7 themes emerged as dominant in nurses' blog posts: concerns of identification of risk of infection and fatality risk of the new virus; nurse risk factors; work overload; lack of PPE; mitigation strategies for public health; family and home impact of the pandemic; and political, economic, and social concerns.

Figure 4 shows the evolution over time of the incidence rates of these 7 themes. The incidence of concerns with risk identification and workload decreased after the initial 2 months but increased with new waves of the COVID-19 pandemic. Concern caused by shortage of PPE peaked from April 2020 to June 2020, but this concern persisted until summer 2020, generating frustration among nurses (Figure 4).

The work concerns during the final 4 months (January 2021-April 2021) revealed a substantially different set of concerns, as shown in Figure 5. Concerns with the COVID-19 vaccine, in particular its effectiveness as a mitigation mechanism and conflict regarding personal choice to be vaccinated, became a dominant theme. Other dominant themes included concerns about task completion (learning new skills), working conditions (safety), and denial or misinformation. Family and home impact remained a top concern.

More interestingly, the emergence of the COVID-19 vaccine was associated with a decrease in work safety concerns. Conversations on nurse risk identification and infection and fatality risk were no longer dominant; risk analysis subthemes focused on the side effects and safety of the vaccine itself, as illustrated in Figure 5 and further detailed in the following section.

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Table 2. Temporal analysis—theme monthly incidence rate.[a]

	Year 2020										Year 2021			
	March	April	May	June	July	August	September	October	November	December	January	February	March	April
Infection and fatality risk, %	*17*	8	0	0	0	4	10	8	4	*11*	4	4	7	3
Virus information, %	6	0	0	0	0	0	0	0	4	0	0	0	7	3
Testing as risk identification, %	6	0	0	0	0	0	0	4	0	0	0	0	4	3
Nursing risk identification, %	0	*25*	0	0	0	4	3	4	0	*11*	0	0	0	0
PPE[b] as risk mitigation, %	6	8	*24*	0	8	0	3	0	0	0	0	0	0	3
Mitigation strategies for public health, %	0	0	0	*22*	8	8	3	4	4	*11*	0	4	*11*	3
COVID-19 vaccine as risk mitigation, %	0	0	0	0	8	0	0	0	4	*33*	*30*	*46*	*18*	*33*
Work overload, %	*11*	8	6	9	8	0	0	4	*13*	0	0	0	0	0
Working conditions, %	6	8	6	4	8	*16*	3	*15*	8	*11*	*11*	0	0	3
Patient care (task completion), %	0	0	6	0	0	4	0	0	0	0	0	4	4	
Task completion and learning skills, %	6	0	6	9	0	8	3	*12*	8	0	*26*	4	7	7
Responsibilities, %	0	0	0	0	8	0	*13*	0	4	0	0	0	0	0
Pay and benefits, %	0	0	6	0	*15*	*12*	3	0	0	0	4	7	0	0
Future job situation, %	6	0	0	0	0	0	0	0	0	0	0	4	0	0
Family and home impact, %	*22*	*17*	6	4	*15*	0	0	4	4	*11*	*11*	0	0	0
Nurse burnout, %	0	0	0	0	0	4	0	0	8	0	4	0	0	0
PES[c] concerns, %	0	0	*18*	*13*	0	4	3	4	8	*11*	0	4	0	0
Mandates and restrictions, %	0	0	6	9	*15*	0	0	4	4	0	0	0	0	10
Government response, %	6	8	0	0	0	0	0	0	4	0	0	4	0	3
Denial and misinformation, %	0	8	6	0	0	0	3	0	0	0	4	7	*29*	10
Total number of themes per month, N	18	12	17	23	13	25	30	26	24	9	27	28	28	30

[a]Italics represent an incidence rate of >10%.

[b]PPE: personal protective equipment.

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[c]PES: political, economic, and social.

Figure 4. Work concerns with higher incidence rates from March 2020 to June 2020. PPE: personal protective equipment.

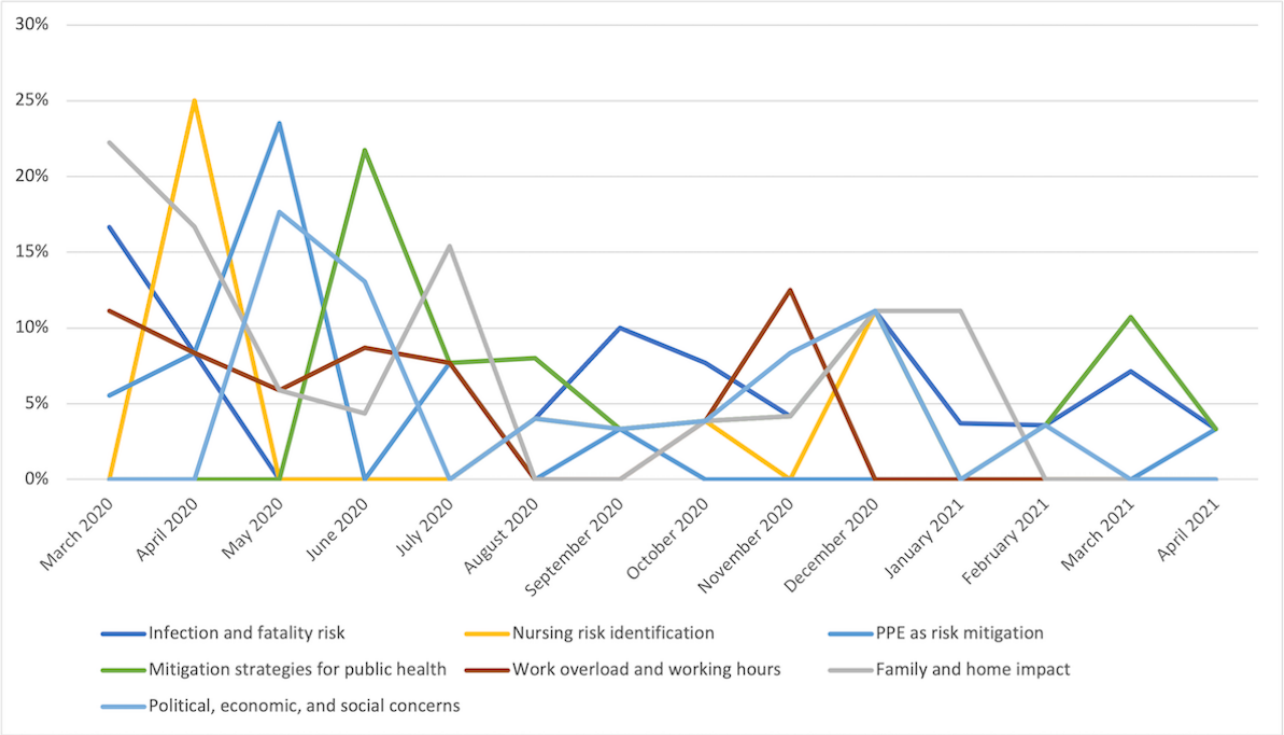
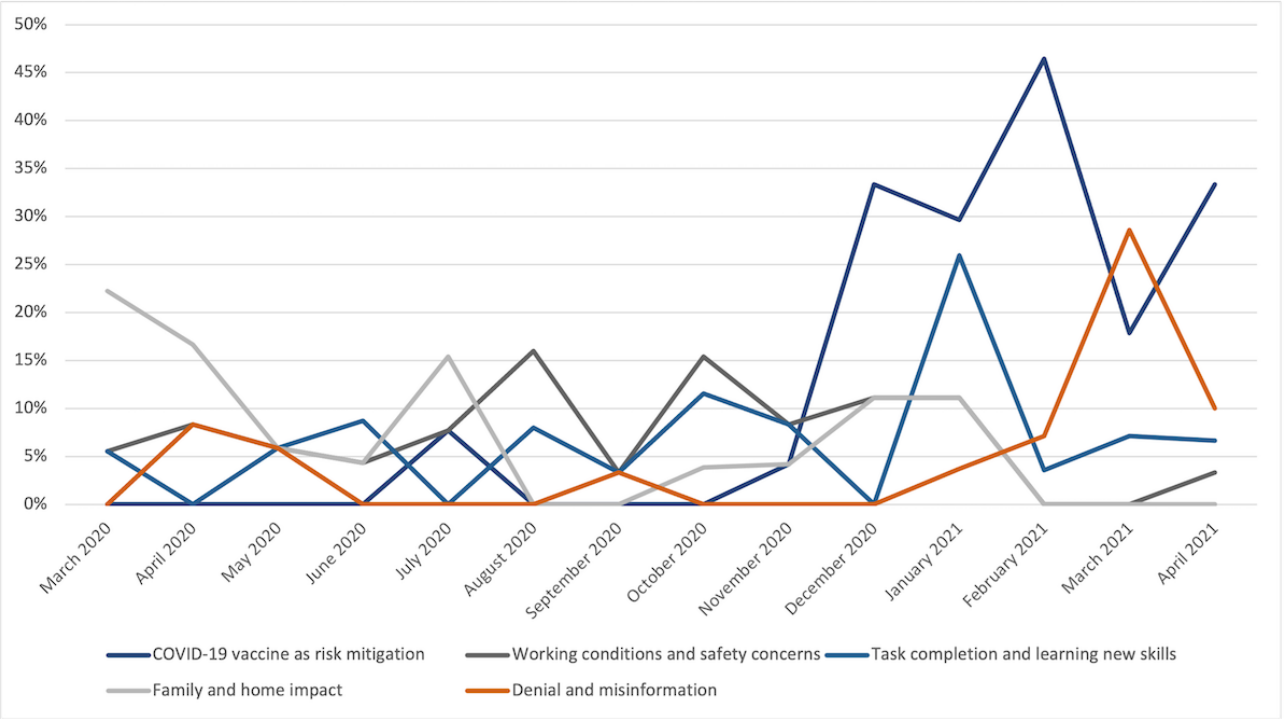


Figure 5. Work concerns with higher incidence rates from January 2021 to April 2021.



Evolution of Themes From the Work Concern Inventory

Figure 6 shows the evolution of the incidence rates only of themes related to the work concern inventory. We do not display macrolevel concerns (themes 16-20), family and home impact (theme 1), testing (theme 3), or COVID-19 vaccine (theme 8). Some trends become apparent from this figure. Concerns with workload peak with the beginning of COVID-19 waves of infection in March 2020, June 2020, and November 2020. Risk identification and risk-mitigation concerns were also dominant themes in the early period and resurged with the COVID-19 waves.

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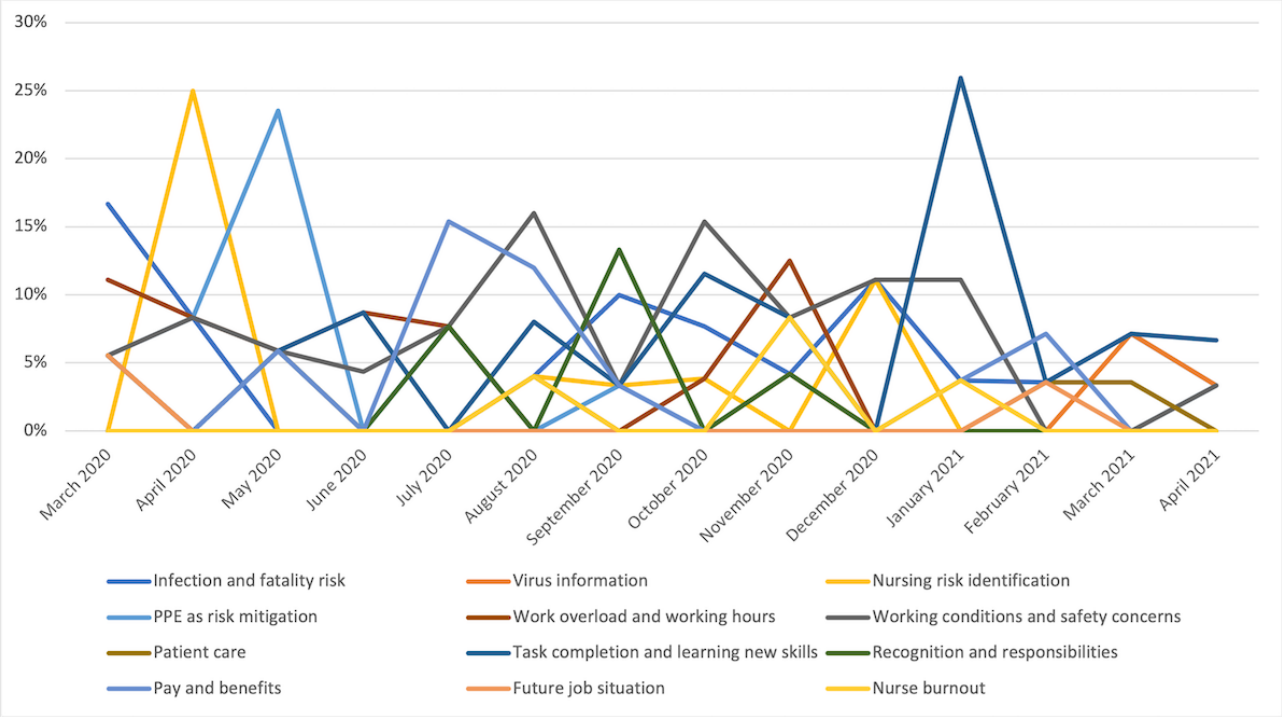
Figure 6. Evolution of work concerns. PPE: personal protective equipment.



Concerns regarding working conditions (safety) became dominant in the intermediate period (July 2020-November 2020) and spanned a variety of subthemes, as shown in Table 1. For instance, conversations about work conditions revealed concerns about coworkers going to work when ill. Research shows that people tend to respond differently in situations of uncertainty and fear [3], one such response being an increase in presenteeism—attending work when ill—as people either feel forced to attend because of heavy job demands (high workload and understaffing) or feel commitment to their organization and engagement with their work.

Work concerns with nurse recognition and responsibilities also became dominant in the intermediate period (July 2020-November 2020), signaling nurse frustration with managerial practices, in particular pay and benefits.

At the beginning of December 2021, as the COVID-19 vaccine became available to health care workers, perceptions of risks and work safety concerns started to fade. The sharing of practices among the nursing community for goals related to task completion and performance became a dominant theme.

Concerns with task completion involving new skills first manifested in the data in March 2020 with the beginning of the pandemic (as shown in Table 1) but only became a dominant theme 9 months later. Arguably, it takes time to create new knowledge and ensure the effectiveness of a new practice to feel confident sharing on social media. However, the focus of attention on concerns regarding risk identification, analysis, and mitigation during a specific period may have enabled those personal goals to have more influence on action than others in determining the information that nurses seek.

COVID-19 Narratives

Overview

A narrative is an account of a sequence of events connected by the logic of cause and effect. Narratives are the primary way in which we understand and give meaning to experiences and can form the basis for theoretical explanations of organizational phenomena [55]. TM based on biweekly blog conversations produced topics that captured the subject within the context and period of that conversation. Further analysis of the prevalence and change in topics within each theme allowed us to summarize sequential patterns of events, providing an understanding of COVID-19 narratives that would otherwise be difficult to identify.

There are five key properties that provide structure to narratives [53]: (1) a sequence in time, (2) focal actors, (3) an identifiable voice, (4) standards to judge the actions of the actors, and (5) context. Our study began with the onset of the pandemic in March 2020 and ended in April 2021 with the easing of CDC guidelines, providing a sequence for the narratives.

