JMIR Nursing

Indexed in Pubmed and Pubmed Central
Volume 3 (2020), Issue 1 ISSN: 2562-7600 Editor in Chief: E. Borycki RN PhD, FIAHIS, FACMI, FCAHS

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Viewpoint

Desirable Features of an Interdisciplinary Handoff

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Abstract

Failure of communication of critical information during handoffs is one of the leading causes of medical errors, resulting in serious, yet preventable, adverse events in hospitals across the United States. Recent studies have shown that a majority of these errors occur during patient handoffs, with notable communication gaps in interdisciplinary handoffs. We suggest some features that would improve the handoff usability and effectiveness for interdisciplinary medical and nursing teams while potentially improving patient safety.

(JMIR Nursing 2020;3(1):e18914) doi:10.2196/18914

KEYWORDS

handoff; transition; sign-out; electronic; interdisciplinary; interprofessional; communication; patient safety

The Challenge

The landmark publication “To Err is Human” cast a spotlight on the devastating effects of adverse events and identified communication failures as one of the root causes of human deaths due to medical errors [1]. The follow-up report, “Preventing Medication Errors,” estimated that 1.5 million preventable adverse events occur each year in the United States, with hospital-based errors costing US $3.5 billion per year [2]. Multiple studies have reported communication failure, particularly during handoffs, as the leading cause of preventable adverse events in hospitals [3-5]. The common errors during handoffs include the exclusion of critical information and the transfer of incorrect information [6].

Patient handoffs are an integral part of health care. We believe that future handoffs should have the following features.

Interdisciplinary Communication Tools

Physicians, nurses, pharmacists, and unlicensed assistive personnel that may be involved in a patient’s care often function independently and communicate inadequately [7]. Coordination between various treatments and interventions is critical for preventing errors and fragmentation of care. Tools designed to support interdisciplinary communication and collaboration were found to result in more positive patient care outcomes [7]. Nurses who were given access to view a computerized patient handoff app that was developed for physicians found that the app was a reliable and timely source of information on patient status and plans for treatment or discharge [8]. Moreover, the access to this app helped the nurses develop effective care plans and increased their work satisfaction [8]. Since the shift time for each health care practitioner is different, making an interdisciplinary handoff is an arduous task. We believe that an interdisciplinary handoff tool will enhance care team collaboration and communication, thus breaking the current “siloed” discipline-specific handoff approach.

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Handoffs written by any health care practitioner should be visible to all practitioners of any health care discipline in the care team.

Standardized Communication Tools

Implementation of a standardized Inpatient Settings Accelerating Safe Sign-outs program resulted in a 23% relative reduction in the overall error rates in 6 out of 9 hospitals, without impeding the workflow [9]. The Situation, Background, Assessment, and Recommendation (SBAR) tool was developed in 2006 and has been widely adopted in nursing practice [10]. Although SBAR is useful for reporting short messages of critical patient information in an organized manner, a systematic review of 95 articles revealed that despite the well-known adverse consequences of inadequate nursing handoffs, very little research had been performed to identify the best practices [11]. The standardization of data collection has been shown to improve communication and reduce errors [12-14].

While there is undoubtedly a need for the implementation of a standardized handoff tool, there are several challenges and limitations that need to be considered [15]. There is considerable variability across institutions regarding preferred methods and formats for verbal and written handoffs [16]. Handoff practices are usually so deeply embedded in a given institution that efforts at improving them necessitate a transformational change of the entire institution's culture [15,16].

More research studies need to be undertaken to identify the best practices and to standardize nursing handoffs across the health care system. Every health care institute should at least develop its own standardized nursing handoff protocol until a health care system-wide standardized handoff is adopted.

Formal Handoff Education for Health Care Professionals

In 2018, the Accreditation Council for Graduate Medical Education (ACGME) published the Clinical Learning Environment Review (CLER) National Report of Findings in which residents, fellows, and nurses expressed that communication during care transitions was often incomplete or inaccurate [3]. Various teaching styles (eg, in-person didactic sessions, simulated clinical scenarios, video- and web-based teaching modules) can be used to teach a handoff curriculum [17]. The ACGME requires residency training programs to provide formal instruction on handoffs and to monitor handoff quality [6]. However, despite these requirements and patient safety concerns, well-established handoff curricula and validated tools to observe and assess the handoff skills of medical and nursing trainees are lacking [18]. The CLER report indicated that a standardized organization-wide approach for training and managing transition of care is uncommon across CLEs [3]. Developing an effective handoff curriculum proves challenging because of the need for standardized protocols, faculty education, cultural resistance to change, and diverse institutional factors.

Nursing and clinician educators at each institute should develop a curriculum to teach and reinforce the use of the handoff, which can be accepted as the institutional standard.

Housed Within the Electronic Health Record

Chui et al [19] noted that the handoff practices in pharmacies were unstructured and variable; therefore, they proposed electronic handoffs for asynchronous transfer of information. Handoff documentation embedded within the electronic health record (EHR) facilitates easy and secure retrieval of pertinent information by various members of the care team [8]. Stein et al [20] showed that centralized electronic handoff documentation was utilized throughout the 24-hour period and not just during the usual shift change times. Handoffs often involve coordination between multiple individuals—each with varying levels of trainings, skills, and responsibility.

Handoffs that are a part of an EHR would facilitate remote and indirect supervision of the quality of handoff. Integration with the EHR would provide data security and enable controlled and accountable access to protected health information. Furthermore, it would facilitate root cause analysis in case of medical errors.

Real-time Integration With EHR

Handoff EHR integration has been shown to aid in clinical decision-making and error-reporting [21]. Handoff information is typically updated at the end of the shift. EHR integration has been shown to improve communication and reduce errors [12,13]. The template must allow the incorporation of information by all the members of the interdisciplinary care team.

A real-time data feed from the EHR would enable the display of relevant up-to-date data (laboratory results, most recent vitals, medications, etc) on the same screen at the same time in which the handoff is being utilized, thereby facilitating better decisions.

Direct Link Between Handoff Screens and Activity Screens

The health care team members should be able to undertake most tasks (eg, placing orders) from the handoff screen. Concurrently, they should be able to quickly navigate back and forth between the handoff screen and other parts of the EHR. The ease of navigation, the ability to review data for decision making, and the ability to implement the follow-up actions would encourage widespread adoption of the handoff.

Availability in Mobile Devices

It is cumbersome for physicians and nurses to leave the task at hand, when paged or called by the patient, to log in to the EHR to find and view the information. Most nurses carry paper handoffs in their pockets during work, which adds an undue burden because loss of a handoff with patient data would be a significant HIPAA (Health Insurance Portability and Accountability Act) violation. Therefore, an increasing number

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of hospitals are providing nurses with HIPAA-secure mobile devices to facilitate their work.

The handoff should be adapted such that it is easily accessible, easy to view, and easy to navigate even on a mobile platform.

Accessibility in Part to the Patient

Traditionally, handoffs occur between members of the patient care team. Granting all patients access to view a part of the handoff would keep them better informed about their plan of care.

Providing patients access to a part of the handoff would enable them to know their overall management plan, what was being planned for them on that day, and when they were approaching the expected day of discharge.

Recommended Template

The first section should allow the medical team formulating the plan of care to summarize the chief reason for admission (Multimedia Appendix 1). This section should be followed by a brief overview of the medical management plan, including the pending evaluations and the actions to be taken in case of positive and negative laboratory test results. A projected course for the patient's chief concern over the next 48 to 72 hours would ensure that the whole team is aware of the expected recovery course.

During the interdisciplinary team rounds in the morning, a daily task list that considers the patient's goals and preferences should be formulated and added to the task list section of the handoff. The tasks should be timed for a specific time of the day so that all the interdisciplinary team members working in the following shifts are aware when the task is due to be completed. Timed interdisciplinary tasks as part of the handoff would not only allow the nursing team to execute the plan to ensure that the daily goals of care are met but also enable them to ensure that the pace is appropriate.

The expected date of discharge, the objective discharge criteria, as well as the stated goals of the patient/family regarding discharge should be a part of the handoff documentation to aid timely and safe transition of the patient to the next site of care. A free text box would allow the nurses, case managers, pharmacists, and other allied health care practitioners in different shifts to voice their concerns and contribute to the plan of care asynchronously, especially when the issue needs to be addressed during interdisciplinary rounds.

Every institute should adapt this template according to their individual needs. Physicians, residents, nurses, case managers, pharmacists, and other health care teams involved in caring for the patient should be taught how to use the handoff with clear expectations for updating it periodically. The handoff should be available within the EHR, pulling in real-time data from the EHR while allowing users to quickly navigate to action screens within the EHR. The same EHR should also be accessible via mobile devices. Hospitals should consider allowing patients to view a part, if not all, of the handoff.

Acknowledgments

All the authors worked together in preparing the literature and organizing the ideas in this paper. The authors did not receive any funding for this work.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Contents of a templated interdisciplinary handoff.
[DOCX File , 12 KB - nursing_v3i1e18914_app1.docx]

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Abbreviations

ACGME: Accreditation Council for Graduate Medical Education
CLER: Clinical Learning Environment Review
EHR: electronic health record
HIPAA: Health Insurance Portability and Accountability Act
SBAR: Situation, Background, Assessment, and Recommendation

Edited by E Borycki; submitted 27.03.20; peer-reviewed by R Poss-Doering, H Akram, E Da Silva; comments to author 01.04.20; revised version received 09.04.20; accepted 12.04.20; published 22.05.20.

Please cite as:
Sule AA, Caputo D, Gohal J, Dascenzo D
Desirable Features of an Interdisciplinary Handoff
JMIR Nursing 2020;3(1):e18914
URL: https://nursing.jmir.org/2020/1/e18914/
doi:10.2196/18914
PMID:

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Viewpoint

mHealth Apps as Effective Persuasive Health Technology: Contextualizing the "Necessary" Functionalities

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Abstract

Persuasive health technology (PHT) is any technology purposely designed to influence, reinforce, change, or shape health-related attitudes or behaviors. Behavioral interventions can be developed for the purpose of maintaining or improving a person's health status. Delivering behavioral interventions via PHTs is a promising approach for encouraging healthy behaviors among individuals and populations. Important attributes of all PHTs include their functionalities. A functionality refers to any useful features, functions, capabilities, or technologies associated with computer hardware or software. Creating effective PHTs requires a deliberate selection of appropriate functionalities for supporting specific behavioral interventions. The number and types of functionalities necessary to create an effective PHT will be specific to the context of each project, influenced by project objectives, stakeholder goals, behavioral interventions, and a variety of real-world constraints. Selecting appropriate functionalities can be challenging. Fortunately, there are frameworks and models developed specifically for guiding the design of PHTs. The Persuasive Systems Design model describes 4 categories, and 28 design principles for creating effective persuasive interventions. These same design principles could also be useful for guiding the selection of appropriate functionalities.

(JMIR Nursing 2020;3(1):e19302) doi:10.2196/19302

KEYWORDS

persuasive health technology; behavioral intervention; persuasive systems design; eHealth; mHealth; nursing informatics

Introduction

Health Determinants

Numerous entwined factors influence a person's individual health status, collectively known as the determinants of health. Some of these determinants are modifiable, while others are not. Organizations such as Health Canada [1] and the World Health Organization [2] include a person's individual behaviors as a determinant of that person's current health state, and future health trajectory. These behaviors include important decisions commonly made about, among others, diet, exercise, sexual activity, substance use, medication adherence, and vaccination [3].

Importantly, many individual health behaviors are modifiable, meaning that well-crafted behavioral interventions can be developed for the purpose of maintaining or improving a person's individual health status. Behavioral health interventions are expected to remain important strategies for promoting health and well-being, preventing illness, and managing disease well into the foreseeable future [4,5]. Alongside traditional approaches (eg, individual coaching, motivational interviewing), delivering behavioral interventions via *persuasive health technologies* (ie, PHTs, such as mobile health [mHealth] technology) is a promising newer approach for encouraging healthy behaviors among individuals and populations [5-7]. However, these objectives can only be achieved if the designers and developers of these interventions and technologies select functionalities that provide *effective* support for achieving their goals.