As we made sense of patterns of events during this period, we considered the other 4 features of a narrative structure: the focal actors were the nurse professionals, whose comments reflected their roles and self-selected goals; nurses also provided a specific point of view of the narratives (identifiable voice); the organizational culture (including values and belief systems) of US health care delivery systems provided the standards for judging actions; and the interpretation of the events was tied to a specific context, the COVID-19 pandemic, which gave meaning to the narratives.

Next, we highlight 3 narratives from our study, sustaining an explanation of changes in work concerns and the connection

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between events and their consequences, namely, nurse frustration and burnout.

Managing PPE: a Case for Social Listening

The 2 subthemes under PPE as risk mitigation are "PPE resource availability and control" and "PPE usage effects." A detailed analysis of the evolution of these themes over time, as reported by nurses on the forum, created a meaningful narrative.

There was a widespread sense that HCOs did not provide the proper equipment or put in place policies to ensure the safety and effectiveness of their staff. Our results demonstrate first the concern with exposure to patients and lack of availability of PPE (March 2020):

> *This is a part of my resignation letter. With the current issues surrounding the Covid 19 crisis it has become clear that the hospital is not prepared with adequate supplies to keep us all as safe against contracting the virus. We were told by management that we do not have enough N95 masks and have to conserve them. We are asked to reuse N95 mask and put it in a paper bag for a week of work with patients on Covid 19 section of the unit. The same applies to the gowns and face shield: one gown has to last for all assigned patients for a week. We have no shoes cover and hair cover that will allow the virus to spread around the unit.*

Caught in firefighting mode relative to PPE and other equipment, HCOs forged ad hoc responses that added further instability, as explained by the following post:

> *We are also told to use surgical masks for a week for all other assign patients that are not suspected to carry Covid19 virus. This contradicts everything we have been taught previously from Infectious Control and the CDC. Even now the policies in the hospital are changing daily for more unsafe that brings chaos, confusion, and anxiety among the staff.*

As time evolved, the topics on the PPE theme revealed further concerns with the purpose of wearing masks, shortage, and complaints about work-arounds from HCOs, leading to user innovation in mask development and discussion of protection options and effectiveness (March 2020 to May 2020), which shifted to concern regarding the consequences of wearing PPE, allergies, and solutions (August 2020) and recommendations and sharing of information on specific task completion practices (August 2020).

By failing to listen, organizations did not adapt to coping problem-solving behaviors of clinicians and envisioned work-around solutions that fell short of meeting standards, contributing to a feeling of high risk of exposure, unsafe work environments, and low valorization of staff:

> *Knowing that inconsistent hospital policy regarding reuse of PPE will fail to keep me safe from contracting the virus I obtained a half face respirator on my own and was forbidden to use it by the nursing supervisor. It a scientific fact that P-100 mask provides better protection against a variety of foreign respiratory particles than N95 and yet I was told by the supervisor that it is against hospital policy now and must be approved by infection control. The hospital should have already UV lights to disinfect our PPE if we have to reuse it and the rooms after Covid patients. I can see that important decisions were not made in a timely matter and action plan not implemented right away to prepare our hospital especially when we were warned by what was happening in New York City more than 2 weeks ago. Hospital had time to prepare but waited till last minute and what it did it locked up and rationed PPE. In this unfortunate situation even asbestos workers with their PPE gear are better equipped to work with Covid19 than us healthcare workers in our PPE given by hospital.*

Further involvement of nurses in the design of safety practices could have contributed to effective solutions while promoting nurse well-being [56]. The role conflict created by the lack of PPE became a work stressor that was associated with nurse resignation:

> *These are the reasons why I am submitting my resignation effective immediately. I am perfectly willing to work and continue help to care for patients conflicted with this virus but with proper PPE. On the other hand, I cannot be asked by my employer to work in the environment that puts my life in danger.*

A Narrative of Nurse Disenchantment

A set of themes shared unigrams in the ML grouping, such as "nurse," "risk," and "pay," and human-in-the-loop thematic analysis often found the post content entangled, such as hazard pay to cover nurse risk factors or compensation as a measure of respect for nurse worth. We show in Table 3 the evolution of conversations regarding nursing risk identification (theme 6), pay and benefits (theme 12), recognition and responsibilities (theme 13), future job situation (theme 14), and nurse burnout (theme 15).

Pay and benefits became a dominant subtheme in July 2020 to August 2020, representing 60% (3/5) of the topics. The topics within pay and benefits were diverse, including pay rates for nurses under different conditions and pay for overtime. Conversations regarding compensation also addressed the fairness of hazard pay for frontline workers and the high pay rate associated with travel nurses' compensation. Nurses struggled with unpaid leave for those who tested positive for COVID-19, salary cuts, and furloughs.

In July 2020, we saw the first concerns regarding nurse recognition and the emergence of nurse burnout as a new subtheme. Nurse recognition emerged as a dominant theme, and the topics within compensation reflected the change of tone in the conversation; compensation emerged as a measure of respect for nurse responsibility and worth and was deemed less important than enabling a reduced workload to prevent exhaustion:

> *Found out our surgical ICU unit (which houses critical covid patients) and ER got a few $$/hour*

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> *increase for covid hazard pay. Meanwhile my unit which is the primary covid telemetry/med-surge unit was denied. Administration and upper management has been honoring their initial plan of keeping us at 3:1 as long as staffing allows which it has been. If I had to choose I would definitely choose 3:1 ratio over $ increase...It's crazy how much time you save by having one less patient.*

Burnout is characterized by emotional exhaustion, cynicism, detachment, and a sense of lack of accomplishment [57]. The following nurse quote illustrates the feeling of "moral distress"—not being able to do their job and care for patients the way they believed they should:

> *The nurse's career and duty are to use good judgment in treating patients—not to be a martyr especially those who have dependent children. The employer's job is to enforce rules that protect nurses other staff and other patients.*

Both the policy of unpaid sick leave and the practice of isolation from family for fear of infection created frustration and negative well-being among nurses.

Table 3. Temporal analysis—nursing risks, pay and benefits, and recognition.[a]

	Year 2020, %										Year 2021, %			
	March	April	May	June	July	August	September	October	November	December	January	February	March	April
Nurse risk identification	0	1	0	0	0	1	0	1	0	1	0	0	0	0
Pay and benefits	0	0	1	0	2	3	1	0	0	0	1	2	0	0
Future job situation	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Nurse recognition	0	0	0	0	1	0	4	0	1	0	0	0	0	0
Nurse burnout	0	0	0	0	0	1	0	0	2	0	1	0	0	0

[a]The table reports the number of topics in each month categorized under the subtheme.

The COVID-19 Vaccine Narrative

The data support the idea that the vaccine was an effective risk-mitigation mechanism [58], producing a substantial shift in the work concerns of nurse professionals. Table 4 shows the sequence of conversations about the COVID-19 vaccine. Although the initial focus in December 2020 and January 2021 was on vaccine safety and assessment of side effects, the dominant theme shifted in February 2021 to the right of refusal and matters of personal choice in receiving the COVID-19 vaccine.

The initial concerns (March 2020 to June 2020) were spread among nurse risk factors, continuation of nurse training, and compensation. The posts related to fear of being infected peaked in April 2020, followed by a decrease in the rate of posts and another increase during the summer and in December 2020 with surges in COVID-19 infection across the United States.

There were early concerns regarding the science behind the COVID-19 vaccine (July 2020), but the COVID-19 vaccine only became a dominant theme in January 2021. A total of 4 main subthemes drove the vaccine narrative: concerns with effectiveness as a risk-mitigation mechanism; vaccine safety and concern with side effects; and, finally, individual willingness to receive the vaccine.

First, there was a sequence of conversations regarding the effectiveness of the vaccine as a mitigation mechanism. The comments on this topic focused on whether the COVID-19 vaccine was effective, supported by a discussion of the science behind it. Some posts suggested that patients may have fewer symptoms after vaccination based on previous experience with the influenza vaccine:

> *Even when people get the flu after receiving an influenza shot that they tend to get less severe forms of the flu and to spend less time in the hospital.*

Others commented that the COVID-19 vaccine should work similarly to previous vaccines:

> *We have proven that previous vaccines work for other viruses that have infected us! If you don't believe in the RNA vaccine then take the conventional vaccine.*

However, many nurses doubted the effectiveness of the COVID-19 vaccine at the early stage of vaccine implementation (from December 2020 to February 2021), arguing that the effectiveness rate was low and that the sample size of experiments was not enough at the early stage of COVID-19 vaccine development.

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Table 4. Temporal analysis—COVID-19 vaccine subthemes.[a]

	Year 2020, %										Year 2021, %			
	March	April	May	June	July	August	September	October	November	December	January	February	March	April
Vaccines: personal choice	0	0	0	0	0	0	0	0	0	0	1	5	0	5
Vaccine effectiveness	0	0	0	0	0	0	0	0	0	1	1	3	2	2
Vaccine science	0	0	0	0	1	0	0	0	1	2	0	2	1	0
Vaccine safety	0	0	0	0	0	0	0	0	0	0	2	2	1	2
Side effects of vaccine	0	0	0	0	0	0	0	0	0	0	3	0	0	1
Optimism after vaccine	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Perception of risk and reward in vaccine	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Vaccine supply chain	0	0	0	0	0	0	0	0	0	0	1	0	0	0

[a]Reports number of topics in each month categorized under the subtheme.

After more people were vaccinated and data from the CDC showed vaccine effectiveness, the narrative changed to focus on the quality of the COVID-19 vaccines. People compared COVID-19 vaccines from Pfizer, Moderna, and Johnson & Johnson. These posts emerged in February 2021:

> *The efficacy rates of the Pfizer and Moderna vaccines are just much more promising to me than J&J. Although the flu vaccine is typically only around 40-45% effective each year and J&J's COVID vaccine outperforms those statistics.*

Vaccine safety emerged as the second concern. Some nurses believed that the COVID-19 vaccine was safe based on scientific knowledge of messenger RNA:

> *mRNA technology is new but not unknown. They have been studied for more than a decade. mRNA vaccines do not contain a live virus and do not carry a risk of causing disease in the vaccinated person. mRNA from the vaccine never enters the nucleus of the cell and does not affect or interact with a person, DNA.*

However, others worried about COVID-19 vaccine safety as it was still in the experimental stage, and data from the CDC showed that the COVID-19 vaccine was not 100% safe, with a certain death rate. Beyond the concern about the early stage of COVID-19 vaccine development, some individuals did not trust any type of vaccine (February 2021 to March 2021):

> *It also stated that long term side effects were unknown due to still being in clinical trials that it may or may not protect against covid-19 and that if injury occurs due to the vaccine it is NOT covered under the vaccine injury program since it is NOT FDA APPROVED. After reading and rereading the paperwork carefully I chose not to get the vaccine.*
>
> *Don't feel I should be forced to take one either. It's my choice. Medical facilities are loaded with diseases and contagions you can pick up at any time and proper precautions were always in place to limit exposure. I am not one to have myself injected with a virus...alive or dead when I am in good health either and take good care of myself.*

The third concern was the side effects of the vaccine. Several nurses shared the care experience of Guillain-Barré syndrome from the influenza vaccine and worried that it may also be observed after COVID-19 vaccine injection:

> *I can only say what I've seen re GB and the flu vaccine. I took care of 3 patients they were all over 50. One man was totally paralyzed but could breathe on his own. I was told he eventually recovered but it took a year, and he was so despondent that he killed himself. I remember him clearly 75-year-old active healthy guy who rode his motorcycle across country and then felled by the flu vaccine. It was so sad and from that time I avoided the flu vaccine till it was made mandatory.*

Others believed that the COVID-19 vaccine had severe side effects based on scientific articles:

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> *Local reactions to the vaccine were generally mild. About half the participants receiving mRNA-1273 experienced moderate to severe side effects, such as fatigue muscle aches joint pain and headache, after the second dose. In most volunteers these resolved within two days. One potential concern about COVID-19 vaccines is an unusual phenomenon called vaccine-associated enhanced respiratory disease or VAERD.*

In addition, nurses shared their own experiences with the side effects of the COVID-19 vaccine. Some people had mild side effects, whereas others had severe side effects:

> *Sore arm after 1st dose for about 2 days otherwise no side effects. Got 2nd dose two weeks later. Started feeling crummy about 16 hours out- sore muscles/joints headache nausea general malaise. Lasted less than a day and then felt completely fine.*
>
> *Some really got hit hard after the first injection others it was the second. Same with our patients the more fragile and older residents spiked some pretty high fevers and GI upset but with Tylenol hydration and plenty of rest they recovered quickly.*
>
> *I got my 1st dose Moderna yesterday. I'm sicker than I ever was with actual covid I had a very mild case. Today I have a high fever muscle aches dizziness and a pounding headache.*

The fourth concern related to the personal choice of being vaccinated. Some people believed that the COVID-19 vaccine would be mandatory in most places and would be related to personal social benefits such as a passport, taxes, schools, and jobs:

> *I believe (in the next 1 to 5 years) failing to have the Covid vaccine may involve giving up things like being able to have a passport attend certain sports or concert venues or even to visit certain private companies or federal facilities as well as exclude you from many institutions of higher learning and many job opportunities. Ultimately you may have to ask yourself how much am I willing to give up? However not getting one would have meant no tax deductions no passport exclusion from most scholarships (or even applications to universities he was homeschooled so school until college wasn't and issue) not to mention exclusion from 95% of all jobs and social security benefits.*

However, others believed that a COVID-19 vaccine should not be mandatory. They indicated that the vaccine should be optional and expressed distaste for strong-arm tactics to force participation, such as fear of job and other social benefit loss, citing that the safety and side effects of the vaccine had not been fully examined with a high standard yet:

> *If you start using well you could choose to take the vaccine then it is an almost endless list. When it comes to something like a vaccine that has both risks, benefits, and involves a medical intervention with regard to your immune system it should always be a choice without fear of job loss or other issues.*
>
> *I don't believe the vaccines should be mandatory at this time due to concerns about both the autonomy of healthcare personnel the lowered bar for safety that comes with emergency use authorization rather than full FDA approval and the possibility of stirring up a bigger backlash against the vaccine.*

The argument of mandatory vaccination seemed to transcend the science and policy perspectives into that of morality. Several posts indicated that nonimmune people might transmit COVID-19 to other people, particularly vulnerable populations such as pregnant women, older adults, and children. Being more vulnerable, they may develop severe symptoms. They believed that social morals should be one of the major considerations when making the decision of receiving the COVID-19 vaccine:

> *You go to the grocery store and unknown to you infect others. A pregnant woman gets ill and dies taking her baby with her. Her children at home are now motherless and the husband is heartbroken and begins drinking neglecting his parenting.*

The COVID-19 vaccine narrative also contributes to understanding the phenomenon of nurse disenchantment and offers insights for organizational action regarding mandatory vaccination and personal choices. Although workplace safety is a priority goal, safety practices that undermine employee satisfaction can lead employees to resent management, avoid strict adherence to policies, and resist whether overtly (ie, quitting) or covertly (ie, calling out) [3]. Nurses' viewpoints on coworkers' choices regarding vaccination and management's stance on vaccine mandates present an opportunity for crafting informed organizational responses.

Discussion

Principal Findings

This study used posts from a professional nurse web-based discussion platform to identify nurses' work concerns during the COVID-19 pandemic.

The data analysis revealed the emergence of work concerns related to risk identification and mitigation, that is, reducing exposure to the risk and the likelihood that the risk will occur. These concerns revealed personal goals in these domains that became critical determinants of behavior in organizational settings [33]. Nurses still expressed concerns about task completion and operating with high performance. In fact, the theme became dominant in later stages of the timeline as risk-mitigation mechanisms came in full force, namely, the vaccine.

Our analysis also shows that the government's inconsistent posture in implementing policies contributed to the emergence of concerns among nurses, a finding consistent with previous studies on public sentiment during the COVID-19 pandemic [59].

Managerial practices have unintended consequences and may create trade-offs that amplify the stress related to work concerns.

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For instance, job rotation serves to make work more interesting by providing variety but can enhance stress [56]. Regarding compensation practices, employees are typically more motivated and satisfied when they receive the rewards that they feel they deserve [60]. However, incentive compensation practices can undermine employee well-being when they introduce inequity into the organization, which is a fairness work concern. The nurse narratives revealed concerns with nurse pay cuts and furloughs in some areas as well as concerns over the merit of hazard pay and the high compensation for travel nurses. These practices were intended for the dynamic adjustment of hospital capacity to meet demand but seemed to leave nurses angry as they deemed them unfair.

We differentiate from previous studies that have analyzed data from social media outlets such as Facebook and Twitter [32] by focusing on a domain-specific outlet, a professional nursing forum. Our work also used ML to categorize the evolution of nursing conversations during the pandemic. We then used a theoretical framework to filter work concerns. Our results show that the conversations were more focused and job-related and less personal.

In our study, we used text created by nurses to infer work-related concerns that affect employee satisfaction and, eventually, their productivity and organizational performance. We contributed to a stream of studies that use text on social media to infer organizational performance [9]. In addition, our study identified new discussion topics regarding COVID-19 work concerns when compared with previous studies [9,32]. Finally, adopting a temporal analysis, our study explored how conversations evolved within themes and offered a narrative of work concerns.

Limitations

There were some limitations to this study. The main limitation of our study lies in the reliance on blog data primarily from a single country, reducing the possible generalization of results to other populations. Another limitation is that the data collected from the web-based media reflect perceived work context characteristics, which could exhibit personal bias and, consequently, not be a true representation of the work environment. Although narratives require an identifiable voice—in our case, nurse professionals—future studies may consider multiple points of view, including other stakeholders such as physicians and administrators. In addition, this study did not conduct sentiment and emotion analyses of comments. Future research can explore public emotions by analyzing comments written in response to original posts.

Practical Implications

The results of this study may assist health care managers and policy makers in being active observers of professional participation and activity in web-based media. Social listening is an important way to gauge health care professionals' concerns and responses. When faced with unexpected events, health care leaders need to devise organizational strategies that support physicians, nurses, and care team members, ultimately promoting organizational justice, which can include manageable workloads, flexibility to facilitate family-work balance, and ensuring that clinicians feel valued and heard [61]. Several suggestions emerged from the data: leaders must communicate best practices clearly; manage expectations; clarify work hours; and provide sufficient resources, including effective PPE. Leaders should aim to monitor clinician wellness and proactively address concerns related to the safety of clinicians and their families. During the pandemic, clinicians should be encouraged to openly discuss vulnerability. Frontline clinicians may individually and collectively identify concerns that arise while facing the reality of the pandemic while considering the importance of team morale and protecting one's emotional strength. HCOs can provide opportunities for social support during crisis situations using internal web-based forums where nurses can share the stress factors that are affecting their work, support one another, and make suggestions for workplace adaptations during a pandemic crisis.

An interesting result is that the risk mitigation offered by the COVID-19 vaccine enabled a shift in focus from concerns regarding risk identification, analysis, and mitigation to task completion and performance and sharing of new practices and skills. It is important for HCOs to sense the personal goals that become dominant work concerns during a specific period as they will have more influence on action and on the information that clinicians seek than other goals. During a pandemic, organizations may deploy mechanisms that focus on task completion and performance based on new skills earlier by seeking to address other self-selected personal goals that have become dominant.

Our findings regarding the evolution of work concerns also inform the design of managerial practices during periods of uncertainty and fear, such as a pandemic. For instance, previous studies suggest that managers achieved positive well-being synergies by involving employees in the design of safety practices [56]. Safety practices that undermine satisfaction can lead employees to resent their supervisors and avoid following the policies. A nurse discussed how mask wearing and social distancing were not followed by coworkers, creating a sense of risk of being infected at work. Some coworkers may prefer the comfort and image of being without safety equipment during breaks or when not close to patients. While responding to a pandemic, managers can collect information on employees' attitudes toward current practices using web-based media to sense and respond to these trade-offs.

Conclusions

Overall, this study stresses the importance of understanding the experiences of nurses during a period of uncertainty and fear created by the COVID-19 pandemic. Nurses serve on the front lines of the health care delivery system, which, in general, was not prepared to respond. Responding to this situation triggered work concerns and produced tensions. The study findings regarding the evolution and interrelation of work concerns serve as a basis for articulating the lessons learned, which will be useful to various government agencies, hospitals, organizations, and communities that wish to design managerial practices that address nurses' work concerns more effectively.

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Conflicts of Interest

None declared.

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Abbreviations

CDC: Centers for Disease Control and Prevention
HCO: health care organization
LDA: latent Dirichlet allocation
ML: machine learning
NLP: natural language processing
PPE: personal protective equipment
TM: topic modeling

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Original Paper

A Nurse-Led Telehealth Program for Diabetes Foot Care: Feasibility and Usability Study

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Abstract

Background: Diabetes mellitus can lead to severe and debilitating foot complications, such as infections, ulcerations, and amputations. Despite substantial progress in diabetes care, foot disease remains a major challenge in managing this chronic condition that causes serious health complications worldwide.

Objective: The primary aim of this study was to examine the feasibility and usability of a telehealth program focused on preventive diabetes foot care. A secondary aim was to descriptively measure self-reported changes in diabetes knowledge, self-care, and foot care behaviors before and after participating in the program.

Methods: The study used a single-arm, pre-post design in 2 large family medical practice clinics in Texas. Participants met individually with the nurse practitioner once a month for 3 months using synchronous telehealth videoconferencing. Each participant received diabetes foot education guided by the Integrated Theory of Health Behavior Change. Feasibility was measured with rates of enrollment and program and assessment completion. Usability was measured with the Telehealth Usability Questionnaire. Diabetes knowledge, self-care, and foot care behaviors were measured with validated survey instruments at baseline, 1.5 months, and 3 months.

Results: Of 50 eligible individuals, 39 (78%) enrolled; 34 of 39 (87%) completed the first videoconference and 29 of 39 (74%) completed the second and third videoconferences. Of the 39 who consented, 37 (95%) completed the baseline assessment; 50% (17/34) of those who attended the first videoconference completed the assessment at 1.5 months, and 100% (29/29) of those who attended the subsequent videoconferences completed the final assessment. Overall, participants reported a positive attitude toward the use of telehealth, with a mean Telehealth Usability Questionnaire score of 6.24 (SD 0.98) on a 7-point scale. Diabetes knowledge increased by a mean of 15.82 (SD 16.69) points of 100 ($P<.001$) from baseline to 3 months. The values for the Summary of Diabetes Self-Care Activities measure demonstrated better self-care, with participants performing foot care on average 1.74 (SD 2.04) more days per week ($P<.001$), adhering to healthy eating habits on average 1.57 (SD 2.12) more days per week ($P<.001$), and being physically active on average 1.24 (SD 2.21) more days per week ($P=.005$). Participants also reported an improvement in the frequency of foot self-examinations and general foot care behaviors. The mean scores for foot care increased by a mean of 7.65 (SD 7.04) points (scale of 7 to 35) from baseline to 3 months postintervention ($P<.001$).

Conclusions: This study demonstrates that a nurse-led telehealth educational program centered on diabetes foot care is feasible, acceptable, and has the potential to improve diabetes knowledge and self-care, which are precursors to preventing debilitating foot complications.

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KEYWORDS

diabetes mellitus, type 2; telehealth; telemedicine; foot care education; self-management; self-care; preventive health services; patient education; diabetes complications; diabetic foot

Introduction

Background

The social distancing and isolation associated with the COVID-19 pandemic have increased amputation risk among patients with diabetes mellitus, owing to the drastic alterations in diabetes care and interruptions in diabetes patient education programs [1,2]. Diabetes can lead to severe and debilitating foot complications, such as infections, ulcerations, and amputations. Despite substantial progress in diabetes care, diabetic foot ulceration remains a major challenge in managing this chronic condition that is associated with high morbidity and mortality rates [1-3]. For example, the 5-year mortality rate in individuals with diabetic foot ulcers is >50%, which is similar to or worse than that in individuals with common cancers [2]. Worldwide, 40 to 60 million people with diabetes experience foot and lower limb complications, and 75% of lower extremity amputations are performed in patients with diabetes [4,5]. From 2009 to 2015, data on nontraumatic lower extremity amputation (NLEA) procedures showed a 62% increase in minor amputations and a 29% increase in major NLEAs [6]. After lower extremity amputation from diabetic foot ulcer, the 3-year mortality rate can reach 70% [7]. The significant increase in the prevalence of NLEA underscores the need to implement effective methods to improve patient outcomes within the primary care setting, where diabetic foot disease is diagnosed, treated, and managed. Studies have shown that deficiencies in early preventive diabetic foot care, such as a lack of patient education and provider management, may contribute to increased amputation rates [8,9]. Although the American Diabetes Association recommends regular foot exams [10], only 30%-33% of provider-patient visits adhere to this guideline [11,12], leading to missed opportunities to address foot care in this population. Despite the prevalence of diabetes-related foot complications, foot care education and prevention programs for people with diabetes are lacking [4].

Early detection and reporting of diabetic foot problems are critical to preventing devastating outcomes and invasive treatment, thus improving quality of life and reducing mortality rates [13]. However, people with diabetes may be unaware of their foot risks, and in-office foot examinations are often overlooked [11,12,14-16]. Without adequate instruction, patients are not equipped with the necessary self-care skills to effectively care for this chronic condition and delay foot care until problems develop, at which time invasive treatment may be necessary. During the COVID-19 pandemic, diabetes-related amputation rates have increased globally [17,18]. Therefore, there is an urgent need to engage patients in the early detection of foot problems, improve their understanding of foot risks, and avoid treatment delays. A major health care innovation during the pandemic is the widespread adoption of telehealth technology. The upsurge in telehealth services during the pandemic provides new communication tools for collaboration between patients and health care professionals [19]. Through mobile devices and internet networks, telehealth includes electronic technology and remote sharing of health information that can be used to prevent diabetes and its complications [20].

Technology continues to revolutionize communication between patients and clinicians via telehealth. The use of telehealth provides an avenue for clinician and patient collaboration between rural and urban clinic sites for the purpose of managing advanced diabetic foot disease [21]. Before videoconferencing technologies were available, clinicians relied on digital cameras, fax machines, desktop computers, modems, phone conversations, and emails to assess ulcer size and infection status [21]. Advancements in high-speed internet and video technology allow health care providers to monitor patients' foot ulcerations and provide guidance on ulcer healing remotely [22]. In terms of ulcer healing and recovery time, telehealth care using web-based consultation and digital imaging has been shown to be comparable with usual treatment [22]. Although recent literature has explored the potential value of telehealth in achieving glycemic control and monitoring existing diabetes complications, research on telehealth technology for foot care education and prevention is lacking. Previous studies have focused on patients with advanced foot ulcerations and chronic nonhealing foot wounds [22]. However, knowing that patients with diabetes may have a lower level of sensual perception and trouble healing [22], preventive foot care education based on individual risks is crucial to avoid serious foot injuries. Therefore, we implemented a theory-based, patient-centered telehealth program delivered using synchronous videoconferencing technology as a potential strategy to prevent diabetes-related foot complications.

Objectives

The primary aim was to examine the feasibility (enrollment, program, and assessment completion) and usability of a telehealth foot care educational program focused on preventive foot care measures. Specifically, the primary objectives were to assess (1) the demand for intervention by people with type 2 diabetes (whether people enroll in the program to learn about foot care) [23], (2) the completion of the telehealth educational program (whether people participate in the videoconferences and complete the surveys) [23], and (3) the usability of the telehealth educational program for people with type 2 diabetes (whether people find the educational program satisfying and want to continue using telehealth) [23]. Usability was measured using the Telehealth Usability Questionnaire (TUQ) [24]. The secondary aim was to descriptively measure self-reported changes in diabetes knowledge, self-care, and foot care behaviors before and after participating in the program.

Theoretical Framework

The Integrated Theory of Health Behavior Change (ITHBC) [25] guided this study [25]. The theory posits that a person's knowledge, beliefs, and social facilitation affect their self-care and ultimately lead to the adoption of self-care behavior [25]. Knowledge of diabetes was measured using the Diabetes

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Knowledge Scale (DKS) [26]. Social facilitation, defined as the quality of positive social interactions, was measured using the TUQ [24]. Together, these factors influence a person's self-care, defined as the ability to apply new knowledge to maintain health, which was measured by the Summary of Diabetes Self-Care Activities (SDSCA) [27]. Finally, the factors leading to the adoption of behavior change, which is to incorporate foot self-care practices into one's daily routine, were measured using the Diabetes Foot Self-Care Behavior Scale (DFSBS) [28].

Methods

Overview

We used a one-arm, pre-post design to assess the feasibility and usability of the telehealth diabetes program. Adults with type 2 diabetes recruited from 2 large family medical practice clinics in Texas completed surveys at baseline, at 1.5 months, and at 3 months after the telehealth diabetes program intervention.

Ethics Approval

This study was reviewed and approved by the University of Texas Health Science Center Institutional Review Board (HSC-SN-21-0240).

Recruitment

The principal investigator provided study flyers to 2 large family medical practice clinics that provide primary care services to patients of all ages living in the urban Houston–The Woodlands–Sugar Land metropolitan area. The institutional review board–approved study flyers were posted in the clinics' waiting areas. The medical practitioners (physicians and nurse practitioners) at each clinic recruited participants. Interested patients then contacted the principal investigator via phone or SMS text message to determine eligibility for participation. Participants were eligible if they (1) were aged 18 to 64 years, (2) had access to the internet with a smartphone or a computer, (3) had a history of type 2 diabetes, and (4) were able to speak and read English. Patients were excluded if they had (1) a history of leg or foot ulcers or amputations or (2) a diagnosis of gestational diabetes. If the patient was deemed eligible, the principal investigator explained the study and obtained informed consent in person or electronically via Research Electronic Data Capture (REDCap; Vanderbilt University for Management of Research Data) [29,30] through a secure link sent to the participant's email.

Intervention

The principal investigator scheduled three 1-hour monthly interactive Zoom (Zoom Video Communications) videoconferences with each participant to discuss comprehensive diabetes foot care and self-care behaviors. Each telehealth session followed a carefully curated outline based on the ITHBC [25] and was planned by an interdisciplinary team with expertise in diabetes, nursing education, and health care technology or informatics. Sources of the educational materials and recommendations were obtained from the American Diabetes Association [31,32], the International Diabetes Federation [4], and the Health Resources and Services Administration, an agency of the US Department of Health and Human Services [31,33]. Sessions were facilitated by the principal investigator, a family nurse practitioner with additional board certification in nursing education. During the first telehealth visit, participants were educated about foot care practices, including foot inspection, toenail care, foot cleaning, and appropriate footwear and the rationales for these behaviors. The second telehealth session focused on maintaining healthy eating habits and adhering to the recommended course of action with the support of family and providers. During the last telehealth visit, the principal investigator reviewed key concepts of diabetes foot care with participants, supported self-goal planning and monitoring, and talked about office examinations for sensory neuropathy and peripheral vascular disease. Additionally, the principal investigator discussed each question on the Health Resources and Services Administration Foot Care Quiz from the American Diabetes Association [31] with the participant and went over any incorrect responses to make sure the participant understood the rationales. The learning objectives of the telehealth educational program were to (1) identify the signs and symptoms of foot ulcerations, (2) describe foot care and diabetes self-care behaviors, and (3) discuss proper follow-up for foot care.