Objectives

This paper will describe the constellation of functionalities (eg, features, technologies) required for developing an effective mHealth-based PHT. Useful frameworks for designing PHTs will be introduced. A detailed list of current mobile IT

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functionalities will be presented, along with an example demonstrating how nurse researchers might design an effective PHT by matching various mHealth functionalities with a selected design framework and a behavioral intervention encouraging social/physical distancing. Finally, examples suggesting how 2 currently available mHealth systems might be adapted to serve as effective PHTs will be discussed.

Background

Persuasive technology is any technology (eg, computers, websites, smartphones and apps, tablets, wearables, computer games) purposely designed to change attitudes or behaviors [8]. PHT (eg, electronic health [eHealth] programs, mHealth apps) is a specialized co-discipline that focuses on influencing, reinforcing, changing, or shaping health-related attitudes or behaviors [9] without using coercion or deception [10], and is most often used for health promotion and prevention or disease management [11]. PHTs for disease management help people comply with and adhere to treatment directives, such as better medication adherence or diabetes management [12]. The study of PHTs includes the design, research, ethics, and analysis of these interactive computing products [13]. The use of PHTs is growing rapidly in many areas of health and wellness [9]. Examples include PHTs encouraging behavior change in physical activity, healthy eating, tobacco cessation, risky sexual behavior, pregnancy, and dental health [12]. Peer-reviewed research has demonstrated benefits from the use of PHTs for promotion, prevention, and management across some chronic diseases [14-17], but there is tremendous opportunity for further study [12].

The WHO Global Observatory for eHealth [18] defines mHealth as medical and public health practice supported by mobile devices, such as smartphones, patient monitoring devices, personal digital assistants, and other wireless devices. Experts in the field of behavioral science agree that influencing healthy behavior change is notoriously difficult [3,19]. While there is increasing interest from researchers and clinicians in harnessing mHealth as a means of delivering behavioral interventions, academic research on the development and evaluation of effective health-related mHealth behavioral interventions is still in the early stages of study. Nevertheless, recent peer-reviewed studies and systematic reviews support (to varying degrees) the use of behavioral interventions delivered by mHealth across many populations and problems. Examples include sexual health [20], cardiovascular disease [21], diabetes [22-30], adolescents and young adults [31], ecological momentary assessments [32], health technology assessment [33], chronic disease management [34-36], sedentary behavior [37], diet and physical activity [38], and diabetic foot ulcers [39-41].

As a research tool, some mHealth solutions offer real-time and real-world measurements of phenomena. Some researchers ask study participants to maintain paper-and-pencil logs. However, the labor-intensive and intrusive nature of paper-and-pencil recording has limited its clinical applicability and underscores the concern that data can be backfilled by patients [42]. Smartphones offer a potential solution by enabling research through apps designed to prompt, collect, time stamp, and securely transfer patient data. Furthermore, researchers believe that conducting studies on smartphones is important because data collection is private, and may reduce potential bias from the Hawthorne effect.

Creating these technologies can be a demanding, but wonderfully creative and beneficial endeavor—developing solutions that combine knowledge from the health sciences, behavioral psychology, and software engineering for tackling many of the health problems experienced today. Each mHealth-based PHT will be made-to-measure, and the design and development of each behavioral intervention and technology will depend on a variety of factors, including project goals, health problem(s), mix of stakeholders (and their individual, possibly conflicting aspirations), advice received from consultation with subject-matter experts, input and feedback from users, available technologies, financial constraints, ethical considerations, and available *functionalities* [43,44].

For the purposes of this paper, a functionality refers to any useful technologies, capabilities, features, or functions associated with computer software or hardware, in particular mobile electronic devices (eg, smartphones, tablets, wearable devices) [45]. It is important to understand that functionalities are chosen to *support* a behavioral intervention [46], and intervention development and functionality selection should proceed in an iterative manner, each informing the other [6]. Furthermore, it is important to understand that the number and types of functionalities necessary to create an effective PHT will be specific to each mHealth project, that is, context will determine which functionalities are *necessary*, not algorithms or formulae [43]. For example, Dobson et al [47] conducted a randomized controlled trial investigating the effectiveness of a smartphone-based behavioral health intervention for supporting self-management among adults living with poorly controlled diabetes. The intervention group received a tailored package of SMS (short message service) text messages, in addition to usual care. The SMS text messages provided information, support, motivation, and reminders related to diabetes self-management and lifestyle behaviors. These researchers relied on a single mHealth functionality and technology (ie, SMS text messaging) and smartphones to deliver their intervention and answer their research and clinical questions. Notably, even when using these few functionalities, the intervention group demonstrated a significant reduction in HbA^{1c} (hemoglobin A^{1c}; blood glucose), and a significant improvement in foot care behaviors, at 9 months' follow-up.

A more complex PHT was proposed by Hussain et al [48], a personalized behavioral intervention for promoting awareness of optimal sun intake (ensuring sufficient vitamin D production), balanced with promoting safe sun exposure. Their persuasive health solution uses both smartphone and wearable technologies, together with multiple functionalities for achieving their project and clinical goals. Their mHealth app collects current weather, global positioning system (GPS), light exposure, and UV data from user's smartphones and sensors in the wearable device. This information is then fed into a custom-built smartphone app providing personalized information to each user by tracking cumulative sun exposure and triggering appropriate smartphone

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alerts and UVI (UV index) warnings via SMS text messaging [49].

Creating effective PHTs requires a deliberate selection of appropriate functionalities for supporting specific behavioral interventions. In many ways, the process for developing an effective mHealth-based persuasive technology is similar to the development process followed for any other well-organized, well-executed software or technology development project [6,43,44], and correctly selecting which functionalities are needed is an important step in the development process [50]. However, even when following a recommended (eg, Agile, Scrum) software engineering methodology [6,51], this process is challenging, and choosing the appropriate functionalities that will result in an effective mHealth-based technology is not always so straightforward. Each PHT will be fit-for-purpose, meaning that cookbook solutions—such as if population X is experiencing health problem Y, then use functionalities a, b, and c to support behavioral intervention Z—do not exist. Confusing matters further, a functionality deemed useful in one context may not be in another. Fortunately, designers and developers can look to a small number of conceptual frameworks and models developed specifically for guiding the design of PHTs [52].

Frameworks

Once a behavioral health intervention has been developed, and the decision made to deliver the intervention using mHealth technology, the intervention must be operationalized via the selected mobile IT functionalities (eg, SMS, GPS, sensors, cameras). A number of frameworks and models have proven useful for developing PHTs [10,52-54]. Among these, the *Persuasive Systems Design* (PSD) model is well-respected, and considered a state-of-the-art framework for designing and evaluating persuasive systems [9]. Many systematic reviews report limited evidence for the efficacy of mHealth apps [55], but note that projects developed using a conceptual framework or behavior theory are often more effective [5,51].

The PSD model is grounded in multiple theoretical constructs and established persuasive design techniques, with a focus on supporting the transfer of design specifications into software functionalities [56]. The PSD model has been applied widely across many disciplines, with researchers actively evaluating its use in many domains [17,57-62]. The PSD framework describes 28 persuasive design principles (Textbox 1) in 4 categories: primary task support, computer–human dialogue support, system credibility support, and social support [9,10]. The design principles found in the *primary task support* category support people when carrying out a primary task (eg, supporting regular blood glucose monitoring for people living with diabetes). Any interactive system provides some degree of system feedback to its users, and there are multiple design principles related to *dialogue support* that help users keep moving toward their goal or target behavior. The principles located in the *system credibility* category not surprisingly describe various ways to design a persuasive system with greater credibility. Lastly, the design principles found in the *social support* category describe how to motivate users by leveraging social influence using concepts such as competition or cooperation [9,10,56].

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Textbox 1. Persuasive Systems Design framework: design principles [10].

1. Primary task support

i. Reduction: A system that reduces complex behavior into simple tasks helps users perform the target behavior, and it may increase the benefit-to-cost ratio of a behavior.

ii. Tunneling: Using the system to guide users through a process or experience provides opportunities to persuade along the way.

iii. Tailoring: Information provided by a system is more persuasive if it is tailored to the needs, interests, personality, usage context, or other factors relevant to a user group.

iv. Personalization: A system that offers personalized content or services has a greater capability for persuasion.

v. Self-monitoring: A system that keeps track of one's own performance or status supports the user in achieving goals.

vi. Simulation: A system that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.

vii. Rehearsal: A system providing a means by which to rehearse a behavior that can enable people to change their attitudes or behavior in the real world.

2. Computer–human dialogue support

i. Praise: By offering praise, a system can make users more open to persuasion.

ii. Rewards: Systems that reward target behaviors may have greater persuasive powers.

iii. Reminders: If a system reminds users of their target behavior, the users will more likely achieve their goals.

iv. Suggestion: Systems offering fitting suggestions will have greater persuasive powers.

v. Similarity: People are more readily persuaded through systems that remind them of themselves in some meaningful way.

vi. Liking: A system that is visually attractive for its users is likely to be more persuasive.

vii. Social role: If a system adopts a social role, users are more likely to use it for persuasive purposes.

3. System credibility support

i. Trustworthiness: A system viewed as trustworthy will have increased powers of persuasion.

ii. Expertise: Incorporating expertise will have increased powers of persuasion.

iii. Surface credibility: System credibility is based on a firsthand inspection.

iv. Real-world feel: A system that highlights people or organization behind its content or services will have more credibility.

v. Authority: A system leveraging roles of authority will be more persuasive.

vi. Third-party endorsements: Third-party endorsements, especially from well-known and respected sources, boost perceptions of system credibility.

vii. Verifiability: Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.

4. Social support

i. Social learning: A person will be more motivated to perform a target behavior if he or she can use a system to observe others performing the behavior.

ii. Social comparison: System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of others.

iii. Normative influence: A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behavior.

iv. Social facilitation: System users are more likely to perform target behavior if they discern via the system that others are performing the behavior along with them.

v. Cooperation: A system can motivate users to adopt a target attitude or behavior by leveraging humans' natural drive to co-operate.

vi. Competition: A system can motivate users to adopt a target attitude or behavior by leveraging humans' natural drive to compete.

vii. Recognition: By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behavior.

Functionalities

Modern mobile devices provide many functionalities; even low-cost phones, tablets, and wearables (eg, smart watches, fitness trackers) can be useful as PHTs. Functionalities will vary by device, often influenced by cost, manufacturer, or hardware specifications, though many will share a number of common features and capabilities. Important hardware functionalities include the display (usually touchscreen), keyboard, headphone jack, camera, volume controls, water-resistant capability, and

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rechargeable battery. Important communication functionalities include calling, SMS text messaging, multimedia messaging service (MMS; audio and video playback), web browser, email, and apps [63,64]. An incredible amount of sensor data can be collected, including location data (GPS, latitude/longitude, altitude, speed, and bearing), motion data (accelerometer, gravity, gyroscope, magnetic field, and pedometer), environmental data (ambient temperature, light, pressure, proximity, and relative humidity), network data (Bluetooth and Bluetooth networks), and others including battery usage, screen state, app usage, and ambient audio [65]. Wearable devices can also collect a variety of physiological data such as heart rate, sleep tracking, electrocardiogram, steps, and calories burned, to name a few [66,67].

It is meaningless to think of each functionality, or combination of functionalities, as effective or ineffective in the context of designing or developing a PHT. An effective mHealth-based solution is the result of selecting appropriate functionalities supporting a specific behavioral intervention. Linking functionalities to the PSD model can assist with this process.

Example

Imagine a team of nurse researchers planning the design for an effective PHT delivered via mHealth technology. To achieve this goal, these nurses must create a behavioral intervention, then select a design framework, and choose functionalities that can operationalize their intervention. The PSD framework describes 28 persuasive design principles (Textbox 1) in 4 categories; these same design principles are useful for guiding the selection of appropriate functionalities. Textbox 2 illustrates how an imagined behavioral intervention (encouraging social/physical distancing) suggested during a global pandemic (eg, COVID-19) could be developed by linking design principles from the PSD model with various context-appropriate mHealth functionalities. It is important to note that not every design principle will be useful for selecting functionalities that support a behavioral intervention; this will be project specific, and limited by a variety of real-world constraints such as budgets or technologies.

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Textbox 2. Examples linking design principles with functionalities for the purpose of developing a PHT for encouraging social/physical distancing.

1. Primary task support

i. Reduction: A system that reduces complex behavior into simple tasks helps users perform the target behavior, and it may increase the benefit-to-cost ratio of a behavior.