Study Procedure

Once participants gave consent, the REDCap [29,30] link automatically directed them to subsequent pages, where we obtained demographic information and the baseline survey data. At baseline, participants were asked to complete (1) a demographics questionnaire, (2) the DFSBS [28] to assess baseline foot care behaviors, (3) the DKS [26] to measure baseline knowledge of diabetes, and (4) the SDSCA [27] to assess participants' self-care. At 1.5 months after the first telehealth visit, we invited participants to complete midintervention surveys electronically via REDCap [29,30]. The midintervention surveys included (1) the DFSBS [28], (2) the DKS [26], and (3) the SDSCA [27]. Three months after the first telehealth visit, we invited participants who attended all 3 telehealth visits to complete postintervention surveys electronically via REDCap [29,30]. The postintervention assessments included (1) the DFSBS [28], (2) the DKS [26], (3) the SDSCA [27], and (4) the TUQ [24] to provide information on the usability of the telehealth program. In the end, participants received a US $50 gift card sent to their email address for completing the study.

Measurement

To meet the primary aim of the study, we measured the feasibility and usability of the telehealth program. At baseline, participants were asked to complete a demographics survey including age, gender, race and ethnicity, level of education, marital status, employment status, and diabetes duration. To assess feasibility, we measured the rates of enrollment, retention, and assessment (ie, survey) completion. The enrollment rate was the proportion of those meeting the inclusion criteria who enrolled, while the retention rate was the proportion who enrolled and completed the study. The assessment completion rate was calculated as the proportion of assigned surveys at each time point that were completed.

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The usability of the program was measured by participants' perceived telehealth usability using the TUQ [24]. The TUQ provided information on the social facilitation construct of the ITHBC model [25] to measure the acceptability, usability, and satisfaction of the participants' telehealth experience [24]. The 21 questions within the TUQ are divided into 5 subcategories: usefulness, ease of use, effectiveness, reliability, and satisfaction. All subcategories of TUQ demonstrated a Cronbach coefficient α of .81 to .93, indicating good to excellent internal consistency reliability [24]. Evidence of content validity has also been reported [24]. The 21-item questionnaire asked participants to rate their telehealth experience on a 7-point Likert scale (1=strongly disagree and 7=strongly agree) [24,34].

To meet the secondary aim of investigating the preliminary effects of participation in the telehealth educational program, we gathered self-reported changes in diabetes knowledge, self-care, and foot care behaviors before and after program implementation. The DKS [26] was used to assess participants' knowledge of diabetes. The scale consists of 18 true or false questions on knowledge of nutrition, exercise, foot health, and overall diabetes monitoring with 2 more specific questions for people taking insulin [26]. Both the general DKS and the insulin subscale demonstrated reliability with a Cronbach coefficient α of .77 and .84, respectively [35]. The scale has demonstrated validity [35]. The questions were scored from 0 to 100, where higher scores represented better diabetes understanding. The average was obtained by adding all the scores and dividing by the number of people who completed the survey.

The participants' self-care in managing diabetes was measured by the SDSCA [27]. The interitem and test-retest reliability demonstrated high to moderate correlations of .47 and .40, respectively [27]. The 13-item questionnaire is divided into sections of diet, exercise, blood glucose testing, foot care, and smoking status, with 2 additional questions for cigarette smokers, and has shown evidence of validity [27]. In the questionnaire, participants were asked to rate the number of days (0-7) they performed a specific self-care activity in the past 7 days. Scores were calculated by obtaining the mean number of days for each section [27]. For the cigarette smoking status, if the respondent was a cigarette smoker, 1 point was entered and added to the number of cigarettes smoked per day [27].

The DFSBS [28] was used to measure the participants' foot self-care behaviors [28]. The DFSBS has a Cronbach coefficient α of .73, and the intraclass correlation coefficient over 2 weeks was 0.92 (P<.001); both coefficients indicate that the DFSBS scale is reliable as a screening tool for daily foot care activities [28]. The scale has shown evidence of validity [28]. The 7-item scale is divided into 2 parts. The first section asked participants to rate the number of days they performed foot care in the past 7 days (0 days, 1-2 days, 3-4 days, 5-6 days, or 7 days). The second part asked them to rate the frequency they performed general foot activities (categorized into never=1, rarely, sometimes, often, or always=5). The items in both sections were added, with a range of 7-35, where higher scores indicated better foot self-care [28,36].

Statistical Analysis

Statistical analysis was conducted using SAS software for Windows (version 9.4; SAS Institute Inc) [37]. We calculated descriptive statistics to assess the feasibility, usability, and self-reported changes in diabetes knowledge, self-care, and foot care measures before and after participating in the telehealth educational program. Paired-sample t tests (2-sided) were conducted to determine if there were any significant differences between the preintervention and 3-month postintervention scores.

Results

Sample Characteristics

Of the 39 participants who consented to participate in the pilot study, 4 did not take part in the subsequent videoconferences because of schedule conflicts. Another participant tried to join the initial videoconference on the wrong date. A total of 29 participants completed all videoconferences at 3 months. Most of the dropouts had attended some college, were married, were employed full-time, were aged 50-59 years, and had diabetes for 1-5 years. They did not differ from the participants who completed the study. Table 1 presents the characteristics of the study sample. The participants were predominately employed full-time (27/39, 69%), male (24/39, 62%), married or cohabiting (29/39, 74%), and aged 50-59 years (20/39, 51%). The level of education varied, with 11 (28%) having completed a bachelor degree, 7 (18%) having a master or doctoral degree, and 5 (13%) having high school or less than high school education. The sample was diverse: 16 (41%) were White, 9 (23%) were African American, 9 (23%) were Hispanic, and 4 (10%) were Asian.

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Table 1. Sample characteristics of participants (N=39).

Characteristics	Participants, n (%)
Age range (years)	
30-39	7 (18)
40-49	5 (13)
50-59	20 (51)
60+	6 (15)
Missing	1 (3)
Gender	
Male	24 (62)
Female	14 (36)
Missing	1 (2)
Marital status	
Single	5 (13)
Married or cohabiting	29 (74)
Divorced	4 (10)
Missing	1 (3)
Employment status	
Unemployed	7 (18)
Part-time	2 (5)
Full-time	27 (69)
Retired	2 (5)
Missing	1 (3)
Educational attainment	
Less than high school	3 (8)
High school	2 (5)
Some college	12 (30)
Associate degree	3 (8)
Bachelor’s degree	11 (28)
Master’s degree	4 (10)
Doctorate	3 (8)
Missing	1 (3)
Race and ethnicity	
White	16 (41)
African American	9 (23)
Hispanic	9 (23)
Asian	4 (10)
Missing	1 (3)
Diabetes duration (years)	
Less than 1	8 (20)
1-5	14 (36)
6-10	10 (26)
More than 10	6 (15)
Missing	1 (3)

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Feasibility: Enrollment, Retention, and Assessment Rates

Of the 50 individuals who were eligible for the study, 39 (78%) consented to participate. After consenting and before the first videoconference, 5 participants (5/39, 13%) dropped out of the study. The availability of participants and the time commitment were the most common issues, as 1 participant shared that he was offered a new job after he consented and could no longer find the time for the study. One participant had other, more critical health issues that needed to be resolved. Of the 39 who consented, 34 (87%) completed the first videoconference and 29 (74%) completed the second and third videoconferences. Therefore, 74% (29/39) finished the study, defined as attending all 3 videoconferences. The percentage of participants completing the baseline assessment was 95% (37/39). The percentage of participants completing assessments at 1.5 months was 50% (17/34). The percentage of participants completing final assessments at 3 months was 100% (29/29). On average, the assessment completion rate for all surveys was approximately 82%.

During the abrupt outbreak of COVID-19, many companies switched to virtual technological platforms such as Zoom to meet. All but 2 of the participants in the study were familiar with Zoom technology. One participant initially had challenges using the technology and needed his daughter to help with joining Zoom meetings. However, by the third videoconference, he successfully connected to Zoom by himself. Another participant had difficulty allowing the camera to turn on in the Zoom application using his mobile device. After getting help from the principal investigator, he was also able to connect with audiovisual media using his smartphone. Most participants used their cellular phones to connect, likely owing to the easy and convenient nature of mobile technology. However, while those who lived in the urban area had no issues with connectivity, 2 participants in the rural areas had poor connection quality and speed, causing the virtual conferences to be rescheduled.

One participant logged in a day early and never rejoined because of a schedule conflict. Several participants also had to reschedule the videoconferences due to work schedule conflicts, severe weather, or simply forgetting, despite calendar reminders sent to their emails. Technology also relies on electrical power and network signals. On September 14, 2021, a tropical storm swept through Texas, resulting in power outages for many individuals, thereby precluding videoconferences at the originally scheduled time.

Telehealth Usability

Overall, participants reported a positive attitude toward the use of telehealth in this study with an overall mean TUQ score [24] of 6.24 (SD 0.98) on a scale of 1 to 7 (Table 2). They found the telehealth modality to be easy to use, effective, useful, and reliable. Participants were satisfied with its overall use and would use it again. The TUQ [24] demonstrated a Cronbach α of .97, indicating excellent reliability.

Table 2. Summary of participants' perceptions of telehealth usability (n=29).

Telehealth usability (score scale 1-7)	Score, mean (SD)
Usefulness	6.14 (0.97)
Ease of use	6.50 (0.93)
Effectiveness	6.32 (0.96)
Reliability	5.58 (1.48)
Satisfaction	6.15 (1.18)
Total score	6.24 (0.98)

Changes in Diabetes Knowledge, Self-care, and Foot Care Measures

The mean scores for diabetes knowledge, self-care, and foot care activities for all participants who took the surveys are presented in Table 3. The paired-sample *t* test analysis revealed that participants' diabetes knowledge, self-care abilities, and foot care activities were higher at 3 months postintervention than at baseline (Table 4). Diabetes knowledge increased by a mean of 15.82 (SD 16.69) points of 100 ($P<.001$) from baseline to 3 months. Postintervention surveys demonstrated significantly better self-care, with participants testing their blood glucose on average 2.26 (SD 2.47) more days per week ($P<.001$), performing foot care an average of 1.74 (SD 2.04) more days per week ($P<.001$), adhering to healthy eating habits on average 1.57 (SD 2.12) more days per week ($P<.001$), and being physically active on average 1.24 (SD 2.21) more days per week ($P=.005$). Cronbach α for the self-care measure [27] was .82, indicating good internal consistency reliability. Participants also reported an improvement in the frequency of foot self-examinations and general foot care behaviors. The mean scores for foot care increased by a mean of 7.65 (SD 7.04) points (scale of 7 to 35) from baseline to 3 months postintervention ($P<.001$). Cronbach α for the DFSBS [28] was .80, indicating good reliability of the scale.

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Table 3. Descriptive analysis of changes in foot care behaviors, self-care, and diabetes knowledge.

Variables	Baseline (n=37), mean (SD)	1.5 months (n=17), mean (SD)	3 months (n=29), mean (SD)
Diabetes Foot Self-Care Behavior Scale	17.75 (7.42)	21.59 (7.21)	25.46 (6.20)
Summary of Diabetes Self-Care Activities (days per week)			
General diet	3.34 (1.97)	3.74 (1.45)	4.74 (1.62)
Blood glucose testing	2.26 (2.34)	2.47 (2.17)	4.28 (2.66)
Foot care	2.69 (2.25)	3.38 (2.24)	4.40 (2.23)
Exercise	2.03 (1.70)	2.32 (1.40)	3.16 (1.81)
Diabetes Knowledge Scale	70.48 (17.86)	75.92 (15.81)	83.89 (10.70)

Table 4. Paired-sample t test analysis of foot care behaviors, self-care, and diabetes knowledge at baseline and 3 months postintervention.

Variables	Participants, n	Baseline, mean (SD)	Three months, mean (SD)	Difference, mean (SD)	95% CI	*t* (*df*)	Significance (2-tailed), *P* value
Diabetes Foot Self-Care Behavior Scale	26	17.81 (6.75)	25.46 (6.21)	7.65 (7.04)	4.81-10.50	5.54 (25)	<.001
Summary of Diabetes Self-Care Activities							
General diet	29	3.17 (1.96)	4.74 (1.62)	1.57 (2.12)	0.76-2.37	3.99 (28)	<.001
BG testing	29	2.02 (2.37)	4.28 (2.66)	2.26 (2.47)	1.32-3.20	4.93 (28)	<.001
Foot care	29	2.66 (2.25)	4.40 (2.23)	1.74 (2.04)	0.96-2.51	4.59 (28)	<.001
Exercise	29	1.91 (1.71)	3.16 (1.81)	1.24 (2.21)	0.40-2.08	3.02 (28)	.005
Diabetes Knowledge Scale	21	68.07 (18.81)	83.89 (10.70)	15.82 (16.69)	8.22-23.42	4.34 (20)	<.001

Discussion

Principal Findings

This study examined the feasibility, usability, and self-reported changes in diabetes knowledge, self-care, and foot care measures before and after participation in a telehealth educational program that focused on foot care during the COVID-19 pandemic. To our knowledge, this study is the first to assess the feasibility, usability, and self-reported changes in foot care measures of a theory-based synchronous telehealth educational program focused on preventive foot care for patients with type 2 diabetes in primary care. We found that the telehealth program was feasible, easy to use, and acceptable for our participants. Participants reported they were satisfied with the overall use of telehealth technology and agreed they would use telehealth sessions again. In addition, the synchronous telehealth program improved self-reported diabetes knowledge, frequency of foot care, and self-care of diabetes management behaviors. Telehealth has frequently been used to diagnose, evaluate, and treat patients [38], and this study demonstrated that telehealth videoconferences can offer theory-based education on foot care for people with type 2 diabetes.

Feasibility of the Foot Care Telehealth Program

In terms of feasibility measures, the overall telehealth enrollment, participation, and assessment completion rates were favorable. The videoconferences can be conducted at home or work via mobile phones or computers and do not require traveling, which may be more convenient for many participants and may make patients more willing to participate in the study. Conversations with individuals during the recruitment process revealed that a lack of time, scheduling conflicts, and other health priorities were the most frequent barriers to participation in the study. A possible solution would be to use a website or a phone app that would automatically send text reminders of an upcoming videoconference. If they are unable to attend, participants could then use the website or mobile app to reschedule the videoconference by choosing a time and date that work best for them.

Five participants (5/39, 13%) attended the first videoconference but did not complete the subsequent ones, so we could not confirm changes in their diabetes knowledge, foot care measures, or self-care behaviors. The reasons for not completing the subsequent videoconferences may have been related to participants thinking that they already knew the information presented, a lack of time, and illness. Of note, everyone who participated in the second session also completed the third videoconference. Those who remained after the first telehealth session were interested in learning more about diabetes foot care, while others who lost interest dropped out. The 26% (10/39) rate of dropout is comparable to what has been reported in research evaluating the impact of telehealth programs in

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patients with type 2 diabetes [39]. The 74% (29/39) completion rate over 3 months resembles what was observed in another study evaluating telehealth to set goals for patients with diabetes [40].

The assessment completion rates were favorable. Compared to the baseline and 3 months, the assessment completion rate was lower at 1.5 months. This may be because many were dealing with the severe weather and power outage as well as additional stressors associated with a COVID-19 surge. Our overall assessment completion rates were high compared with those reported in a previous study that administered telehealth surveys to people with diabetes [38]. Establishing a trusting relationship with participants and offering incentives after each assessment is completed may further improve survey response rates. Sending SMS text message reminders to people who have not finished the assessment surveys may also increase completion rates.

Telehealth Usability

In terms of usability, participants of various ages and racial and ethnic backgrounds reported that the telehealth technology with videoconferencing was easy to use, useful, and effective. Although those who dropped out of the study did not complete the TUQ, the characteristics of those who responded were similar to those of the dropouts. All participants were able to videoconference with the principal investigator using either their smartphones, desktop computers, or laptops. A few people experienced minor audio and video issues, but these were promptly resolved. These findings are consistent with other research evaluating telehealth interventions in people with diabetes [40]. Scores on the telehealth reliability subsection of the TUQ were lowest, most likely attributable to the severe weather that resulted in a power outage in the Houston area and interrupted internet access, forcing telehealth sessions to be rescheduled. Overall, the telehealth technology was well-liked by the participants, and they reported they would use it again. Although most participants did not have major technical difficulties, individuals who were unfamiliar with the application might find it helpful to have a trial session with the research team before the first scheduled videoconference.

Participants also reported that the videoconferences with the nurse practitioner kept them accountable and helped them learn new information, especially when they could ask questions during the videoconferences and obtain immediate answers. Similarly, in a recent review, videoconferencing telehealth consultation was associated with greater engagement and psychological buy-in, compared with phone consultations, allowing opportunities for social support and real-time discussions [41]. In addition, several participants reported that the telehealth discussions about self-care were therapeutic, informative, and supportive. They noted that the nurse practitioner's sincere demeanor and compassionate presence when discussing foot care had a favorable effect on their mental well-being while fostering awareness of diabetes foot management. Participants also expressed satisfaction with the quality and practicality of the telehealth-delivered foot care sessions. A drawback of the telehealth videoconferencing modality mentioned by some participants was the absence of the "human touch" one would often have with a clinician during an in-person consultation. These sentiments are similar to those reported in a previous study examining the advantages and disadvantages of telehealth technology in diabetes education [42]. The benefits of telehealth technology still outweigh the limitations, as virtual video platforms were accepted among participants of various ages in our study.

Changes in Diabetes Knowledge, Self-care, and Foot Care Measures

In terms of the secondary aims, most participants were unaware of the importance and necessity of foot care for people with diabetes or how diabetes affects the feet. The lack of foot care knowledge and inconsistent practice of foot management are also consistent with prior studies [43,44]. After the 3 telehealth videoconferences, participants' self-reported diabetes knowledge, self-care behaviors, and foot care measures improved significantly. Participants were particularly interested in learning about measures to prevent foot ulcers and injuries (eg, avoiding direct heat sources to the feet, protecting against cold exposure, and using well-fitted shoes and socks) as well as specific foot self-care behaviors (specifically what to look for when examining, moisturizing dry skin, and thoroughly drying the toes and feet) to prevent skin infections and breakdown. Participants were unaware of the need to check the inside of the shoes before putting them on or that moisturizer should not be applied between the toes. Several people reported the difficulty of wearing proper shoes when the temperatures are extremely high in Texas; hence, they chose to go barefoot or wear sandals rather than shoes. Others reported they walk around the house barefoot due to cultural customs. Taking culturally appropriate foot care practices into account could help meet the social and cultural needs of a diverse population. The positive self-reported foot self-care behaviors align with previous studies showing that video-based educational programs are helpful in setting diabetes self-care goals [40], reaching glycemic control, reducing hemoglobin A_{1c} levels [45-48], and decreasing hyperglycemic complications [49].

Participants with various diabetes durations reportedly incorporated foot care activities after the telehealth sessions, suggesting that people with diabetes may overlook or have a limited understanding of diabetes foot care, even if they have had diabetes for years. In fact, several participants said they wished they had the foot care education earlier. According to a recent study [18], most people with diabetes referred to a multidisciplinary foot team did not know the reasons for the referral and were less aware of their risks for foot complications. Our study is novel, as we focused on using telehealth technology to engage patients in diabetes foot care, an area often missed in the primary care setting [15]. Thus, telehealth sessions focusing on diabetes foot care have the potential to ease the profound morbidity and mortality associated with diabetic foot complications, especially during the COVID-19 pandemic. Because of the favorable results from this study, a nurse-led telehealth educational program may be a promising strategy for increasing patients' awareness of foot care and preventing foot complications.

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Our positive results for self-reported changes in knowledge, self-care, and foot care behaviors validate the logic of the ITHBC [25], which we used to inform our intervention design. According to the theory, diabetes knowledge and social facilitation are precursors to engaging in self-care actions, including adhering to foot care, nutrition, and physical activity recommendations. In the telehealth intervention, we offered general diabetes education with a focus on foot care, highlighting the need for self-examination and how to effectively manage diabetes. Participants valued the opportunity to talk about their personal stories and reported that the support offered during the telehealth sessions helped them adhere to practice recommendations. The participants then applied the new knowledge to cultivate self-care behaviors and involvement in foot care practices. As a result of increased diabetes knowledge and supportive social interactions, participants developed skills to plan, monitor, implement, and assess their diabetes self-care. They reported an increase in the number of days per week they adhered to foot care, healthy nutrition, and physical activity recommendations. The theory posits that the commitment to implementing these changes is the short-term result, and the changes in health outcomes are the long-term result. Using this theory, we emphasized patient-centered care by meeting with each participant individually to integrate foot care knowledge and promote positive social facilitation to allow each participant to be more attuned to foot care behaviors and to optimize health outcomes. Patient-centered care recognizes that each participant is unique and yields increased patient satisfaction and improved outcomes [50]. Supported and satisfied participants may be more likely to adhere to treatment regimens, leading to better behavioral and clinical outcomes [50].

Limitations

Although our study included a diverse population, these promising results from 2 family medical practice clinics in Texas need to be validated in additional settings using a randomized trial study design to determine efficacy and examine long-term clinical outcomes. The feasibility of our diabetes telehealth program may be due to our participants' easy access to broadband mobile technology and the novelty of attending virtual Zoom sessions, rather than interest in diabetes foot care. With the wide availability of mobile broadband networks in urban areas, most participants connected using their cell phones rather than computers. People in rural settings may experience more challenges accessing broadband connectivity for telehealth services and have decreased access to critically needed health care services [51]. In addition, well-educated patients may be more likely to have extra time and technology resources to participate in telehealth programs. Efforts to improve broadband internet access in all geographical areas are needed to meet the needs of rural communities for remote telehealth services and to improve health outcomes [51]. When developing a telehealth program, we must consider the unique challenges patients may face with broadband mobile technology, including a lack of comfort with using new mobile apps, reduced broadband connectivity in rural areas, lack of resources, and privacy concerns. Participants' educational levels should also be considered.

We measured patient self-reported outcomes over 3 months and cannot confirm whether the increased foot care behaviors would be sustainable over longer periods of time and would be correlated with decreased incidence of infections and amputations. The scheduling of the monthly telehealth videoconferences varied slightly, despite our effort to maintain consistency, to account for adverse weather conditions, illness, and participants' various schedules. The schedule variations prove the flexibility of telehealth programs and are a realistic depiction of a practical study. Nurse practitioners should screen patients at risk for diabetic foot disease and advocate for increased access to telehealth technologies for foot care education and support. Ongoing diabetes foot care education and support for all patients are essential to improving diabetes knowledge and self-care behaviors that are precursors to preventing debilitating foot complications.

Conclusions

Our preliminary results demonstrate that a synchronous telehealth educational program focused on foot care is feasible, easy to use, and acceptable in patients with type 2 diabetes. Our study showed significant improvements in self-reported diabetes knowledge, self-care, and foot practices after 3 months of participation in the program. Telehealth technology is an essential tool for ensuring accessible health care [41]. It represents an innovative path to support patients with diabetes in performing foot care. Using the ITHBC [25], we demonstrated that a telehealth educational program centered on diabetes foot care during the COVID-19 pandemic has the potential to engage patients to be actively involved in managing their health and improve their diabetes knowledge. Therefore, an educational program incorporating telehealth videoconferences to improve diabetes foot care is urgently needed for providing optimal care to people with diabetes. Further investigation is needed to determine the long-term efficacy of a telehealth program to promote diabetes foot care and self-care behaviors.

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Conflicts of Interest

None declared.

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Abbreviations

DFSBS: Diabetes Foot Self-Care Behavior Scale
DKS: Diabetes Knowledge Scale
ITHBC: integrated theory of health behavior change
NLEA: nontraumatic lower extremity amputation
REDCap: Research Electronic Data Capture
SDSCA: Summary of Diabetes Self-Care Activities
TUQ: Telehealth Usability Questionnaire

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Original Paper

Smartphone-Based Remote Monitoring for Chronic Heart Failure: Mixed Methods Analysis of User Experience From Patient and Nurse Perspectives

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Abstract

Background: Community-based management by heart failure specialist nurses (HFSNs) is key to improving self-care in heart failure with reduced ejection fraction. Remote monitoring (RM) can aid nurse-led management, but in the literature, user feedback evaluation is skewed in favor of the patient rather than nursing user experience. Furthermore, the ways in which different groups use the same RM platform at the same time are rarely directly compared in the literature. We present a balanced semantic analysis of user feedback from patient and nurse perspectives of Luscii, a smartphone-based RM strategy combining self-measurement of vital signs, instant messaging, and e-learning.

Objective: This study aims to (1) evaluate how patients and nurses use this type of RM (usage type), (2) evaluate patients' and nurses' user feedback on this type of RM (user experience), and (3) directly compare the usage type and user experience of patients and nurses using the same type of RM platform at the same time.

Methods: We performed a retrospective usage type and user experience evaluation of the RM platform from the perspective of both patients with heart failure with reduced ejection fraction and the HFSNs using the platform to manage them. We conducted semantic analysis of written patient feedback provided via the platform and a focus group of 6 HFSNs. Additionally, as an indirect measure of tablet adherence, self-measured vital signs (blood pressure, heart rate, and body mass) were extracted from the RM platform at onboarding and 3 months later. Paired 2-tailed *t* tests were used to evaluate differences between mean scores across the 2 timepoints.

Results: A total of 79 patients (mean age 62 years; 35%, 28/79 female) were included. Semantic analysis of usage type revealed extensive, bidirectional information exchange between patients and HFSNs using the platform. Semantic analysis of user experience demonstrates a range of positive and negative perspectives. Positive impacts included increased patient engagement, convenience for both user groups, and continuity of care. Negative impacts included information overload for patients and increased workload for nurses. After the patients used the platform for 3 months, they showed significant reductions in heart rate (P=.004) and blood pressure (P=.008) but not body mass (P=.97) compared with onboarding.

Conclusions: Smartphone-based RM with messaging and e-learning facilitates bilateral information sharing between patients and nurses on a range of topics. Patient and nurse user experience is largely positive and symmetrical, but there are possible negative impacts on patient attention and nurse workload. We recommend RM providers involve patient and nurse users in platform development, including recognition of RM usage in nursing job plans.

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KEYWORDS

heart failure; health-related quality of life; mHealth; nurse specialist; patient engagement; self-management; self-care

Introduction

Despite effective treatment options, patients with chronic heart failure with reduced ejection fraction (HFrEF) have a low quality of life [1]. The importance of improving patient self-management is appreciated by international clinical guidelines including the European Society of Cardiology [2], but achieving this remains a major challenge in HFrEF care [3]. Regular clinical review by heart failure specialist nurses (HFSNs) is the cornerstone of community-based management. This includes a range of tasks such as monitoring patient-measured vital signs, asking about symptoms, uptitrating prognostic medication doses, altering diuretic doses, answering ad hoc questions, and delivering education for patients and carers. Although HFSN management decreases hospital admissions [4] and nurse-led education is known to improve quality of life [5], there is no consensus on the optimal way to deliver this care.

Community management by HFSNs typically relies on high-frequency monitoring of vital signs and regular symptom review via serial face-to-face outpatient appointments [6]. In practice, not only are these appointments burdensome for patients to attend, but there is no systematic way to capture rapid changes in patients' clinical states between the appointments, so that timely intervention can be provided. This potentially misses a window of opportunity, which may lead to increased morbidity and worse quality of life.

Remote monitoring (RM) is one way to monitor and manage patients with chronic diseases, without requiring frequent face-to-face appointments. RM for HFrEF is an area of active research, but the majority of studies focus on clinical outcomes such as medication optimization [7], health care usage and mortality [8], rather than user experience [9]. Although user feedback and preferences for smartphone-based RM in cardiovascular disease have been reported in the literature [10,11], it is heavily skewed in favor of patients' and caregivers' user experience rather than the nurses' user experience. Specifically, the impact of RM technologies on nurse user experience and workload is underreported in the literature [12,13]. Furthermore, even in the minority of studies evaluating the user experience of caregivers, the patient perspective is often not simultaneously reported [10]. Therefore, there is a gap in the literature for more studies conducting a balanced evaluation of user experience from both patient and nursing perspectives, using the same type of RM strategy for HFrEF at the same time. A few studies have had this type of design previously, but the RM strategy has been invasive [14] or telephone-based [15], rather than noninvasive smartphone-based RM with patient education. Increasingly, smartphone-based RM is available for HFrEF [16], but the impact of this type of RM on the experience of both patient users and nurse users remains unknown.

In this study, we evaluate the impact of a novel smartphone-based RM platform called Luscii. This strategy of RM combines noninvasive self-measurement of blood pressure, pulse rate and body mass, self-reporting of heart failure, depression and anxiety symptoms, pill usage, a messaging functionality for patient and HFSN communication, and a suite of tailored e-learning modules in a single smartphone app. Specifically, we evaluate usage type and user experience from the point of view of both patients and HFSN users. Additionally, we analyze the change in self-reported vital signs measurements submitted by patients over a 3-month period. Our primary aims are to (1) evaluate how patients and nurses use this type of RM (usage type), (2) evaluate patients' and nurses' user feedback on this type of RM (user experience) and (3) directly compare the usage type and user experience of patients and nurses using the same type of RM platform at the same time.

Furthermore, nonadherence to guideline-directed medical therapy for HFrEF contributes to worse clinical outcomes; RM using mHealth strategies may be one way to improve medication adherence [17]. Previous studies have shown a beneficial impact of RM on medication adherence [18], which is usually measured by patients' self-reported compliance. Guideline-directed medical therapies for HFrEF (such as angiotensin-converting enzyme inhibitors and β-blockers) are known to lower blood pressure and heart rate, whereas body mass is often used as a measure of effectiveness and adherence to loop diuretics [19]. In this study, we additionally hypothesize whether RM of vital signs such as blood pressure, pulse rate, and body mass could be a useful surrogate for medication adherence that does not depend on patients reporting for themselves whether they have taken their tablets. Therefore, additionally, our secondary aim is to investigate whether there is a significant change in blood pressure, heart rate, and body mass in the first 3 months of using this type of RM platform.

Methods

Study Design

Using a mixed methods approach consisting of qualitative free-text thematic analysis and quantitative analyses of vital signs measurements, we retrospectively analyzed the usage type and user experience of two groups of users of the RM platform:

1. Patient users: patients with HFrEF (index left ventricular ejection fraction [LVEF] <40% measured by echocardiography) being treated in our regional heart failure service in London, United Kingdom. The inclusion criteria were consenting to using and being onboarded to the RM platform between April 2021 and November 2021 and having submitted at least 2 measurements per week for at least 3 months. Demographic data, medical comorbidities, and heart failure severity (measured by LVEF on echocardiogram and New York Heart Association class) were extracted from the electronic health record.