For example, using SMS text or MMS messages, or the ability to link to instructional web-based videos for delivering social/physical distancing instructions

ii. Tailoring: Information provided by a system is more persuasive if it is tailored to the needs, interests, personality, usage context, or other factors relevant to a user group.

For example, using feedback from individual user surveys, alerts, Bluetooth data, or sensor data that provides personalized social/physical distancing information important for each individual user and delivered via SMS text or MMS messaging

iii. Self-monitoring: A system that keeps track of one's own performance or status supports the user in achieving goals.

For example, feedback and information provided to users about their daily social/physical distancing habits directly from individual sensor data, Bluetooth data, or health and wellness tracking apps

2. Computer–human dialogue support

i. Praise: By offering praise, a system can make users more open to persuasion.

For example, praise delivered by automated SMS text or MMS messages, triggered by survey responses, or physiologic and proximity sensor data when proper social/physical distancing practices are recorded

ii. Reminders: If a system reminds users of their target behavior, the users will more likely achieve their goals.

For example, alerts and reminder messages about effective social/physical distancing delivered via mobile devices or wearables and triggered by, for example, time of day, GPS location, motion sensors, or proximity sensors

iii. Suggestion: Systems offering fitting suggestions will have greater persuasive powers.

For example, suggestions for improving the effectiveness of social/physical distancing practices delivered via SMS text or MMS messages and triggered by, for instance, time of day, GPS location, Bluetooth data, motion or proximity sensors

3. System credibility support

i. Surface credibility: System credibility is based on a firsthand inspection.

For example, building systems using professional user experience software design

ii. Authority: A system leveraging roles of authority will be more persuasive.

For example, including content from local, national, or international health agencies and their social/physical distancing recommendations

iii. Third-party endorsements: Third-party endorsements, especially from well-known and respected sources, boost perceptions of system credibility.

For example, including SMS text messages from family members, friends, or celebrities

4. Social support

i. Social facilitation: System users are more likely to perform target behavior if they discern via the system that others are performing the behavior along with them.

For example, sharing user data from health or wellness tracking apps, individual sensor data, or survey responses via SMS text or MMS messaging may also facilitate cooperation

ii. Competition: A system can motivate users to adopt a target attitude or behavior by leveraging humans' natural drive to compete.

For example, sharing user data from health or wellness tracking apps, individual sensor data, or survey responses via SMS text or MMS messaging, or using a bespoke app that tracks social/physical distancing data

iii. Recognition: By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behavior.

For example, sharing user or group progress with other users about social/physical distancing

Conclusions

Creating effective mHealth-based PHTs requires a deliberate selection of necessary functionalities. These functionalities are only *necessary* in the context of providing support for specific behavioral interventions. To operationalize a behavioral intervention, nurse researchers can build a bespoke PHT themselves (assuming they have the required technical skills), hire professional designers and developers (assuming they have significant financial resources), or modify an existing platform (assuming such platforms exist, and permission to modify is possible at an affordable cost).

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This third option is appealing because it can be quick to develop, affordable, and requires limited technical skills. For example, the Ethica research platform provides researchers with many functionalities [68] and could be adapted for use as a persuasive technology. When comparing Ethica functionalities with the PSD model design principles, it appears Ethica could offer support for every principle, meaning that Ethica could offer support for any behavioral intervention developed using the PSD model. By contrast, the REDCap research platform provides researchers with far fewer functionalities [69], mainly lacking the ability to process sensor data, but it could also be adapted for use as a persuasive technology. This means REDCap could offer support for a smaller number of PSD model design principles and behavioral interventions. Does this mean REDCap is less useful than Ethica as a PHT? Not necessarily; as argued in this paper, context and requirements will determine the *necessary* functionalities.

Acknowledgments

I thank Dr Nate Osgood and Dr Donna Goodridge for expert advice, support, and enthusiastic encouragement.

Conflicts of Interest

None declared.

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Abbreviations

MMS: multimedia messaging service
PHT: persuasive health technology
SMS: short message service
WHO: World Health Organization

Edited by T Risling; submitted 12.04.20; peer-reviewed by L Brosseau, H Akram; comments to author 24.05.20; revised version received 26.05.20; accepted 10.06.20; published 15.07.20.

Please cite as:
McLean A
mHealth Apps as Effective Persuasive Health Technology: Contextualizing the "Necessary" Functionalities
JMIR Nursing 2020;3(1):e19302
URL: https://nursing.jmir.org/2020/1/e19302/
doi:10.2196/19302
PMID:

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Viewpoint

Simulation Modeling as a Novel and Promising Strategy for Improving Success Rates With Research Funding Applications: A Constructive Thought Experiment

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Abstract

Writing a successful grant or other funding applications is a requirement for continued employment, promotion, and tenure among nursing faculty and researchers. Writing successful applications is a challenging task, with often uncertain results. The inability to secure funding not only threatens the ability of nurse researchers to conduct relevant health care research but may also negatively impact their career trajectories. Many individuals and organizations have offered advice for improving success with funding applications. While helpful, those recommendations are common knowledge and simply form the basis of any well-considered, well-formulated, and well-written application. For nurse researchers interested in taking advantage of innovative computational methods and leading-edge analytical techniques, we propose adding the results from computer-based simulation modeling experiments to funding applications. By first conducting a research study in a virtual space, nurse researchers can refine their study design, test various assumptions, conduct experiments, and better determine which elements, variables, and parameters are necessary to answer their research question. In short, simulation modeling is a learning tool, and the modeling process helps nurse researchers gain additional insights that can be applied in their real-world research and used to strengthen funding applications. Simulation modeling is well-suited for answering quantitative research questions. Still, the design of these models can benefit significantly from the addition of qualitative data and can be helpful when simulating the results of mixed methods studies. We believe this is a promising strategy for improving success rates with funding applications, especially among nurse researchers interested in contributing new knowledge supporting the paradigm shift in nursing resulting from advances in computational science and information technology.

(JMIR Nursing 2020;3(1):e18983) doi:10.2196/18983

KEYWORDS

simulation modeling; computational science; funding application; grant funding; grant writing; nursing; research; thought experiment; persuasive technology; peripheral vascular disease

Introduction

Establishing a successful career as a nurse researcher working in a faculty or research position depends on a variety of factors. These factors typically include contributions toward research and publishing, teaching, service, and clinical practice [1], among others. Mastering each of these demanding roles is essential for retention, promotion, and tenure [2,3]. As part of their role in research, nurse researchers must write grant proposals and other funding applications to support their work, a challenging task [4,5], with often uncertain results. Recent (2014-16) success rates in the Canadian Institute of Health Research open grant competitions have hovered around 12%

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[6]. In similar competitions and over a similar period, the National Institute of Health (USA), Australian Research Council, and Medical Research Council (United Kingdom) reported better (but still low) success rates around 18%, 20%, and 24%, respectively [7-9]. These low success rates not only threaten the ability of nurse researchers to conduct relevant health care research [10] but may also negatively impact their career trajectories.

Grant writing is an established method for supporting research, enhancing institutional prestige, and promoting individual career advancement [11,12]. Many individuals and organizations have offered advice for improving success with funding applications [11-15]. Their recommendations often overlap, with consistent themes emerging—nicely summarized by Wisdom, Riley, and Myers [15]:

> *(1) research and identify appropriate funding opportunities; (2) use key proposal components to persuade reviewers of project significance and feasibility; (3) describe proposed activities and their significance persuasively, clearly, and concisely; (4) seek review and feedback from colleagues; (5) establish a study design that is simple, logical, feasible, and appropriate for the research questions; (6) develop a timeline for the proposal process; (7) select a novel, high-impact project; (8) conduct an exhaustive literature review; (9) ensure that budgets are reasonable; and (10) consider interdisciplinary collaborations.*

And while these are all excellent recommendations, they are also common knowledge and simply form the basis of any well-considered, well-formulated, and well-written funding application. For nurse researchers interested in taking advantage of innovative methods and leading-edge analytical techniques that could be used to complement the usual recommendations [15], we propose adding the results from computer-based simulation modeling experiments to funding applications. We believe this is a promising strategy for improving success rates with such applications, especially among nurse researchers interested in contributing new knowledge supporting the paradigm shift in nursing resulting from advances in computational science, information technology, and health information science.

This paper is meant to be the first step in a multi-stage strategy intending to test this approach for improving success rates with research funding applications. Initially, we hope to gather feedback from interested individuals that will help us develop a proof-of-concept funding application model that includes simulation modeling experiments. We will then circulate this example for review among individuals with experience assessing funding applications. Based on their feedback, we will either: (1) discard this concept as either infeasible or ill-advised, (2) rework this concept and recirculate among our experts for further review, or (3) submit a bona fide funding application that includes results from simulation modeling experiments.

Objectives

This paper is written as a constructive thought experiment to encourage discussion, reflection, and critique. We will briefly introduce some fundamental concepts concerning thought experiments and computer-based simulation modeling—including its utility and limitations (within the context of improving success rates with funding applications), and advice for those interested in exploring this approach further. We will not review the practical details of constructing, calibrating, testing, validating, and reporting credible simulation models in this short paper; appropriate references are provided.

We include an example of a simulated randomized controlled trial (RCT)—a simulation based on an imagined research proposal with multiple experiments describing the use of persuasive health technologies for improving health outcomes among a cohort of people living with peripheral vascular disease. We will demonstrate how the results from these simulation experiments may be used by nurse researchers in a research funding application, and present arguments supporting this approach for improving application success rates.

Thought Experiments

A thought experiment is an experiment performed in the imagination [16]. Though abstractions, thought experiments are more than 'just thinking about something,' and more than a 'think piece,' which is defined as a piece of writing meant to be thought-provoking and speculative [17]. Instead, a thought experiment is a deliberate and systematic approach to exploring some problem or idea [18]. Thought experiments are used for hypothesizing, theory selection, theory implementation, conceptual analysis, counterfactual thinking, exploration, education, entertainment, and the opportunity to ask a variety of 'what if' questions [18], which are only limited by our curiosity and creativity.

While the value of thought experiments is debated by some [19], it is widely agreed they play an essential role in many disciplines, predominantly physics and philosophy [16]. Well-known examples remind us of their tremendous influence and consequence: Newton's bucket, Maxwell's demon, Einstein's elevator, Leibniz's mill, Thomson's violinist, Heisenberg's gamma-ray microscope, and Schrodinger's cat [18-20], to name a few. Thought experiments played a crucial role in the development of quantum mechanics and Einstein's theory of relativity [18].

The modest thought experiment presented in this paper is based on a taxonomy proposed by Brown [21], the *constructive thought experiment*. Constructive (also known as apologetic or heuristic) thought experiments aim to provide positive support for an idea, concept, or theory and are often developed as a heuristic aid, enabling a person to discover or learn something new for themselves [21]. A constructive thought experiment is an appropriate framework with which to investigate the promise of simulation modeling for improving success with research funding applications; the approach is novel and promising, as

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yet untested by the authors, and we are unable to find either published or anecdotal evidence for same.

Simulation Modeling

Simulation modeling is a systems science and computational methodology that examines behaviors and outcomes resulting from interactions, linearities/nonlinearities, and feedback loops occurring between multiple system actors over time [22]. Simulation modeling is a robust research methodology for theory development, testing, critique, and refinement. Simulation modeling is a rich, robust, and versatile research tool—dynamic, highly visual, and on the leading edge of health care research [23,24]. As with thought experiments, simulation modeling allows nurse researchers the opportunity to ask a variety of 'what if' questions using a deliberate and systematic approach. Simulation modeling can be viewed as a method for *operationalizing* a thought experiment, allowing nurse researchers the opportunity to present their understanding of a system or problem in a tangible form that can be more readily shared and scrutinized.