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2. HFSN users: the cohort of HFSNs at our hospital who routinely used the RM platform to manage patients with chronic HFrEF.

Ethics Approval

Institutional approval was granted by the Imperial College Healthcare National Health Service (NHS) Trust Audit and Quality Improvement Committee (Ref CAR/077). Participants were informed that their feedback would be used anonymously for audit and research. All participants consented to the use of their anonymous responses by participating in the feedback or focus group. Patients used their own mobile devices to run the RM app.

Data Collection

For the patient user group, all users were invited to submit free-text comments via the RM platform. There were no specific questions asked, but patients were told that they could use the unstructured free-text response field to express their feedback about topics such as the RM platform itself, their reasons for using RM, how they used it, their positive and negative experiences of RM, and their views on RM in general. Text comments were extracted from the RM database by bespoke searches written in the SQL query language.

Self-measured vital signs (pulse rate, blood pressure, and body mass) submitted by patients to the RM platform were also extracted at two timepoints: (1) at onboarding (week 1 of platform use) and (2) 3 months after onboarding (week 12 of platform use). To be included in this part of the analyses, patients had to have submitted at least 5 measurements in the first week and in the 12th week of platform use (ie, at both timepoints). To enable robust comparison of average readings, rather than analyzing single values of measurements that have high interday and intraday variability, the mean value of all measurements submitted in week 1 and week 12 was calculated. The difference in mean systolic blood pressure, diastolic blood pressure, heart rate, and body mass between week 1 and week 12 was compared.

For the HFSN user group, we conducted a focus group of HFSNs who managed patients with HFrEF using the RM platform. The focus group was semistructured, allowing HFSNs to express their feedback on a range of issues pertaining to the RM platform. The topics discussed were as follows:

1. How HFSNs used the RM platform
2. Their perceived positive impacts of this type of RM
3. Their perceived negative impacts of this type of RM
4. Their views on smartphone-based RM for HFrEF in general

The focus group was facilitated by a trained member of the research team and transcribed. The text comments from patient users and HFSN users were combined with the HFSN focus group transcription, resulting in a single large text data set of user feedback for qualitative analyses (Multimedia Appendix 1).

Primary Analyses: Semantic Analysis of Usage Type and User Experience

The text data generated from the patient user feedback and the HFSN focus group were thematically analyzed using the method described by Braun and Clarke [20] by 2 independent members of the research team. The following stages of analysis were used: familiarization with the data, generating initial codes, searching for themes or subthemes, reviewing themes or subthemes, defining and naming themes or subthemes, producing the final report, and checking validity.

Detailed methodology for these analyses is described in Multimedia Appendix 1. The final themes, subthemes, and relevant quotation examples from the raw data were identified for presentation in the results.

Secondary Analyses: Difference in Vital Signs Over 3 Months of Platform Use

These analyses pertained only to the self-measured vital signs data collected from patients after week 1 and week 12 of RM platform use.

Paired 2-tailed *t* tests were used to evaluate the difference between mean systolic blood pressure, diastolic blood pressure, heart rate, and body mass between week 1 and week 12. For each type of measurement, the null hypothesis was that there was no statistically significant difference between the mean measurement at onboarding and the mean measurement after 3 months. P values of $<.05$ were deemed statistically significant.

The RM Platform

The RM intervention in this study used the Luscii platform. This is a commercially available smartphone-based RM platform.

The intervention combined three modules within a single smartphone app:

1. Measurements module (Figure S1 in Multimedia Appendix 2): patients were given a digital sphygmomanometer, pulse rate monitor, and body mass scale connected to the smartphone app via Bluetooth. Patients were prompted to submit measurements daily, with no upper limit on the number of allowable measurements. All previously submitted measurements were viewable by the patient and clinicians in graphical and tabulated formats. Patients could also complete optional questionnaires about heart failure symptoms, pill usage, anxiety, and depression.
2. Self-care module (Figure S2 in Multimedia Appendix 2): e-learning modules written by HFSNs in our department were uploaded to the Luscii app. These covered topics such as prognostic heart failure medication, information about different cardiac investigations, and device therapy.
3. Messages module (Figure S3 in Multimedia Appendix 2): patients had the option to add free-text comments to their measurements, which were sent to clinicians in the form of messages. In this module, clinicians (typically HFSNs) could respond to these messages or send new messages as unstructured free text. HFSNs were available to interact with patients using this module between 9 AM and 5 PM, Monday to Friday.

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Screenshots of the different modules in the Luscii platform are shown in Multimedia Appendix 2.

From the clinician-facing side of the platform, HFSNs could review previous measurements of vital signs, review responses to the Heart Failure Questionnaire and anxiety and depression questionnaires, view comments and messages sent by patient users, send messages to patient users, set personalized thresholds for vital signs to automatically alert HFSNs, and upload heart failure educational material through e-learning modules.

Results

Participant Characteristics

A total of 83 patients with HFrEF were onboarded onto the RM platform between April 2021 and November 2021; 4 patients used the platform for fewer than 3 months (2 dropped out and 2 died), so 79 patients (mean age 62 years; 35%, 28/79 female) were included in the analyses. Demographic data, medical comorbidities, and heart failure severity of the patient users included are shown in Table 1.

Table 1. Characteristics of 79 patient users with heart failure with reduced ejection fraction who were onboarded to the remote monitoring platform and used it for at least 3 months.

Characteristic at the point of onboarding to the remote monitoring platform	Value
Demographics	
Age (years), mean (SD)	62.0 (13.4)
Female, n (%)	28 (35)
Ethnicity, n (%)	
White	43 (55)
Black	13 (16)
Asian	8 (10)
Mixed	7 (9)
Other	8 (10)
Medical comorbidities, n (%)	
Ischemic heart disease	24 (30)
Atrial fibrillation	22 (28)
Hypertension	27 (34)
Stroke	5 (6)
Type 2 diabetes mellitus	13 (16)
Chronic obstructive pulmonary disease	10 (13)
Chronic kidney disease	8 (10)
Heart failure parameters	
Left ventricular ejection fraction (%), mean (SD)	32 (11)
New York Heart Association classification, n (%)	
I	12 (15)
II	39 (49)
III	23 (29)
IV	5 (7)

Primary Results: Usage Type and User Experience

Of the 79 patients, 58 (73%) submitted feedback in the form of text comments via the RM platform. A total of 6 of 9 (67%) HFSNs participated in the focus group.

Usage Type

The RM platform enabled bilateral information exchange between patients and HFSNs. Both user groups used the platform to exchange information on a wide range of topics including reporting symptoms, medication queries, appointments, and administration and technical issues (Figure 1). HFSNs were able to create e-learning modules that were delivered via the RM platform. These educational modules were another major method of information exchange between the 2 user groups and aided delivery of advice regarding symptoms and medications.

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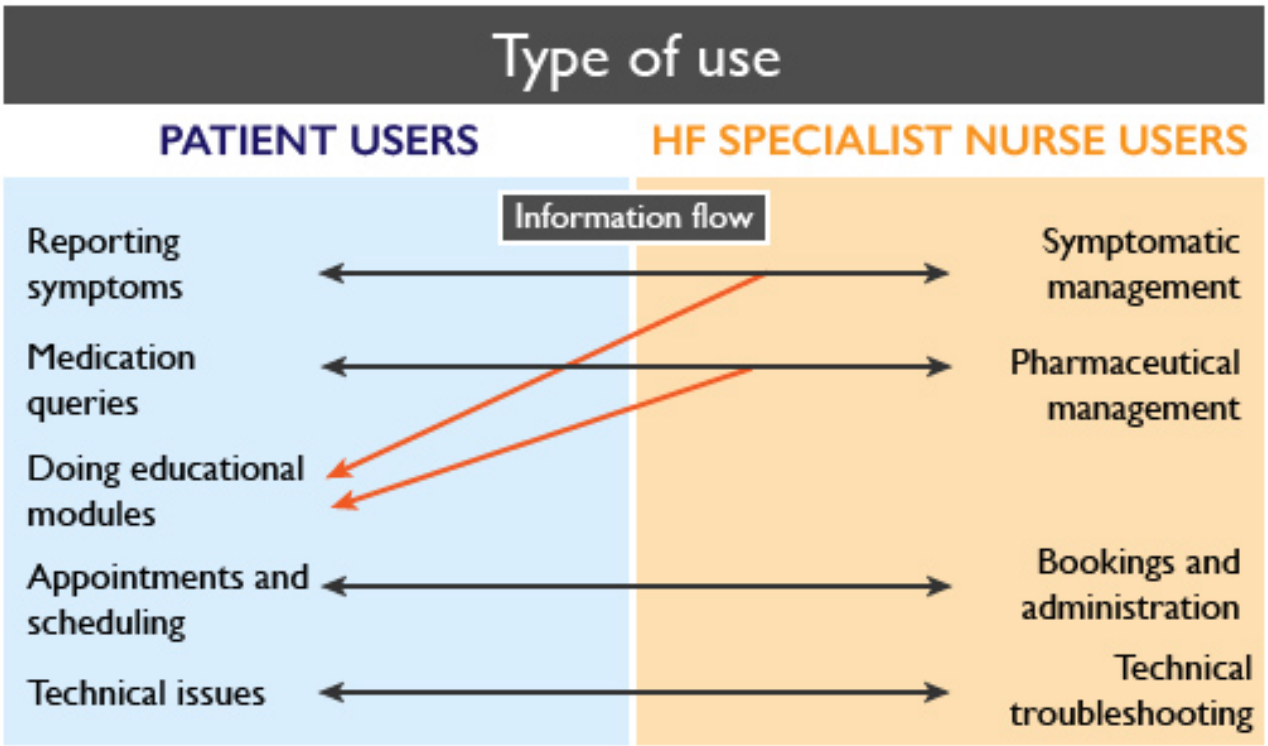
Figure 1. Different ways the patient users and heart failure specialist nurse (HFSN) users used the remote monitoring platform. The arrows indicate the direction of information flow.



User Experience

Thematic analysis of free-text questionnaire responses and focus group data revealed 2 key themes for each user group: positive impacts and negative impacts. Within these themes, there were multiple subthemes that overlapped between the patient users and HFSN users (Table 2).

Table 2. Thematic analysis of free-text comments from 58 patient users and a focus group of 6 heart failure specialist nurse users of the remote monitoring platform. Two main themes are of positive and negative impacts. Different subthemes for each user group are nested within each theme. Examples of text data within each subtheme are provided as quotations.

Theme and Subtheme (examples)	
Patient users	Heart failure specialist nurse users
Positive impacts	
• Increased engagement and understanding: ("...makes me pay closer attention to my weight and blood pressure.") • Reassurance and security: ("I feel much safer...peace of mind knowing there is a team watching over me.") • More convenient: ("...makes me feel...protected without the inconvenience of being in hospital"; "...I don't have to rely on nurses coming round to do blood pressure checks.") • Early abnormality detection: ("...makes it possible to take actions in advance to prevent heart attacks.") • Enhanced communication: ("...allows patients to express their concerns and knowing there is somebody there who will listen and reply to them.")	• Increased engagement and understanding: ("...promotes patients being more proactive in self-management of their condition.") • Enhanced usual care: ("...good adjunct to usual care, does not replace but enhances.") • Admissions avoidance: ("...we have avoided admissions"; "...useful way to...prevent hospital admissions.") • Early abnormality detection: ("...allows trends to be spotted more quickly and actions to be taken for patients deteriorating or at risk of hospital admissions.") • Medication optimizations: ("...useful aid when titrating medications remotely.")
Negative impacts	
• Lack of human interaction: ("...having a 'human' voice to talk to is far better.") • Information overload: ("I check it too often and read too much or too little into it.") • Technical issues: ("...when I can't get it to connect it gets me very frustrated...")	• Increased workload: ("Sometimes can be difficult to manage the additional alerts"; "On-boarding can be complicated and time-consuming for staff.") • Accessibility limitations: ("...only suitable for those that are tech savy and access to a smartphone.") • Technical issues: ("Very much dependent on whether connections are good.")

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Overall, the positive subthemes outnumbered negative subthemes. Both user groups reported that the RM enabled early detection of abnormalities while increasing patient engagement and understanding of HFrEF. Patient users felt that RM was more convenient than traveling to attend face-to-face appointments, offered them reassurance, and enhanced communication with HFSNs. HFSN users reported efficiency gains due to fewer appointments, admission avoidance, and medication optimization.

Negative subthemes from the analysis of patient user feedback included information overload and a lack of human interaction compared with face-to-face appointments. Analysis of negative HFSN user feedback revealed concerns that RM monitoring was not accessible to all and highlighted the potential of increased clinical workload. The negative subtheme of technical issues was symmetrically reported by both user groups (Table 2).

Secondary Results: Impact of RM on Self-measured Vital Signs

The majority of patients provided measurements of pulse rate (73/73, 100%), blood pressure (70/73, 96%), and body mass (65/73, 89%) at both timepoints. Missing data were handled using complete case analysis (only patients who had sufficient measurements to calculate an average at both timepoints were included). For the patients who had incomplete data, no obvious relationship was found between them at either variable level or timepoint level. The missing data were therefore deemed to be missing completely at random and unlikely to bias the complete case analysis approach.

Post hoc calculations found that at least 64 patients were required to detect a 10% decrease in blood pressure, heart rate, and body mass between the 2 timepoints at an α of .05 and power of 80%. On average, after 3 months of RM use, there were significant reductions in pulse rate (P=.004) and blood pressure (systolic P=.008; diastolic P=.002) but no change in body mass (P=.97; Table 3).

Table 3. Table3. Self-measured vital signs for patients using the remote monitoring platform. Values were measured at 2 timepoints: at onboarding to the platform and 3 months later.

Patient-measured parameters	Onboarding, mean (SD)	After 3 months, mean (SD)	*P* value
Heart rate (bpm; n=79)	73 (13)	69 (10)	.004
Systolic blood pressure (mm Hg; n=76)	123 (19)	119 (16)	.008
Diastolic blood pressure (mm Hg; n=76)	76 (12)	73 (10)	.002
Body mass (kg; n=70)	86.4 (24.2)	86.4 (22.6)	.97

Discussion

Principal Findings

In this study, we present a balanced evaluation of how a smartphone-based RM platform is used by patients with HFrEF and HFSNs at the same time and their respective user experiences over a 3-month period. We also report the change in vital signs after 3 months of RM use. This study has 4 key findings. First, this type of RM is feasible in this population (dropout rate 2% over 3 months). Second, the RM platform was used for sharing bilateral information between patients and HFSNs. Third, both user groups reported predominantly positive impacts on their experience, and there was considerable overlap in the type of experience reported by each group. Finally, after 3 months of RM platform use, there was a significant reduction in blood pressure and heart rate, but not body mass.

Qualitative Benefits of Smartphone-Based RM

The feasibility of RM in patients with HFrEF observed in this study is in line with previous work [9]. Although the majority of research in this area is to do with the impact of RM on clinical outcomes [6], comparisons between patient and nurse user experience for the same type of RM at the same time are less well known [21]. This study fills this gap in the literature by providing a balanced analysis of the qualitative impact on both user groups.

Both user groups reported that this type of RM was more convenient than serial face-to-face appointments. This is particularly relevant for heart failure because patients with HFrEF have high rates of frailty and low mobility, which is independent of age [22]. From a nurse perspective, smartphone-based RM is likely to be more convenient than telephone-based RM because measurements and communication can be conducted asynchronously [23]. As previously described, this gives HFSNs more flexibility to fit the RM tasks around other clinical commitments [16].

The patient users in this study expressed that RM had a positive impact on continuity of care, engagement, awareness, and feelings of safety. This was mirrored by HFSNs who reported that their interactions with patients via the RM were more fulfilling. This is in line with previous work [14,24]. This type of RM may improve continuity of care, which is particularly important to patients with HFrEF. Our study supports previous findings that improving bilateral continuity of care may increase the adoption and engagement with RM technology for both user groups [25].

Our analyses also revealed some unexpected uses of the RM platform. This included symptom reporting and appointment scheduling (Figure 1). Although this was not an intended purpose of the platform, it illustrates that users are able to creatively adapt their use to maximize functionality and convenience. In this way, smartphone-based RM may have additional utility beyond just clinical optimization. Indeed, patients taking an active role in the timing and frequency of their follow-up may be a measure of increased “self-management” (when patients monitor their own signs and

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symptoms, adhere to treatment, are able to recognize changes in their clinical state, and respond to these by altering their behavior or seeking assistance).

Impact on Medication Adherence

Improving medication adherence is a key aim of RM in HFrEF [26]. In this study, we considered reduction in heart rate, blood pressure, and body mass as a possible surrogate for investigating medication adherence in our secondary analyses. Previous studies have shown that eHealth self-management interventions such as RM can improve medication adherence in heart failure [18]. Compared with when they were onboarded, we found that patients had significantly lower blood pressure and heart rate after 3 months of RM use. This may reflect adherence with prognostic medications such as angiotensin-converting enzyme inhibitors, β-blockers, and mineralocorticoid receptor antagonists. Interestingly, there was no significant difference in body mass, a metric that is often used to assess the overall fluid status and degree of fluid overload and to guide titration of diuretics. The lack of reduction in body mass in this study may be because patients were not too fluid overloaded at onboarding (almost 50% of patients were only New York Heart Association II at the point of starting RM, ie, they had mild symptoms); therefore, they had relatively little fluid to lose in the first place.

Potential Downsides of RM

Our analyses revealed that the user perceptions of smartphone-based RM for HFrEF were not universally positive. First, HFSNs reported an increased workload due to checking and responding to alerts on the RM platform, which was typically in addition to existing clinical commitments. This is in line with previous studies that have reported greater nursing activity for patients having telehealth monitoring; in one study, nurses had twice as much activity with RM patients as with controls [27]. However, almost a third of the activities were to do with the provision of health information or lifestyle education. The RM strategy in our study has built-in e-learning for self-care and education. Aside from being more convenient for patient users, compared with telephone-based monitoring, this may be an important intervention to enable users to benefit from the upsides of RM without overburdening HFSNs with the responsibility of providing synchronous patient education. As RM becomes increasingly prevalent in clinical practice, we recommend that organizational routines and reimbursement be adjusted to specifically account for this additional activity [14]. Furthermore, developers of RM platforms should be mindful not to overwhelm the nurse users with excessive alerts that are known to be distracting [28]. This is in line with a previous study that found that RM caused some nurse user distress due to increased responsibility and workload [14]. We support their recommendations to adjust organizational routines and reimbursement systems to give nurse users more security when using RM technology.

Second, patient users experienced some information overload. This potential pitfall has been reported previously for another type of monitoring technology [29] and can also affect clinicians [30]. The risk of information overload may indeed be higher for this smartphone-based RM than telephone-based RM because the ease and convenience (any time of the day, with no capping of the number of measurements allowed) of the former is likely to generate much more data than traditional RM approaches. We recommend that developers be mindful not to create platforms that overwhelm users, leading to lower usability and more inefficiency.

Third, both user groups reported technical issues with the RM platform. This led to frustration from patient users and inefficiency for HFSNs. Although the inevitability of some technical issues is appreciated by previous work [31,32], there is a dearth of studies evaluating their impact on the user experience. This study highlights that these issues can have substantial negative impact on user experience for both patients and nurses. Technical issues risk undermining trust in the RM platform, which may have implications for wider adoption and acceptance. This also highlights the importance of having end users involved in the development and testing stage of smart RM technologies [33]. Further research should be directed to evaluating the extent and impact of technical issues on the quality of user experience.

Impact of Smartphone-Based RM on Health Inequalities

The risk of RM technologies increasing health inequalities was a negative subtheme reported by HFSN users. Nurses expressed concern that this type of technology risked excluding patients who did not own smartphones or were not technologically savvy. Socioeconomic status is one driver of RM adoption [34]. This is supported by the fact that our cohort of patient users were on average from a higher socioeconomic class (measured by the indices of multiple deprivation [35]) than the general population (median indices of multiple deprivation decile 3 vs 5).

Age is another important factor. The mean age for a new heart failure diagnosis in the United Kingdom is 76.6 years [36]. The mean age of the cohort of patient users in this study is much less (62 years). This reflects the fact that older patients, in general, did not opt for this RM strategy, which is in line with previous research [37]. As a result, we recommend that RM should be viewed as a supplement to, not a replacement for, usual guideline-directed clinical care. Smartphone RM may optimize management remotely for those who choose it, enabling redistribution of resources to enhance standard care for those who are unwilling or unable to have RM [34]. With smartphone use becoming ever more prevalent [38], the proportion of patients unable to use smartphone RM technology will also reduce [39]. We recommend that health care providers be mindful of the risk that RM technology could increase rather than reduce health inequalities and concerted efforts to engage a broad user group while maintaining a high quality of usual care so that those to choose not to have RM are not worse off [40].

Limitations

First, this study evaluates the RM experience of patients and HFSNs at one center in one part of London. More studies are needed with a larger sample size to replicate these findings before practice recommendations can be made.

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Second, not all eligible participants participated in all analyses; however, the response rate was still high: the response rate for patient feedback was 73% (53/73), 67% (49/73) of HFSNs participated in the focus group, and >89% of patients were included in vital signs analyses. Furthermore, patients were not obligated to provide any feedback, so there may be a selection bias of opinions skewed in favor of those who chose to. However, we did not find any relationship that linked the patients for whom data were missing. Therefore, it is unlikely that the missingness of these data substantially biased our analyses. Nevertheless, the majority of eligible participants contributed data to each analysis so the results can be seen to be widely representative of the population studied. Future studies should aim to increase the response rate further so that the full gamut of user opinion is captured and use alternative methods of handling missing data such as multiple imputation if the reason for missing data turns out to be nonrandom.

Third, in this study, we evaluated the initial impact of this technology on its users over a 3-month period. This was our experience in the first 3 months using this type of RM in our region. Previous studies have shown that adherence to RM itself reduces with time [26]. Further research to see whether the impact we found in this study is sustained in the long term is ongoing.

Fourth, during the study period, the RM platform was licensed only for use in patients with HFrEF (LVEF <40%). We have not analyzed how it impacts patients with preserved ejection fraction. These patients make up a large proportion of the heart failure population, and future research should include their experiences and comparison of these experiences with those of patients with HFrEF.

Finally, our secondary findings relating to the use of vital signs as a surrogate for medication adherence should be contextualized within the limitations of possible biases of self-measurement, inter- and intraday variation, the lack of a non-RM comparator arm, and the fact that there are no corresponding prescription data in this study. However, it may suggest a way for future studies to leverage RM of vital signs to measure adherence to medical therapy.

Conclusions

Smartphone-based RM of vital signs with integrated bilateral information sharing and patient education is feasible in HFrEF. Over a 3-month period, this platform had positive impacts on patient users such as increased convenience, reassurance, and self-care. A significant reduction in blood pressure and heart rate over 3 months may reflect good adherence to guideline-directed medical therapy and warrants further investigation. Nurse users reported symmetrical impacts including more continuity and the potential for admission avoidance. We found potential pitfalls, such as information overload for patients, increased workload for nurses, and technical issues for both user groups. To maximize RM adoption and acceptance, we recommend that RM providers actively involve both patient and nurse users in platform development and that managers formally recognize time spent using RM in nursing job plans.

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Conflicts of Interest

CB receives educational and consultant honoraria from AstraZeneca, educational honoraria from Vifor and Novartis, and consultancy honoraria from Omron and Boehringer Ingelheim. CP receives educational honoraria from AstraZeneca and Boehringer Ingelheim.

Multimedia Appendix 1
Detailed methods for thematic (semantic) analysis of text data from patient user feedback and a heart failure specialist nurse user focus group.
[DOCX File , 16 KB - nursing_v6i1e44630_app1.docx]

Multimedia Appendix 2
Screenshots of the remote monitoring intervention smartphone app.
[DOCX File , 9602 KB - nursing_v6i1e44630_app2.docx]

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Abbreviations

HFrEF: heart failure with reduced ejection fraction
HFSN: heart failure specialist nurse
LVEF: left ventricular ejection fraction
NHS: National Health Service
RM: remote monitoring

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Original Paper

Performance of the Large Language Model ChatGPT on the National Nurse Examinations in Japan: Evaluation Study

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Abstract

Background: ChatGPT, a large language model, has shown good performance on physician certification examinations and medical consultations. However, its performance has not been examined in languages other than English or on nursing examinations.

Objective: We aimed to evaluate the performance of ChatGPT on the Japanese National Nurse Examinations.

Methods: We evaluated the percentages of correct answers provided by ChatGPT (GPT-3.5) for all questions on the Japanese National Nurse Examinations from 2019 to 2023, excluding inappropriate questions and those containing images. Inappropriate questions were pointed out by a third-party organization and announced by the government to be excluded from scoring. Specifically, these include “questions with inappropriate question difficulty” and “questions with errors in the questions or choices.” These examinations consist of 240 questions each year, divided into basic knowledge questions that test the basic issues of particular importance to nurses and general questions that test a wide range of specialized knowledge. Furthermore, the questions had 2 types of formats: simple-choice and situation-setup questions. Simple-choice questions are primarily knowledge-based and multiple-choice, whereas situation-setup questions entail the candidate reading a patient’s and family situation’s description, and selecting the nurse's action or patient's response. Hence, the questions were standardized using 2 types of prompts before requesting answers from ChatGPT. Chi-square tests were conducted to compare the percentage of correct answers for each year's examination format and specialty area related to the question. In addition, a Cochran-Armitage trend test was performed with the percentage of correct answers from 2019 to 2023.

Results: The 5-year average percentage of correct answers for ChatGPT was 75.1% (SD 3%) for basic knowledge questions and 64.5% (SD 5%) for general questions. The highest percentage of correct answers on the 2019 examination was 80% for basic knowledge questions and 71.2% for general questions. ChatGPT met the passing criteria for the 2019 Japanese National Nurse Examination and was close to passing the 2020-2023 examinations, with only a few more correct answers required to pass. ChatGPT had a lower percentage of correct answers in some areas, such as pharmacology, social welfare, related law and regulations, endocrinology/metabolism, and dermatology, and a higher percentage of correct answers in the areas of nutrition, pathology, hematology, ophthalmology, otolaryngology, dentistry and dental surgery, and nursing integration and practice.

Conclusions: ChatGPT only passed the 2019 Japanese National Nursing Examination during the most recent 5 years. Although it did not pass the examinations from other years, it performed very close to the passing level, even in those containing questions related to psychology, communication, and nursing.

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KEYWORDS

ChatGPT; artificial intelligence; natural language processing; registered nurses; National Nurse Examination; Japan

Introduction

What is ChatGPT?

ChatGPT is a large language model developed by OpenAI [1]. Based on the GPT architecture, it is capable of generating high-quality, human-like text in response to prompts. Pretrained on a large corpus of text data, it has been fine-tuned for specific natural language processing (NLP) tasks such as language generation and summarization. With several variants available, ChatGPT—the largest one containing over 175 billion parameters [2]—is one of the largest deep learning models in existence. Its potential applications include being used as a chatbot, language translation, text summarization, and content generation, making it a significant advancement in NLP.

Application of ChatGPT to Medical Fields

Artificial intelligence (AI) applications have been used in the medical field, including medical chatbots, and applications that analyze and summarize electronic medical record systems, perform image diagnosis, analyze and organize the medical literature, and perform patient monitoring [3,4]. Release of the high-quality chatbot ChatGPT has also attracted attention in the field of medical education, as questions on the United States Medical Licensing Examination were reportedly answered with 60% accuracy, which is the threshold for passing the examination [5-7]. In addition, studies have evaluated the ChatGPT's responses to questions on counseling for the treatment of infectious diseases [8] and prevention of cardiovascular diseases [9].

Differences Between Physician and Nurse Specialties

Although physicians and nurses both play critical roles in the health care system, their specialties and responsibilities differ. Physicians focus on diagnosing and treating illnesses, whereas nurses focus on providing direct patient care and support. Nurses monitor patient health, administer medications, assist with activities of daily living, and provide emotional support to patients and their families. Nurses also communicate with other health care professionals to ensure that patients receive the appropriate care. Therefore, their training and responsibilities generally focus more on patient care and communication than on diagnosis and treatment.

Evaluating the Performance of ChatGPT on the National Nurse Examinations in Japan

While passing the national examination does not guarantee the ability to practice in a clinical setting, a different scenario arises when considering the performance on registered nurse licensing examinations. These examinations feature questions that emphasize on patient emotions and communication, contrasting with those found in physician licensing examinations. Notably, if excellent performance can be demonstrated in these nursing examinations, it is likely to pave the way for a significant expansion of AI applications in the medical field. However, the performance of ChatGPT on nursing licensing examinations has not yet been evaluated.

We aimed to evaluate the performance of ChatGPT on national examinations for registered nurses in Japan.

Methods

Input Data Sets From the National Nurse Examinations in Japan

The data sets included questions and answers from the National Nurse Examinations in Japan from 2019 to 2023 (Multimedia Appendix 1). These examinations are conducted annually and include 240 multiple-choice questions, in which candidates are required to select 1 or, in some cases, multiple correct answers (ie, all that apply) from several options. These examinations were divided into morning and afternoon sessions, each comprising 120 questions. The questions covered 32 areas, including basic nursing skills, adult nursing, gerontological nursing, pediatric nursing, pathology, anatomy, and physiology. The Japanese National Nurse Examinations consist of 2 types of questions, basic knowledge and general questions, and all 240 questions must be answered. The basic knowledge questions are based on basic issues of particular importance to nurses, such as fundamental knowledge and basic nursing skills, while the general questions are based on the extensive knowledge of each nursing specialty, covering anatomy, physiology, and disease. As inappropriate questions are excluded from scoring, the criteria could change slightly; however, the passing criteria are 80% for basic knowledge questions and approximately 60% for general questions. In addition, the situation-setup questions included among the general questions were worth 2 points, whereas all other questions were worth 1 point. While the simple-choice questions are mainly multiple-choice knowledge questions, the situation-setup question requires the candidate to read a description of the situation of the patient and the patient's family, and then select the action to be taken by the nurse or the response to the patient.

Data Exclusion

Each year, the Ministry of Health, Labor and Welfare (MHLW) of Japan, which certifies the qualification of registered nurses nationwide, reviews questions among conducted examinations, which cannot be answered with just 1 answer, or questions for which no correct answer exists, based on the MHLW's own checks and comments from a third-party organization—the Japan Nursing School Association. Then, the MHLW deems these as "inappropriate questions" and removes them from the examinations. The inappropriate questions were excluded from this study. In addition, all questions were screened, and questions containing visual assets, such as clinical images, medical photography, and graphs, were removed because ChatGPT (GPT-3.5) is an interactive language AI that does not support image recognition.