Experts in nursing science view advanced computational techniques as necessary for moving nursing research, policy, education, and practice into the future [25,26]. Conveniently, the broad concept of simulation will not be mysterious or unfamiliar to most nurses. Role-play simulations are simplified and safe reproductions of real-world health care situations [27]. High-fidelity simulation manikins have been used effectively for many years to teach clinical skills [28], and nursing simulations using virtual or augmented reality are now proving valuable in clinical education [29,30], and practice [31]. Computer-based simulation modeling creates a unique type of simulation experience. Using simulation software, nurse researchers can build a virtual space where they may create models of real-world systems, and then explore a wide array of research questions within those computer-based worlds. These models produce theoretical outputs based on modifiable input data, giving nurse researchers the ability to examine the behaviors of complex systems over a wide range of hypotheses [32]. A computational simulation strategy is cost-efficient, but it also allows nurse researchers to explore problems in a risk-free environment where they can experiment, make mistakes, refine their models, assumptions, or interventions, and begin again [33].

There are three types of simulation modeling approaches commonly used; system dynamics, agent-based, and discrete-event (also termed process modeling). It is also possible to combine these approaches and produce hybrid (also termed multi-method) models. Only a synopsis of each simulation modeling approach will be presented in this brief paper, but references are included for those readers interested in delving deeper into the subject.

System Dynamics

System dynamics (SD) is a highly abstract method of modeling. This approach typically ignores the fine details of a system and produces a high-level representation of a system or problem. These simulation models are often used for long-term planning and strategic decision-making [34]. SD simulation modeling has been used in epidemiologic research and policy planning for many years and continues to provide new insights [35]. Interested readers are encouraged to review papers describing SD simulation modeling: in greater detail [34], with applications in health care [36], and health care policy [37].

Agent-Based

Agent-based modeling (ABM) simulates the characteristics, behaviors, and interactions between autonomous agents and their environment [38]. Agents may be any entity we wish to represent, anything from the real world important for answering a research question. We can give our agents attributes, define the behaviors of those agents, place those agents in a simulated environment, establish connections and relationships between agents—then create scenarios, and run experiments. Nurse researchers can then observe the global behavior of their model over time, resulting from the many interactions of the individual agents and environment [39]. Interested readers are encouraged to review papers and texts describing agent-based simulation modeling: in greater detail [34,36,40,41], with applications in nursing research [26], and health care practice [42,43].

Discrete-Event

Discrete-event simulation (DES) modeling focuses on the processes in a system at an individual level of abstraction. Many health care processes and problems can be described as a sequence of separate, discrete events. DES is particularly useful for modeling resource-constrained workflows, such as patient flow through an outpatient clinic, perioperative suites, or emergency department. DES modeling is widely used in health care, and interested readers are encouraged to review papers describing discrete-event simulation modeling: in greater detail [34,36], and with applications in health care [44,45].

Hypothetical Example

The purpose of the hypothetical example we present here is to demonstrate how the results of simulation modeling experiments could be useful and advantageous when included with a typical funding application. This example is fictitious and is not meant to represent an actual or complete funding application; as such, much of the detail and referencing is unnecessary and is not included. Naturally, our example presents positive results, and for obvious reasons, we would advise nurse researchers against including the results of simulation modeling experiments in funding applications, which indicated otherwise. Our example describes a hypothetical RCT—a simulation based on an imagined research proposal with multiple experiments describing the use of persuasive health technologies for improving health outcomes among a cohort of people living with peripheral vascular disease.

Background

Chronic diseases are among the most common, costly, and preventable of all health problems worldwide. In 2016, roughly 244,000 (89%) of the 273,000 deaths registered in Canada were attributable to chronic diseases. Peripheral vascular disease (PVD) is a serious chronic health problem affecting blood vessels throughout the body, excluding the heart and brain. PVD

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interferes with normal circulation, and the long-term sequelae include a higher susceptibility to lower-limb and foot wounds—serious wounds frequently leading to infection, ulceration, gangrene, and ultimately surgical amputation. Persuasive health technologies (eg, eHealth programs, mHealth apps) typically use theories of motivation and persuasion to influence, reinforce, change, or shape health-related attitudes and behaviors.

Objective

The study aim is to investigate the efficacy of a behavioral intervention delivered using persuasive health technologies (smartphone app) to align study participants' lower-limb self-care behaviors with clinical guidelines, among people living with PVD. Aligning self-care behaviors with clinical guidelines assists with the earlier identification of changes in the lower-limb and foot that may indicate the early development of serious wounds. With prompt care-seeking and treatment, we can reduce the incidence of complicated lower-limb and foot infections, ulceration, gangrene, and surgical amputation.

Design

The study is an RCT design, recruiting people living with PVD from centers across western Canada. The goal is to recruit 100 participants from each center, for a total of 700 study participants. Approximately half will be randomized to the control group, with the remaining participants assigned to the intervention group. A variety of metrics (e.g., incidence, resource utilization, costs) will be tracked. The study will be run over 4 years.

Model

A hybrid model was developed using elements from system dynamics, agent-based, and discrete-event simulation modeling (Figure 1). Each element and their associated connections represent some entity or relationship from the real world necessary for answering our research objective. Figure 1 is an example of a typical user interface a nurse researcher might see on their computer screen when building a model using simulation modeling software; in this case, AnyLogic simulation software [46]. One of the key benefits of using simulation modeling over some other modeling approaches (eg, Excel), is its ability to provide a visual representation of the research design, which is helpful when explaining a simulation modeling approach to people unfamiliar with the concept.

The ABM component in Figure 1 depicts the recruitment of participants from each of the seven centers, randomization between control and intervention arms (gold and orange rectangles), and the possible health states of each fictional study participant, ranging from healthy to requiring amputation. At any time, an individual health state (blue and red rectangles) is determined by an algorithm, based on the available evidence (eg, incidence and prevalence data, rates of disease progression). For example, an agent might move from the 'healthy' state to the 'infection' state based on the probability of developing an infection derived from research among people in this population. Also, an agent might move from the 'ulcer' state and return to the 'healthy' state based on known rates of recovery and informed by treatment assumptions included in the development of this model.

Simulation models must generate sensible results; therefore, the evidence used to create model algorithms must be the same as the evidence used to support the written funding application. It would be especially misleading to create model algorithms designed solely to generate positive results, and we would strongly recommend against such deceit. We recommend nurse researchers provide a transparent description of all assumptions, parameters, and variables guiding their models.

The DES component in Figure 1 illustrates the flow of each fictional study participant through different services within the health care system. In our example, study participants visit primary care for treating infections, specialty clinics for treating ulcers and gangrene, and hospital services providing amputation. Patient flow through these services would be determined by an algorithm, again based on the available evidence (e.g., rates of infection, ulceration, gangrene, amputation, rates of recovery). If a participant remains in a healthy state throughout the study, they will not enter any of the DES care pathways. Resource utilization can be easily tracked within the DES component of the model; for example, cumulative nursing hours spent treating ulcers. If a simulation model demonstrates a reduction in these hours among participants in the intervention arm, this statistic could be added to the other arguments supporting an application seeking funding for that intervention.

The SD component in Figure 1 tracks expected annual costs to the health care system within our hypothesized study. Costs are accumulated using an algorithm based on available cost data for each type of treatment or procedure, and population estimates could be derived after extrapolation. It is essential to understand that each element in this model can 'communicate' with other elements. For example, data generated in the DES care pathways (e.g., RN hours spent on each treatment, number of procedures) can be used to inform the cost calculations in the SD component using specific parameters or variables (Figure 1).

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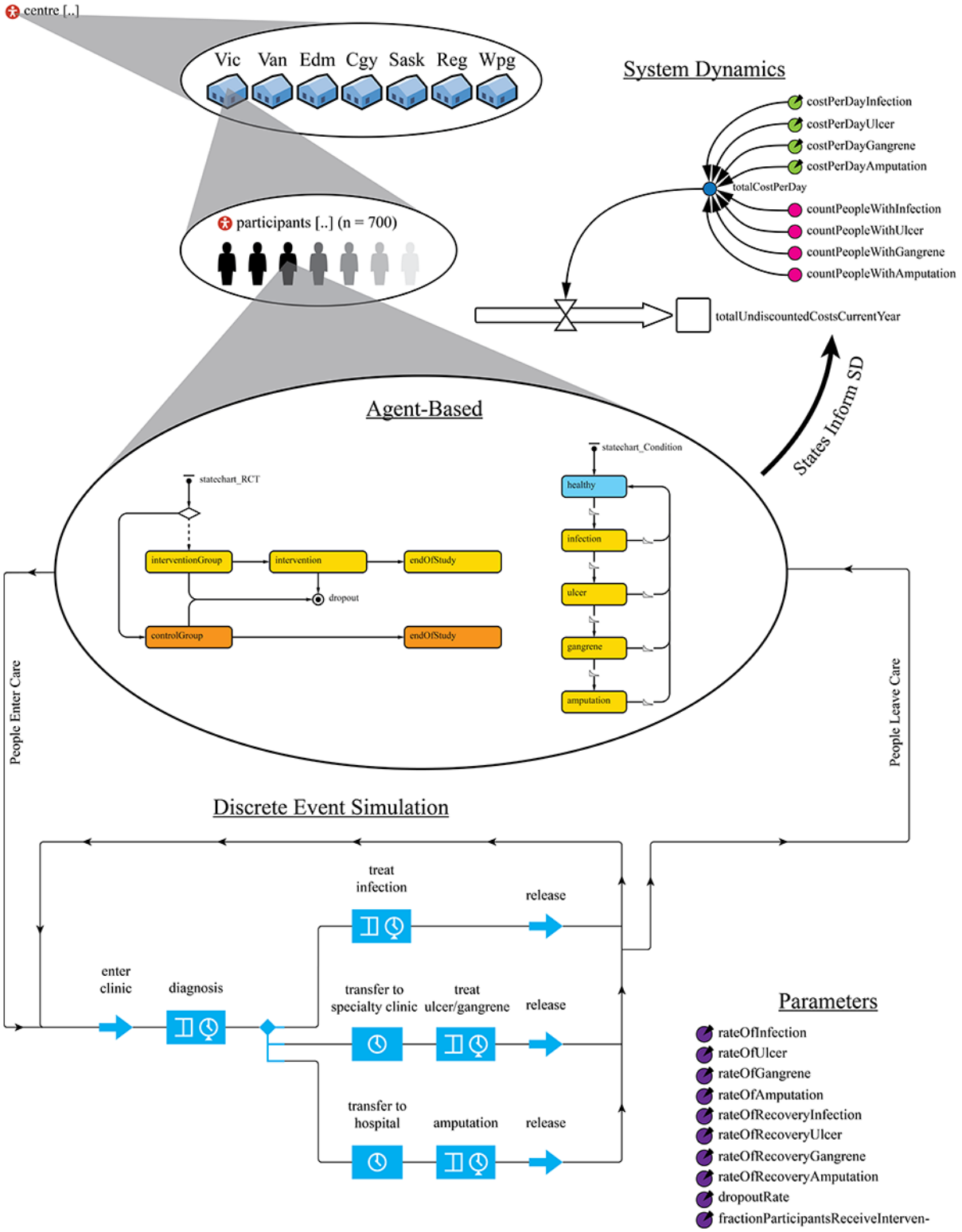
Figure 1. Simulation model design.



Results

Figures 2 and 3 represent only a few examples of the many possible results and output graphs that could be generated by simulation experiments, and that could be included with funding applications. Figure 2 displays the results of our imagined intervention on incidence per year, and Figure 3 displays the results of our intervention on resource utilization and costs per year. And while these results are wholly theoretical and highly dependent on the assumptions and data informing our model, at a minimum, these results can suggest the possibility of positive outcomes in a real-world trial, and proper use of the requested funding.

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Figure 2. Incidence, per year.

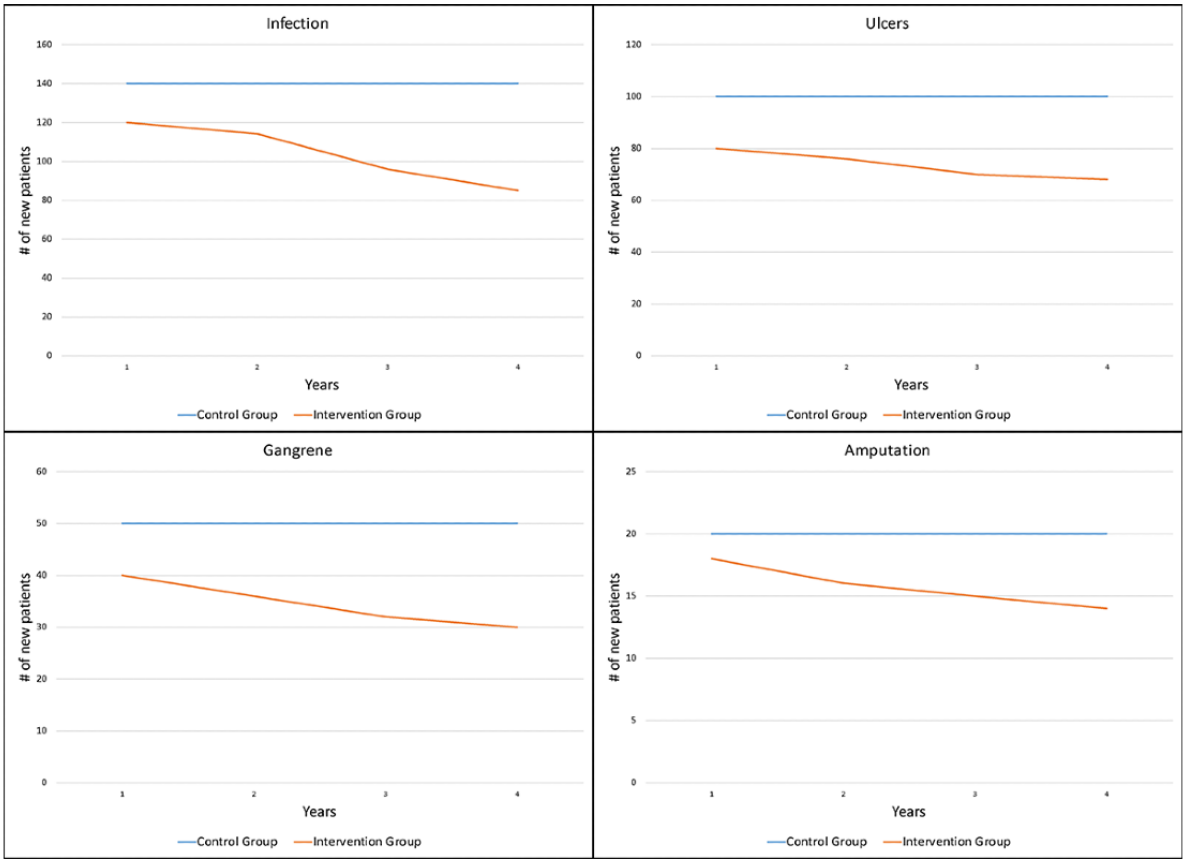
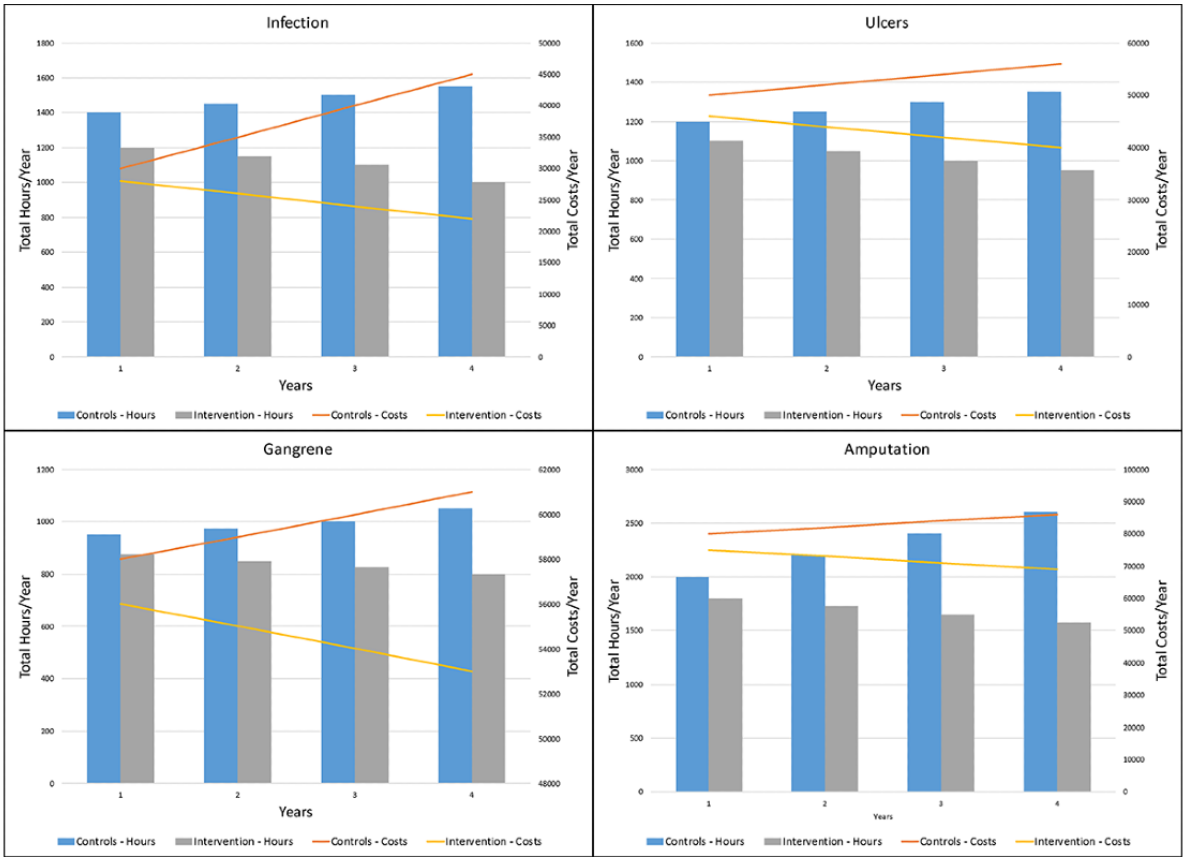


Figure 3. Resource utilization and costs, per year.



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Challenges

We anticipate several problems with using the results from computer-based simulation modeling experiments as a strategy for improving success rates with funding applications. Most reviewers will likely be unfamiliar with computer-based simulation modeling, meaning that an adequate explanation of simulation modeling, a description of the model, and results from the simulation experiments must be included with an application. However, typical research funding applications often have strict page restrictions, and there simply may not be enough space to include the necessary background information. Additionally, learning how to use simulation modeling software and creating models will require a serious commitment by interested nurse researchers. Fortunately, educational information is readily available, as are many powerful open-source and proprietary simulation software packages. Most modern computers and laptops are capable of running simulation software and partnering with experienced simulation modelers is an option.

Conclusion

Nurse researchers face a difficult problem. The competition for scarce research funding is intense, while at the same time, research funding awards are essential for continued employment, promotion, and tenure. Adding to the challenge, nurse researchers must compete among themselves for this funding, and often against researchers from other health care disciplines, undoubtedly limiting the amount of nursing-specific research they can contribute. However, new strategies such as computer-based simulation modeling may prove useful for improving success rates with funding applications. With this paper, we hope to open a discussion among our nursing colleagues about this novel and promising approach. As a next step, we hope to gather feedback from interested individuals that will help us develop a proof-of-concept funding application model that includes simulation modeling experiments.

The World Health Organization has designated 2020 as the International Year of the Nurse and the Midwife, and the International Council of Nurses has chosen the theme [47], Nurses: A Voice to Lead – Nursing the World to Health. *Nursing Now* is a three-year campaign to raise the status and profile of our profession, and nurse scholars, practice leaders, and educators around the world will be working toward influencing and enacting public and health policy globally, from a nursing perspective [48]. As nurse researchers and colleagues, we can contribute valuable insights toward these goals through our research; securing additional funding will result in additional research and knowledge we can translate from a nursing perspective. Surely this makes computer-based simulation modeling a strategy worthy of discussion and consideration.

Acknowledgments

We thank Dr Nate Osgood for expert advice, support, and enthusiastic encouragement. We also thank the AnyLogic Company for generously providing the modeling software used to create our example model.

Conflicts of Interest

None declared.

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Abbreviations

ABM: agent-based modeling
DES: discrete-event simulation modeling
PVD: peripheral vascular disease
RN: registered nurse
SD: system dynamics modeling

Edited by E Borycki; submitted 30.03.20; peer-reviewed by M Kleib, H Akram; comments to author 18.04.20; revised version received 21.04.20; accepted 22.04.20; published 30.07.20.

Please cite as:
McLean A, McDonald W, Goodridge D
Simulation Modeling as a Novel and Promising Strategy for Improving Success Rates With Research Funding Applications: A Constructive Thought Experiment
JMIR Nursing 2020;3(1):e18983
URL: https://nursing.jmir.org/2020/1/e18983/
doi:10.2196/18983
PMID:

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Original Paper

Assessing Hand Hygiene and Low-Level Disinfection of Equipment Compliance in an Acute Care Setting: Mixed Methods Approach

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Abstract

Background: Hand hygiene and low-level disinfection of equipment behaviors among hospital staff are some of the leading cost-effective methods to reduce hospital-acquired infections (HAI) among patients.

Objective: The aim of this study is to examine hand hygiene and low-level disinfection of equipment practices in a central Texas hospital and to explore pertaining gaps, perceptions, and challenges.

Methods: Data were collected using a multipronged mixed methods approach that included the following: (1) observation of hand hygiene and low-level disinfection practices (12 and 8 units during morning and evening shifts, respectively); (2) observation of usability/placement of hand sanitizer dispensers; (3) semistructured interviews; and (4) a follow-up email survey.

Results: In total, 222 (156 morning shift and 66 evening shift) staff members were observed. Of 526 hand hygiene and 33 low-level disinfection opportunities, compliance was observed 410 (78%) and 17 (51%) times, respectively. Overall, 6 units (50%) had ≥0.80 (favorable) hand hygiene compliance during the morning shift and 2 units (25%) had ≥0.80 hand hygiene compliance during the evening shift. Aggregated low-level disinfection compliance was 0.54 during the morning and 0.33 during the evening. Overall, the odds of noncompliant hand hygiene behavior were 1.4 times higher among staff who worked during night shifts compared to day shifts; however, this relationship was not statistically significant (95% CI 0.86-2.18; *P*=.18). Noncompliant behavior was most likely among unit B staff during the evening; however, this relationship was not statistically significant (OR 5.3, 95% CI 0.84-32.9; *P*=.07) All units, except one, had similar hand sanitizer dispenser usability characteristics. In the qualitative part of the study, the following challenges were identified: “shortage of time while seeing patients,” “sometimes the staff forgets,” “concern about drying hands,” “behavior is difficult or requires reminders,” and “there may be issues with resources or access to supplies to perform these behaviors.” Staff also stated that “a process that is considered effective is the Stop the Line program,” and that the “behavior is easy and automatic.”

Conclusions: Hand hygiene and low-level disinfection compliance is dependent on several personal and nonpersonal factors. Issues such as time constraints, peer pressure, work culture, available resources, and understanding of guidelines could influence staff behavior. The information collected through this study can be used to re-examine similar or related issues at a larger scale.

(JMIR Nursing 2020;3(1):e18788) doi:10.2196/18788

KEYWORDS

compliance; hand hygiene; low-level disinfection; patient safety; qualitative; quality improvement; infection prevention; infection control; nursing; mixed-methods; HAI; health care-associated infections; hand washing; hand sanitizers

Introduction

Hand hygiene and low-level disinfection of equipment behaviors among hospital staff are some of the leading cost-effective methods in reducing hospital-acquired infections (HAI) among patients [1-3]. Low compliance with hand hygiene practices and protocols among health professionals is common and, in some instances, found to be less than 50% [1,2]. A North

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Carolinian study showed a 6% reduction in the rate of overall HAI, a 14% reduction in the rate of hospital-acquired *Clostridioides difficile* infections (CDI), and significant cost reductions due to high hand hygiene compliance [4]. This is a strong indicator that maintaining a high level of compliance to infection prevention protocols should be paramount to hospital processes. Nosocomial infections are one of the most preventable types of disease. It is widely accepted that maintaining hand hygiene among health professionals is a highly effective way to reduce the transmission of virulent bacteria [5].