Prompt Engineering

Because prompt engineering significantly affects generative output, we standardized the input formats of the questions [10]. Question and answer prompts were created optimally based on

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the Prompt-Engineering-Guide published on GitHub [11] to achieve conservative performance rather than simply achieving the highest scores. As the National Nurse Examinations include 2 types of questions, 2 prompts were created (Textbox 1).

Textbox 1. Prompts for questions.

Prompt 1: Simple-choice questions

Please answer the following questions briefly and by number.

Question: <Questionnaire contents>

1. <Option 1>

2. <Option 2>

3. <Option 3>

4. <Option 4>

Prompt 2: Situation-setup questions

Based on the following situation setup, please answer the questions briefly and by number.

Situation-setup: <Situation-setup contents>

Question: <Questionnaire contents>

1. <Option 1>

2. <Option 2>

3. <Option 3>

4. <Option 4>

Data Analyses

Based on the scoring criteria of the official nursing examination, the percentage of correct answers provided by ChatGPT (GPT-3.5) was calculated separately for basic knowledge and general questions. We calculated the percentage of correct answers for each of the simple-choice questions (1 point, prompt 1) and the situation-setup questions (2 points, prompt 2) and conducted a chi-square test to compare the percentage of correct answers between the 2 prompts. Finally, the percentage of correct answers was calculated for each of the 32 subject areas, and areas with higher and lower percentages of correct answers compared with the overall mean and 1 SD were extracted. All statistical analyses were performed using R (version 3.6.2; R Foundation for Statistical Computing).

Ethics Approval

This study did not require ethics approval because we only analyzed data from a published database.

Results

Input Data Statistics

Five years of the National Nurse Examination data showed that the largest number of inappropriate questions occurred in 2019, with 10 questions having been excluded from the scoring and 2 or 3 inappropriate questions in the other years. The number of questions with figures and tables ranged from 6 to 16. Thus, the number of questions analyzed in this study was 214 of 240 in the lowest year and 232 of 240 in the highest year (Table 1).

Table 1. Questions included and excluded in the analysis from 2019 to 2023.

Year	Included questions (mean 225.8, SD 6.2), n	Inappropriate questions (mean 4, SD 3)[a], n	Questions with chart (mean 10.2, SD 3.4)[a], n	Total, n
2019	214	10	16	240
2020	229	3	8	240
2021	228	2	10	240
2022	232	2	6	240
2023	226	3	11	240

[a]"Inappropriate questions" and "questions with chart" were excluded in the analysis.

Evaluation Outcomes

The 5-year average percentage of correct answers provided by ChatGPT was 75.1% (SD 3%) for basic knowledge questions and 64.5% (SD 5%) for general questions (Figure 1). Throughout the study period, the percentage of correct answers exceeded the passing criteria in 2019 for basic knowledge questions (passing criterion: 80%) and in all years from 2019 to 2023 for general questions (passing standard: approximately 60%). The percentage of incorrect answers per question ID tended to be higher in the morning and afternoon sessions for IDs 51-60, and in the afternoon session for IDs 91-120

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(Multimedia Appendix 2). IDs 51-60 included questions in the areas of pediatric and maternal nursing and IDs 91-120 included situation-setup questions. Items with high percentages of incorrect answers included questions with complex situational settings and a combination of questions requiring the selection of 2 correct answers from a set of choices (both of which must be correct) and a situation-setup question. The percentage of incorrect answers for questions in which the options included a combination of 2 items, such as combinations of words connected by hyphens (1. A ———B, 2. C———D, 3. E———F, 4.G———H), were also high.

Comparing simple-choice questions (prompt 1) and situation-setup questions (prompt 2), the average percentage of correct answers for prompt 1 was 66.3% (SD 3%) and 65.9% (SD 7%) for prompt 2. Differences in the proportions of correct answers between prompts 1 and 2 were not observed throughout the study period (Table 2). However, prompt 1 showed no significant change over time, while prompt 2 showed a gradual downward trend over time (Figure 2).

Figure 1. Percentages of correct scores provided by ChatGPT.

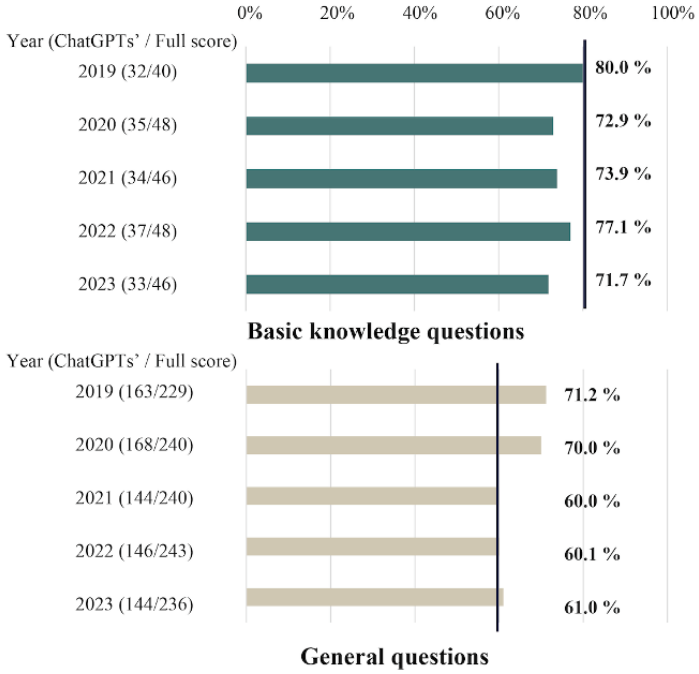

Table 2. Percentages of correct answers by prompt type.

	Total, n	Correct, n	Incorrect, n	Correct answers, %	*P* value (chi-square test)
2019					.24
Prompt 1	159	109	50	68.6	
Prompt 2	55	43	12	78.2	
2020					.94
Prompt 1	170	121	49	71.2	
Prompt 2	59	41	18	69.5	
2021					.78
Prompt 1	170	108	62	63.5	
Prompt 2	58	35	23	60.3	
2022					.78
Prompt 1	173	111	62	64.2	
Prompt 2	59	36	23	61.0	
2023					.77
Prompt 1	170	109	61	64.1	
Prompt 2	56	34	22	60.7	

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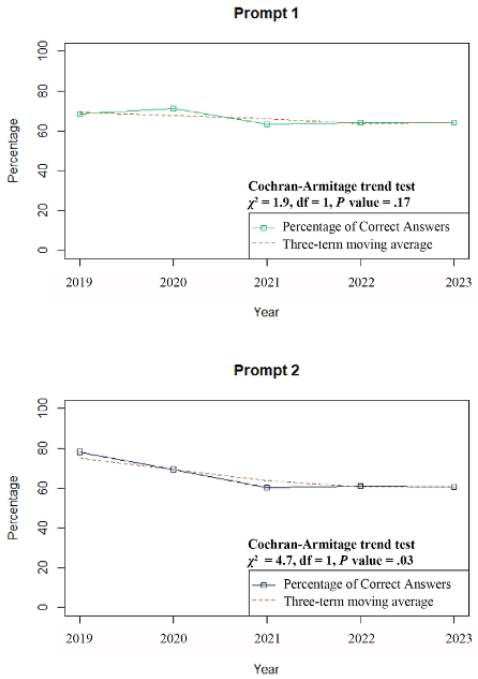
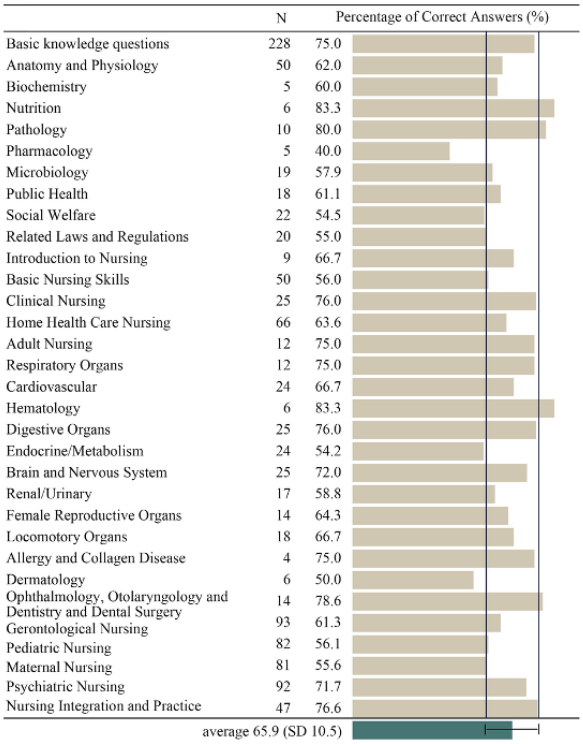
Figure 2. Trends in the percentage of correct answers for prompts 1 and 2.



On comparing the percentages of correct answers for each subject area among all questions included in the analysis, the average percentage of correct answers for all areas was 65.9% (SD 10.5%; Figure 3). The subject areas with a mean value that is lower than 1 SD (55.4%) included pharmacology, social welfare, related law and regulations, endocrinology/metabolism, and dermatology. The subject areas with a mean value that is higher than 1 SD (76.4%) included nutrition, pathology, hematology, ophthalmology, otolaryngology, dentistry and dental surgery, and nursing integration and practice. ChatGPT also performed well on dialogue-related questions, with no significant difference in the percentage of correct answers to non–dialogue-related questions (P=.36; Multimedia Appendix 3). A dialogue question is a question in which the options are sentences enclosed in brackets; in Japanese, the brackets are the spoken words of a person.

Figure 3. Percentages of correct answers by question area.



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Discussion

Principal Results

ChatGPT met the passing criteria for only the 2019 Japanese National Nurse Examination. Although it did not pass the 2020-2023 examinations, it scored very close to the passing criteria, with only a few more correct answers required to pass. Variations in the percentages of correct answers over the 5-year period were small, the probability of obtaining a high score by chance was low, and the performance of ChatGPT was stable. Therefore, although not significantly different, the possible reasons the percentage of correct responses tended to decrease with each passing year from 2019 to 2023 include the following: (1) lack of up-to-date data (ChatGPT only studied records until 2021) and (2) increased question complexity. Although GPT-3.5 learned data only up to 2021, it is crucial to highlight that ChatGPT is able to answer first-time questions; in other words, it is not simply filling in holes using existing internet sources, as there was no sharp decrease in scores in the 2022 and 2023 examinations. The fact that the situation-setup questions were also answered correctly without significant difference indicates that ChatGPT seemed to do well on the questions dealing with the human mind, such as those involving conversations with patients. Meanwhile, the possibility of losing track of relevant issues in complex situational settings and of having limitations such as difficulty recognizing certain expressions, including the frequent use of hyphens and other expressions, were also shown. If the current version of ChatGPT were used in nursing practice, it could be difficult to assess patients whose situations are complex, such as those requiring treatment for multiple diseases or those with socioeconomic problems. However, this is likely to depend on the amount of information that ChatGPT can store in its short-term memory, which would be resolved in the future models.

Strengths and Limitations

This study used all questions from the 2019-2023 National Nursing Licensing Examinations in Japan, and the results were highly reliable for the performance assessment of the ChatGPT's answers with low variability. However, this study has some limitations. First, questions with figures and tables were excluded. Although GPT-3.5, which was used to measure the performance in this study, was unable to judge figures and tables, Wang et al [12] reported that combining ChatGPT and image judgment AI could interpret radiographs, and it is highly likely that these questions will be supported in future ChatGPT updates. Second, this study did not involve advanced prompt engineering or explanatory assistance for questions or answer options. More detailed and complex prompt engineering—such as providing a question and several sample answers and then having the candidate answer them, rephrasing a question into a sentence when it uses too many hyphens or other symbols, or allowing additional exchanges rather than 1 answer per question—could have resulted in a score above the passing standard. We originally planned to validate ChatGPT's performance in line with the actual question format, and it is important to determine whether a simple question can be answered correctly by ChatGPT. Third, it should be noted that ChatGPT is like an advanced and sophisticated autocomplete system and may not inherently understand the meaning or content of the questions entered. The degree to which ChatGPT's expressions and responses deviate from those of humans is a subject of debate; however, ChatGPT sometimes provides completely false responses without prior warning. Therefore, it may be important to prompt ChatGPT not to answer if ChatGPT is not confident in its answer or to conduct multiple dialogues to clarify the ChatGPT's decision-making process. Finally, some of ChatGPT's answers were misaligned between the number of choices and the content of choices, and the number of digits in computational questions was not adjusted properly. We have counted the number of questions that were misaligned between the number of choices and the content of the choices, and the number of questions included were 5 in 2023, 6 in 2022,12 in 2021, 13 in 2020, and 6 in 2019. One computational question did not adjust its digits properly in 2019 and 2020; however, this was not the case in the other years. Although there were slightly more in 2020 and 2021, there were no significant differences among other years, so the impact on the overall results is expected to be limited.

In principle, judgments were made based on the content of choices, and computational questions were judged as being correct if the formula and the results of the calculation were correct.

Comparison With Prior Work

In general, AI using a large language model is known to perform better in English than in other languages [13], although as with the United States Medical Licensing Examination [5-7], a high percentage of correct responses for the Japanese National Nurse Examinations was observed. The National Nurse Examinations include emotion-based questions, such as those involving talking to patients, which could have been appropriately handled by ChatGPT, as it reportedly has been acquiring a human-like psychological maturity [14]. A previous study pointed out that access to medical databases was limited among the training data for ChatGPT [8], and statistical data related to health, medical care, and welfare in Japan may not have been acquired because they are provided on interactive websites such as e-Stat [15] or in PDF format, thus potentially having influenced the accuracy rate of the ChatGPT's responses.

In the future, if additional data in the areas of poor performance are acquired and tuned so that questions and options can be understood appropriately without prompt engineering or supplementary human explanation, it is highly likely that the passing criteria will be exceeded in a stable manner. More advanced tools, such as GPT-4 or Bard (developed by Google), superseding the capabilities of ChatGPT, continue to be released and are expected to be used in many clinical situations such as diagnosis, explanation of treatments and drugs, and communication with patients. However, further research will be needed on ethical issues such as the division of roles between human nurses and AI, decision-making responsibilities, and the risks for patients when applied in clinical practice.

Conclusions

ChatGPT passed or performed very close to the passing level on the Japanese National Nurse Examinations. With additional

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learning, prompt engineering, and tuning of ChatGPT, it will likely exceed the passing criteria. ChatGPT has the potential to assist nurses with decisions based on data regarding the patient's physical condition, and to provide support for psychological issues.

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Authors' Contributions

KT designed the methodology, carried out the formal analysis, and drafted the manuscript. TI conceptualized the study, designed the methodology, acquired funding, and reviewed and edited the manuscript. AH curated and validated the data, and reviewed and edited the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Data Sources for the 2019–2023 Japanese National Nurse Examination.
[DOCX File , 61 KB - nursing_v6i1e47305_app1.docx]

Multimedia Appendix 2
Heatmap of correct and incorrect answers by question ID.
[DOCX File , 167 KB - nursing_v6i1e47305_app2.docx]

Multimedia Appendix 3
Comparison of percentage of correct answers between dialogue and non-dialogue questions.
[DOCX File , 62 KB - nursing_v6i1e47305_app3.docx]

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Abbreviations

AI: artificial intelligence
MHLW: Ministry of Health, Labor and Welfare
NLP: natural language processing

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