Baylor Scott & White Medical Center-Hillcrest (also known as Hillcrest Hospital) is a 236-bed acute care facility in Waco, Texas. Rates of HAI that could be prevented by hand hygiene and low-level disinfection of equipment practices at Hillcrest Hospital are comparable to the national average [6]. From April to December 2017, Hillcrest's Standard Infection Ratio (SIR), which expresses the reported number of infections compared to the predicted number of infections, was 0.945 for MRSA and 0.885 for CDI [6]. There were 4 reportable cases of MRSA and 27 reportable cases of CDI during this same time period [6]. This motivated us to examine hand hygiene and low-level disinfection of equipment behaviors in a health care facility to establish baseline information pertaining to these practices.

Hand hygiene guidelines include decontaminating hands before and after entering a patient's room by using a handwashing technique or, if hands are not visibly soiled, an alcohol-based hand sanitizer [7]. Hand hygiene techniques should also be performed before donning gloves, before direct contact with patients, after contact with inanimate objects, and after contact with any body fluids or excretions [7]. Environmental and equipment cleaning guidelines include the cleaning and disinfection of patient care equipment, portable patient care equipment, and computers on wheels. Noncritical nonelectric equipment such as wheelchairs and crutches should be cleaned and disinfected after each patient use and whenever visibly soiled. Noncritical electric equipment, such as blood pressure and oximetry monitors, should be cleaned and disinfected after each patient use and whenever visibly soiled [7]. These guidelines are mandated by the Infection Prevention and Control staff at Hillcrest Hospital.

This article highlights the situation of hand hygiene and low-level disinfection practices at Hillcrest. The aim of this quality improvement project was to identify and understand associated gaps, staff perceptions, challenges, and resource-related issues that could affect and improve health care and nursing staff's performance and compliance.

Methods

Hand Hygiene and Low-Level Disinfection Compliance Data Collection

The data collection strategy was modeled on a method that was previously used by Cure and Van Enk [8]. The hand hygiene and low-level disinfection observations took place at 12 units during the morning shift and 8 units during the evening shift. The study was conducted in inpatient medical and/or surgery, surgical and medical critical, emergency, women and children, and rehabilitation units from May to June 2019 by an observer that spent 1 hour at each unit. The "Observations" indicate the number of times the investigator observed compliant behavior (using hand sanitizer, washing hands, or cleaning equipment) and "Opportunities" correspond to the number of opportunities or instances in which compliant behavior should have been practiced. The compliance rate was then calculated by using the following equation:

> Compliance rate (CR)=Number of times staff followed appropriate behavior / Total number of observed opportunities

If the door to a room was closed or the staff member was out of view, the behavior was not documented.

Hand Sanitizer Dispenser Placement (Usability) Factors

The usability of hand sanitizer dispensers was measured based on the criteria described elsewhere [8] and comprised the following: (1) easily visible on entry, (2) easy, unobstructed access, (3) close to the point of care, (4) visible from point of care, (5) along the workflow path, (6) close to the entrance or exit, and (7) placed at optimal height (85 to 110 centimeters). A final criterion, (8) visible on exit, was also added.

Semistructured Interviews

Semistructured interviews were modeled using the existing Theoretical Domains Framework [9,10]. This framework was created to help assess the potential factors that may influence the behavior of health care professionals. The interview questions (Multimedia Appendix 1) were derived from a succinct table describing the 12 domain details, which are available elsewhere [9]. In total, 4 staff members were consented and interviewed, 2 each from units with ≥0.80 and ≤0.80 compliance, respectively. The Theoretical Domains Framework is useful for studying the implementation of desired behaviors among health care professionals and developing interventions to alter or improve behaviors [10].

Secondary Email Survey

Findings of the quantitative phase and semistructured interviews were shared with each unit's clinical staff leaders along with an open-ended 8-question survey (Multimedia Appendix 2). The aim of the follow-up survey was to understand leadership perception and insight pertaining to the results of both steps of the study. This survey was answered by 2 leaders representing 4 main hospital units.

Analysis

An Excel worksheet (Microsoft Corp) was used to provide frequencies, percentages, and average and total compliance rates. MedCalc for Windows Version 15.0 (MedCalc Software) was used for testing the statistical significance of different associations between morning and evening shift compliance, and reporting odds ratios (OR) and 95% confidence intervals. Qualitative analysis software NVivo Version 12 (QSR International) was used to classify responses under each theme and analyze differences in interview responses depending on

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the aggregate compliance score of the unit that interviewees were associated with.

Verbal informed consent was obtained from the participants of the qualitative survey. Units were informed of the observational part of the study prior to implementation. Although no personal identifiers of respondents and staff were recorded, the data was kept in secured and password-protected computers. The study was designed as a practice-based quality improvement project; hence, institutional review board approval was not required.

Results

Hand Hygiene and Low-Level Disinfection Compliance

The characteristics and activities of the sample of staff observed within each unit are displayed in Table 1. We observed 222 staff members (156 during morning shifts and 66 during evening shifts). Of 526 hand hygiene and 33 low-level disinfection opportunities, compliance was observed 410 (78%) and 17 (51%) times, respectively.

Table 1. Characteristics and activities of observed sample.

Shift and unit	Sample of staff observed, n (%)	Hand hygiene		Low-level disinfection	
		Observations, n (%)	Opportunities, n (%)	Observations, n (%)	Opportunities, n (%)
Morning shift					
A	18 (11.5)	40 (13.5)	51 (14.3)	0 (0.0)	1 (4.2)
B	10 (6.4)	29 (9.8)	31 (8.7)	1 (7.1)	1 (4.2)
C	21 (13.5)	52 (17.5)	69 (19.3)	2 (14.3)	2 (8.3)
D	10 (6.4)	16 (5.4)	17 (4.8)	1 (7.1)	1 (4.2)
E	12 (7.7)	21 (7.1)	32 (9.0)	2 (14.3)	6 (25.0)
F	11 (7.1)	26 (8.8)	29 (8.1)	1 (7.1)	1 (4.2)
G	16 (10.3)	16 (5.4)	26 (7.3)	1 (7.1)	5 (20.8)
H	14 (9.0)	18 (6.1)	22 (6.2)	1 (7.1)	1 (4.2)
I	10 (6.4)	24 (8.1)	27 (7.6)	0 (0.0)	1 (4.2)
J	11 (7.1)	18 (6.1)	25 (7.0)	3 (21.4)	3 (12.5)
K	10 (6.4)	8 (2.7)	11 (3.1)	__[a]	—
L	13 (8.3)	37 (12.5)	42 (11.8)	2 (14.3)	2 (8.3)
Morning shift total	156 (100.0)	297 (100.0)	357 (100.0)	14 (100.0)	24 (100.0)
Night shift					
A	11 (16.7)	14 (13.3)	20 (13.8)	0 (0.0)	1 (11.1)
B	6 (9.1)	11 (10.5)	15 (10.3)	—	—
C	8 (12.1)	11 (10.5)	15 (10.3)	1 (33.3)	1 (11.1)
D	7 (10.6)	13 (12.4)	16 (11.0)	2 (66.7)	2 (22.2)
E	8 (12.1)	16 (15.2)	21 (14.5)	—	—
F	9 (13.6)	15 (14.3)	18 (12.4)	0 (0.0)	4 (44.4)
G	7 (10.6)	12 (11.4)	19 (13.1)	—	—
H	10 (15.2)	13 (12.4)	21 (14.5)	0 (0.0)	1 (11.1)
Night shift total	66 (100.0)	105 (100.0)	145 (100.0)	3 (100.0)	9 (100.0)
Grand total	222	402	502	17	33

[a]Not available.

Table 2 and Multimedia Appendix 3 (detailed data) show the compliance scores by each unit. During the day shift, 6 of the 12 observed units had hand hygiene compliance scores less than 0.80 while 5 of the 8 units observed during the night shift had below 0.80 compliance. Low-level disinfection compliance was below 0.80 in 5 of 11 units observed during the day shift and 3 of 5 units observed during the night shift.

We compared the odds of noncompliant behavior in hand hygiene between morning and night shifts by considering the night shift as adverse exposure and assuming that compliance

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may be lower during evening hours. The odds of noncompliant behavior in hand hygiene were higher among 6 of the 8 observed units; however, this relationship was not statistically significant (Table 3).

Table 2. Aggregate unit compliance scores for hand hygiene and low-level disinfection of equipment guidelines.

Unit	Day shift		Night shift	
	Hand hygiene	Low-level disinfection of equipment	Hand hygiene	Low-level disinfection of equipment
A	0.78	0.00	0.70	0.00
B	0.94	1.00	0.73	__[a]
C	0.75	1.00	0.73	1.00
D	0.66	0.29	0.76	—
E	0.94	1.00	0.81	1.00
F	0.90	1.00	0.83	0.00
G	0.62	0.20	0.63	—
H	0.82	0.50	0.65	0.00
I	0.89	0.00	—	—
J	0.72	1.00	—	—
K	0.73	—	—	—
L	0.88	1.00	—	—
Total	0.80	0.54	0.73	0.33

[a]Not available.

Table 3. Odd ratios of hand hygiene compliance by night versus morning shift and by observed units.

Unit	Morning shift compliance		Night shift compliance[a]		Odds ratio	95% CI	*P* value
	Yes	No	Yes	No			
A	40	11	14	6	1.56	0.48-5.0	.45
B	29	2	11	4	5.27	0.84-32.9	.07
C	52	17	11	4	1.11	0.31-3.95	.86
D	21	11	16	5	0.59	0.17-2.06	.41
E	16	1	13	3	3.69	0.34-39.83	.28
F	26	3	15	3	1.73	0.31-9.69	.53
G	16	10	12	7	0.93	0.27-3.16	.91
H	18	4	13	7	2.42	0.58-10.03	.22
All units	218	59	105	39	1.37	0.86-2.18	.18

[a]Night shifts were considered adverse exposure and we assumed compliance would be lower during night hours.

Hand Sanitizer Dispenser Placement (Usability) Factors

The observer determined the usability of hand sanitizer dispensers based on their placement in each unit. The scores were marked down as “0” if the usability factor was not met and “1” if it was adequate. In most units, the dispensers met criteria 2, 5, 6, 7, and 8 but did not meet criteria 1, 3, and 4 (Table 4). All units, except one, had similar usability characteristics; hence, their impact on hand hygiene compliance was not analyzed.

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Table 4. Hand sanitizer dispenser placement (usability) factors and compliance by units.

Observations and factors	Unit										
	H	G	F	E	D	B	C	A	I	J	K
Hand sanitizer dispenser placement factors											
1. Easily visible on entry	0	0	0	0	0	0	0	0	0	1	0
2. Easy, unobstructed access	1	1	1	1	1	1	1	1	1	1	1
3. Close to the point of care	1	1	1	1	1	1	1	0	1	0	1
4. Visible from point of care	0	0	0	0	0	0	0	0	0	0	0
5. Along the workflow path	0	0	0	0	0	0	0	1	0	1	0
6. Close to the entrance or exit	1	1	1	1	1	1	1	1	1	1	1
7. Placed at optimal height	1	1	1	1	1	1	1	1	1	0	1
8. Visible on exit	1	1	1	1	1	1	1	1	1	0	1
Scores	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.5	0.625
Hand hygiene compliance											
Compliance during day shift	0.82	0.62	0.9	0.66	0.94	0.94	0.75	0.78	0.89	0.72	0.73
Compliance during night shift	0.65	0.63	0.83	0.76	0.81	0.73	0.81	0.7	—[a]	—	—
Overall compliance	0.735	0.625	0.865	0.71	0.875	0.835	0.78	0.74	0.89	0.72	0.73

[a]Not available.

Interview Data Findings

In total, 4 staff members, 2 each from units with morning shift compliance ≥0.80 (units B and E) and ≤0.80 (units D and G) consented to interviews. Using the Theoretical Domains Framework to analyze the results from the interview data, we identified several themes across units and compliance levels. Staff had the knowledge and skills to maintain hand hygiene and low-level disinfection of equipment; however, time shortage while seeing patients can make implementation of these skills difficult:

> *Whenever you're [a clinical staff member is] trying to get from one place to another it's easy to...think that you did it.* [hand hygiene behavior]
>
> *It's sometimes automatic to where you don't think that you're doing it and sometimes you can completely skip it.*
>
> *When we're shorthanded, yes.* [it is difficult to maintain low-level disinfection of equipment]

Despite the difficulty, staff members do think of hand hygiene and low-level disinfection as a standard part of their patient consultations. This indicates that they have the self-standard to adhere to the guidelines. Furthermore, staff had the self-efficacy to complete the steps required to perform these behaviors:

> *It [hand hygiene] just becomes second nature.*
>
> *It's [low-level disinfection of equipment is] not difficult at all.*

Self-efficacy can become an issue if the patient load is high or time is an issue:

> *It [hand hygiene] comes down to the time.*
>
> *It's [whether or not low-level disinfection behavior is performed is] purely based on staffing, how staffing is and how challenging the patient load.*

The staff has greater self-efficacy when they see visual cues such as soiled hands. They were familiar with the consequences of not performing the behavior, with one participant stating that *"Infection rates would go up and I... would get sick more often."* They also thought that these behaviors are automatic and do not require reminders; however, one respondent said, *"you're* [a clinical staff member is] *going to forget* [to perform low-level disinfection of equipment] *sometimes but the key is to try to be consistent."* When specifically asked if these behaviors take up too much time, they generally stated, *"No because those wipes* [which are used for low-level disinfection of equipment] *dry out in like 2 minutes."* However, *"if we're* [unit staff members are] *busy and they can't get to it* [cleaning equipment using low-level disinfection] *then that's a chore that's time-consuming."* This suggests that staff members mostly agree that the environment is conducive to performing these behaviors but that, in a given context, it can take up too much time. Other answers around environmental constraints varied and included the following:

> *If we're [unit staff members are] super busy.*
>
> *It's [whether or not low-level disinfection of equipment is performed is] going to be staffing issues.*
>
> *I just think about all the germs and I don't want to carry that home or give it to anybody else.*

Being highly aware of the risks involved with failing to carry out the protocols was the most common answer as to why the work environment motivated staff members to perform a behavior.

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Answers regarding social influences or norms also varied. Some staff members thought that social influences had a role in their hand hygiene behavior, including the following:

> *Keeping each other accountable.*
>
> *If you [a clinical staff member] see other people doing it [low-level disinfection of equipment], it helps remind you to do it.*

Other staff members indicated that social influences do not correlate with their hand hygiene or low-level disinfection of equipment behavior:

> *I know it's [performing low-level disinfection of equipment] automatic…*
>
> *I do it as necessary so no.* [staff do not feel pressured to perform behavior when witnessing other unit members performing it]
>
> *I know that's [hand hygiene behavior is] something we have to do and something we should do just because it's important to keep your hands clean.*

In addition, themes surrounding behavioral regulation varied greatly. Staff thought that maintenance of behavior was dependent upon access to supplies:

> *Just to constantly have the equipment.* [needed to perform low-level disinfection]
>
> *Making sure environmental services keeps the hand sanitizer machines full.*

It also depends on time:

> *Maybe I could wait the 2 minutes I'm supposed to after I clean it.* [equipment requiring low-level disinfection]

In contrast to behavioral regulation, social norms, and the environmental context domains explored, staff members agreed that emotion is not a factor in hand hygiene or low-level disinfection of equipment behavior. They also agreed that these behaviors are habitual within the given context.

Commenting on whether or not hand sanitizer dispensers located in the hallway, rather than the patient room, would change their hand hygiene habits, a unit G staff member answered, *"I don't think the hand sanitizer is good to tell you the truth."* A unit D staff member responded that *"having it outside the room I think you'd* [a clinical staff member would] *see it more."* These units both had an aggregate compliance score of ≤0.80 for both hand hygiene and low-level disinfection behavior. The unit E interviewee responded with the following:

> *I feel like that really helps especially if you like sat down and you're like I forgot to do it, so it's [the hallway hand sanitizer dispenser is] right there you can always do that.*

However, the unit B respondent did not think that any change would occur, stating *"I think it would be the same."* Units E and B both had an aggregate compliance score of ≥0.80 for both behaviors.

When asked to comment on the changes that could improve low-level disinfection compliance rates, the 2 units with compliance ≤0.80 stated that access and supplies can help:

> *Only thing I can think of would be…[to]...put it [cleaning supplies needed for low-level disinfection] at every door on the outside of rooms...that way you [a clinical staff member] could literally walk out of the room, grab them, wipe it down, throw them away, go to the next.*
>
> *Have more purple top wipes [ammonium and alcohol-based wipes] available and bleach wipes.*

Suggestions from the other units with compliance ≥0.80 included education and staffing:

> *They [cleaning staff] literally just don't understand that they're supposed to do it [clean certain equipment] so I think like re-education or education initially is a big deal.*
>
> *Actually have a person here 24/7 to help with cleaning our big equipment.*

Regarding the availability of the cleaning supplies for low-level disinfection, staff generally believed that access to them is easy; however, there could be more supplies:

> *There is easy access to it but there's no such thing as having too much there's always room for more.* [supplies for low-level disinfection of equipment]
>
> *There needs to be more because they [hospital supply managers] only put a certain amount on our floor.*

Table 5 shows the differences in interview responses given by staff from low- and high-compliance units. Each factor has an aggregate compliance score from 4 units. The scores under each factor were compiled by sorting interviewee responses into 36 relevant categories.

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Table 5. Compiled responses to interview questions analyzed using NVivo 12[a].

Factors	Compliance ≥0.80	Compliance ≤0.80
1. Awareness of guidelines	8	8
2. Awareness of risk prompts behavior	8	6
3. Behavior causes drying of hands	2	2
4. Behavior creates burdens	3	5
5. Behavior does not create burdens	5	3
6. Behavior is automatic	15	19
7. Behavior is difficult	0	4
8. Behavior is difficult in the work setting	11	11
9. Behavior is easy	19	17
10. Behavior is easy in the work setting	13	15
11. Behavior is influenced by team members	9	9
12. Behavior is not influenced by team members	8	8
13. Behavior is not time consuming	7	9
14. Behavior is prompted by visual cues	7	3
15. Behavior is standard in work setting	8	8
16. Behavior is time consuming	11	9
17. Behavior requires reminders	13	5
18. Benefits of behavior outweigh burdens	7	5
19. Equipment for behavior is adequate	4	4
20. Equipment for behavior is easily accessible	5	5
21. Equipment for behavior is inadequate	0	2
22. Equipment for behavior is not easily accessible	7	7
23. Guidelines are credible and valid	8	10
24. Improvement (access and supplies)	5	5
25. Improvement (education)	1	3
26. Improvement (increase behavior)	3	3
27. Improvement (staffing)	2	0
28. Improvement (time)	3	1
29. Improvement (visual cues)	0	4
30. Intention to practice behavior	8	8
31. Mood is not a factor	8	4
32. Other team members would agree	5	7
33. Trained in skill of behavior	8	8
34. Understands consequences	8	10
35. Understands guidelines	13	11
36. Understands reasoning behind guidelines	7	9

[a]Results from compliance with low-level disinfection of equipment and hand hygiene behavior were compiled into “behavior” before conducting the analysis.

Secondary Qualitative Data Results

One theme that emerged from this data was that there might be issues with resources or access to supplies needed to perform these behaviors. For example, one respondent said that “resources are not readily available” and that having holders for the wipe containers in patient rooms could be a viable solution to improve rates of low-level disinfection behavior. In addition, the respondent believed another way of improving compliance scores would be to hold team members accountable.

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When asked about processes that are in place to maintain these behaviors, the respondents referred to the survey readiness audits, suggesting that these are effective in monitoring behavior. Another process that was considered effective is the Stop the Line program, which urges staff members to speak up in situations where they feel that patient safety is at risk. Having more hand sanitizer dispensers in hallways as opposed to primarily in patient rooms was also proposed as a solution to improve hand hygiene compliance.

Discussion

In this study, we found that 6 (50%) and 2 (25%) units had over 80% (0.80) hand hygiene compliance during the morning and evening shifts, respectively. Aggregated low-level disinfection compliance was 0.54 during the morning shift and 0.33 during the evening shift. The odds of noncompliant hand hygiene behavior were 1.4 times higher among staff who worked night shifts compared to those who worked day shifts; however, this relationship was not statistically significant (P=.45). All units, except one, had similar hand sanitizer dispenser usability characteristics. During the qualitative part of the study, some identified challenges included the following: “shortage of time while seeing patients,” “some time staff forgets” [sic], “concern about drying hands,” “behavior is difficult or require reminders” [sic], and “there may be issues with resources or access to supplies to perform these behaviors.” Staff also stated that “a process that is considered effective is the Stop the Line program,” and that the “behavior is easy and automatic.”

Observation results reflected compliance levels that are comparable to the findings from other studies [2,3,11]. An increase in hand hygiene compliance could reduce nosocomial infection rates and lead to improved patient safety [12,13]. Although qualitative data does provide some insight into the cognitive aspects of behavior, further investigation as to why compliance scores are less than optimal in certain areas is needed. The observer noted that higher compliance scores were connected with several behaviors or traits of the unit, including the ability or willingness to accept criticism or feedback from peers. In addition, we found that high compliance scores were associated with task ownership and overall accountability as a team. There is a well-documented association between a good team environment and the promotion of health care worker behavior that is associated with reduced risk to patient safety [14-16]. Furthermore, adherence and commitment to organizational processes can also improve staff compliance positively [17].

Interview responses associated with different levels of compliance as analyzed using NVivo 12 also indicated what kind of intervention components need to be implemented. Clinical staff members from units with compliance scores over 0.80 tended to be more willing to admit that the behaviors were not automatic (Table 5, item 6) and reminders were needed to maintain them (Table 5, item 17). They indicated actively using visual cues as reminders (Table 5, item 14), which is in contrast to clinical staff members from units with compliance scores below 0.80, who stated that visual cues could be used to improve behavior (Table 4, item 29). Additionally, clinical staff members from units with compliance scores over 0.80 did not indicate that the behavior was ever difficult, whereas clinical staff members from units with scores below 0.80 indicated that the behavior was difficult at times. The combination of these differences suggests that reminders are needed to ensure higher levels of compliance.

In addition, qualitative methods revealed data that is consistent with other studies that assessed health care workers’ attitudes toward these behaviors [18]. When asked about barriers to hand hygiene behavior, two unit members commented that the products can cause drying of hands; in addition, time constraints within the work setting were consistently mentioned by respondents. This is consistent with findings by Kirk et al [18].

Limitations of our study include difficulties with observations (eg, not being able to witness all observations due to the room doors being closed, a long walking distance from one patient to the next, and observing without intruding on medical practice. Semistructured interviews and email survey samples were relatively small; thus, the points of view shared by respondents may not be generalizable to the whole facility or another institution. However, these two methods still revealed important information.

In summary, hand hygiene and low-level disinfection of equipment compliance is dependent on several personal and nonpersonal factors. Issues such as time constraints, peer pressure, work culture, available resources, and understanding of guidelines were found to be most connected with staff behavior and consistent with existing literature [19]. Novel approaches such as sanitizer-dispensing door handles can improve hand hygiene practices and compliance [20]. Furthermore, the working culture and environment in a health care setting can influence staff behavior as well as patient safety outcomes [21].

Conflicts of Interest

None declared.

Multimedia Appendix 1
Interview guide.
[DOCX File , 14 KB - nursing_v3i1e18788_app1.docx]

Multimedia Appendix 2
Qualitative data collected via email.

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[DOCX File , 13 KB - nursing_v3i1e18788_app2.docx]

Multimedia Appendix 3
Results from the observation of hand hygiene and low-level disinfection of equipment.
[DOCX File , 15 KB - nursing_v3i1e18788_app3.docx]

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Abbreviations

CDI: *Clostridioides difficile* infections
HAI: hospital-acquired infections
SIR: Standard Infection Ratio

Edited by E Borycki; submitted 18.03.20; peer-reviewed by A McLean, H Letzing, A Sudaryanto; comments to author 12.04.20; revised version received 13.04.20; accepted 18.04.20; published 05.06.20.

Please cite as:
Akram H, Andrews-Paul A, Washburn R
Assessing Hand Hygiene and Low-Level Disinfection of Equipment Compliance in an Acute Care Setting: Mixed Methods Approach
JMIR Nursing 2020;3(1):e18788
URL: https://nursing.jmir.org/2020/1/e18788
doi:10.2196/18788
PMID:

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Original Paper

Understanding the Association Between Electronic Health Record Satisfaction and the Well-Being of Nurses: Survey Study

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Abstract

Background: Intensive care unit (ICU) nurses experience high levels of burnout related to the high-stress environment. Management of electronic health records (EHR) is a contributing factor to physician burnout. However, limited research has established the relationship between the nurse's well-being and EHR use.

Objective: The objective of this study was to examine the association between EHR use and the well-being of nurses.

Methods: We surveyed registered nurses employed at a major Southeastern medical center in the United States about their demographics, experience with EHRs, satisfaction with EHRs, and elements of well-being. The correlation between subgroup demographics and survey questions was examined using Kendall and Fisher tests.

Results: A total of 113 ICU registered nurses responded to the survey, of which 93 (82.3%) were females. The population had a mean age of 35.18 years (SD 10.65). A significant association was found between satisfaction and well-being scores, where higher EHR satisfaction was associated with higher self-reported well-being (correlation 0.35, $P<.001$). Nurses who were unhappy with the time spent in EHR use compared with direct patient care reported higher levels of stress ($P<.001$) and isolation ($P=.009$). Older nurses reported higher dissatisfaction with the amount of time spent on EHR tasks related to direct patient care compared to younger nurses ($P<.001$).

Conclusions: Although nurses reported acceptable satisfaction scores with EHR use, deeper analysis suggests that EHR indirectly affects the well-being of nurses. These findings strongly indicate that lower EHR satisfaction can impact the well-being of nurses. More research is needed to optimize the nurse-EHR experience through more user-centered design approaches.

(JMIR Nursing 2020;3(1):e13996) doi:10.2196/13996

KEYWORDS

electronic health record; nursing; satisfaction; critical care

Introduction

Background

The professional well-being of health care workers has been a topic of interest in research for decades, first mentioned in a study addressing physician burnout in 1981 [1]. A wealth of research has been conducted since then to analyze what burnout is, the risk factors for its development, its negative outcomes, and potential interventions to reduce its incidence. It has been defined as one having feelings of hopelessness, apathy, and the eventual inability to function effectively in one's professional role [2,3]. In addition, burnout typically develops over time with a relatively slow onset, related to continued exposure to contributing factors [4].

Although burnout has been described in a variety of manners, three overarching themes identified by Maslach, Jackson, and Leiter [5] shape the preeminent definition of burnout: feelings

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of emotional exhaustion, depersonalization, and reduced personal accomplishment. Of considerable importance when discussing burnout concerning nursing is the topic of factors that contribute to its development. Factors such as high patient or unit acuity, inadequate staffing levels, and conflict with the administration were identified as key contributors to developing burnout [6]. In addition, Hunsaker et al [4] identified age as a risk factor for nurses, with younger nurses exhibiting higher levels of burnout when compared with their older colleagues. This finding is likely related to the large learning curve experienced by new nurses and can be expected to be higher in young nurses on high acuity units. Another contributing factor to the high patient or unit acuity is the relative prevalence of burnout by unit type. Research on nursing burnout has primarily focused on intensive care unit (ICU) nurses with the consensus that ICU nurses experience very high levels of burnout, related to the high-stress environment [7-9]. Longer (≥12 hours) shifts and lower education levels (below a master's degree) were also identified as significant factors in nursing burnout development [4]. Additional studies identified nurses working in emergency departments as having elevated rates of burnout [4]. When considering other acute care settings such as medical-surgical units, burnout is less prevalent, but most notably affects younger nurses on such units [10].

The negative outcomes resulting from nurses experiencing burnout are numerous [11,12]. Of primary consideration are the mental health and general well-being of the affected nurses. Mealer et al [13] identified that approximately 21% of nurses with burnout syndrome had a concurrent diagnosis of posttraumatic stress disorder. Those nurses with both diagnoses were likely to experience high levels of anxiety and nightmares, altered perception, and attitude toward elements of their personal lives [13]. High levels of burnout also significantly increase the rates of turnover on a unit, negatively affecting nurse retention [4]. Finally, high levels of nursing burnout are correlated with decreased patient safety and satisfaction [14].

In the present technological age, a significant part of a health care provider's day revolves around computerized charting systems, typically referred to as electronic health records (EHRs). EHRs are made up of a variety of functions such as computerized provider order entry, clinical notes, test results, clinical decision support tools (ie, drug interaction warnings and allergy warnings), electronic paging, and electronic communication with patients [15]. Although these systems have notable effects on decreasing hospital costs and increasing care quality, several issues with EHRs have been identified [16]. Nurses have indicated that the increased time spent on documentation and the abundance of checkboxes negatively impacted their nursing work [17]. Usability-specific issues related to EHR design and changes to workflow have shown to contribute to a negative perception of EHRs, and, in conjunction, contribute to decreased efficiency and satisfaction among physicians [16,18]. Decreased professional satisfaction among physicians with EHR use was reported to be because of the experience of clerical burden [15,19]. The use of EHRs and the associated clerical burden is related to increased levels of physician burnout, regardless of their satisfaction with EHRs in general [20]. In contrast, the study conducted by Harris et al [21] regarding EHR-related stress and advanced practice registered nurses (APRNs) identified negative attitudes toward EHRs as strongly associated with APRN burnout.

When considering physicians and APRNs, researchers arrive at the same conclusion: EHRs and EHR-related stress are associated with burnout and well-being [21]. These studies examined the statistical relationships between participant scores on separate measures used to identify burnout and EHR satisfaction. In this regard, these studies provide valuable information about the impact of the EHR on clinician well-being by focusing on physicians and APRNs. Like physicians and APRNs, nurses spend large quantities (up to 50%) of their work time using EHRs, although their tasks within the EHR differ [17,22]. Despite the number of studies addressing clinician well-being to EHR use, and nursing burnout and nurses' perception of EHRs separately, a gap in the literature exists regarding the correlation between the well-being of nurses and EHR use. For these reasons, we hypothesize that EHR use negatively affects satisfaction and overall well-being for nurses.

Objective

This study aimed to address this literature gap by examining the association of EHR use with nursing satisfaction and the overall perceived well-being of nurses in a hospital setting.

Methods

Setting and Participants

Participants in this study were registered nurses employed at a Southeastern medical center in the United States. The medical center has a total of over 800 beds. Participants were asked to indicate their highest degree held, which included Associate Degree in Nursing, Bachelor of Science in Nursing, Master of Science in Nursing, and Doctorate of Nursing Practice. Participants indicated the name of the unit on which they worked. These units included a variety of ICUs, stepdown units, medical-surgical floors, and others. Participating nurses were recruited via email listservs and in-person on select units. Participants completed the paper or electronic survey on a volunteer basis and were not compensated for their participation.

Materials

The survey was developed for this study through the utilization of previously developed instruments. The demographics section asked participants about their age, gender, unit in which they worked, and the highest degree held. This section also included questions about the number of years of experience they had using the EHR and the estimated number of hours weekly that they used the EHR.

We investigated using an existing survey tool for our study; however, we could not find a survey instrument that included all measures of interest. Therefore, we built a hybrid survey on the basis of validated EHR questions from the description of technology use in practice and the Maslach Burnout Inventory. Participant satisfaction with EHR systems was measured by 3 questions (Q1-Q3) adapted from the description of technology use in practice measure developed by Shanafelt et al [15]. These questions utilized 5-point Likert scales, asking participants to

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rate EHR satisfaction on a scale ranging from *very dissatisfied* to *very satisfied* and *strongly disagree* to *strongly agree* for the remaining 2 questions. The well-being variable was measured by an additional 6 questions (Q4-Q9) adapted from the Maslach Burnout Inventory [5]. Each of the questions utilized a 5-point Likert scale, asking participants to indicate agreement with the provided statement by choosing *strongly disagree*, *disagree*, *neutral*, *agree*, or *strongly agree*. A copy of the paper survey is in Multimedia Appendix 1.

Procedure

Participants were either verbally instructed or informed via an email that the survey was designed to explore any potential correlation between EHRs and the well-being of nurses. Data were collected by hard copy and electronically by Qualtrics survey, both of which were designed to complete within 5 min. Participation in the survey was voluntary, and participants could discontinue at any time. Participants who completed the paper survey were additionally given a copy of the consent form to review before completing the survey. The anonymity of these participants was maintained by not collecting the signed consent forms. Completed paper survey forms were placed in a folder for later data entry. The Qualtrics survey link was distributed electronically via email along with the consent form available for review as an attachment to the sample population. The participants were requested to contact the principal investigator or the institutional review board if they had any questions or concerns. Institutional review board approval was obtained before starting this research.

Outcome Variable

The outcome variables were *satisfaction score* and *well-being score.* The *satisfactionscore* measured the satisfaction with a prominent EHR system, which was the mean score of Q1 to Q3. *Well-being score* measured the degree of nursing EHR well-being experienced by an individual participant, which was the mean score of Q4 to Q9. These metrics were derived from the arithmetic mean of the accumulated score of all 9 survey questions. On a range of 0 to 5, the lower the *well-being score*, the higher the degree of burnout.

Statistical Analysis

Data Analysis

Incomplete entries (either missing some demographic information or some response) were not eliminated beforehand. Instead, we performed only necessary removals before carrying out various statistical analyses. Questions 5, 7, and 8 were negative scoring questions; the responses were reversely coded for analysis. We used Pearson correlation to test the relationship between satisfaction (mean score of questions 1-3) and well-being (mean score of questions 4-9). We also used Pearson correlation to correlate each survey question with satisfaction score and well-being score.

Kendall Test and Fisher Test

Each subgroup's association with every question was examined either by the Fisher test or by the Kendall test. As gender is a nominal variable, the former one was used to test its relationship with each survey question. As the remaining subgroups were ordinal, their relationship to each survey question was investigated by the Kendall test. Both tests returned P values, whereas the Kendall test further provided a correlation coefficient, which was between −1 and 1. The sign of this coefficient noted the positivity or negativity of the relationship, and the absolute value of it represented the relation's strength.

Results

Demographic Characteristics

A total of 113 ICU registered nurses responded to the survey, of which female nurses were 82.3% (93/113) of the surveyed population, whereas males comprised 17.6% (20/113). The population had a mean age of 35.18 years (SD 10.65). Approximately 3 of 4 participants were under the age of 45 years, indicating a relatively young population. Among the participants, 87 held a Bachelor of Science in Nursing as their highest completed degree, whereas 17 participants held an Associate Degree in Nursing, 5 participants held a Master of Science in Nursing, and only 1 held a Doctorate of Nursing Practice. Table 1 displays the characteristics of the study participants.

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Table 1. Descriptive analysis of participants population (N=113).

Characteristics	Participants, n (%)	Well-being score (SD)
Average	113 (100.0)	3.22 (0.17)
Gender		
Male	20 (17.7)	3.27 (0.44)
Female	93 (82.3)	3.23 (0.5)
Age[a] (years)		
18-24	12 (10.6)	3.29 (0.34)
25-34	49 (43.3)	3.3 (0.38)
35-44	22 (19.4)	3.32 (0.58)
45-54[a]	18 (15.9)	2.89 (0.56)
≥55	6 (5.3)	3.41 (0.63)
N/A	6 (5.3)	__[b]
Years of practice[a]		
0-1	5 (4.4)	3.6 (0.37)
1.5-3.5[a]	34 (30.0)	3.05 (0.44)
≥4	72 (63.7)	3.3 (0.49)
N/A	2 (1.7)	—
Hours per week in EHR[c]		
0-19	34 (30.0)	3.25 (0.52)
20-39	59 (52.2)	3.25 (0.47)
40+	16 (14.1)	3.15 (0.51)
N/A	4 (3.5)	—
Highest degree attained		
ADN[d]	17 (15.0)	3.12 (0.77)
BSN[e]	87 (76.9)	3.27 (0.43)
MSN[f]	5 (4.4)	3.09 (0.46)
DNP[g]	1 (0.8)	2.89 (N/A[a,h])
N/A	3 (2.6)	—

[a]Self-reported data.
[b]Missing data
[c]EHR: electronic health record.
[d]ADN: Associate Degree in Nursing.
[e]BSN: Bachelor of Science in Nursing.
[f]MSN: Master of Science in Nursing.
[g]DNP: Doctorate of Nursing Practice.
[h]N/A: not applicable.

Descriptive Study of Participants

The population average of well-being score was 3.22, which was between neutral and satisfied with their experience with nursing EHR. The responses of nurses were subsequently analyzed in subgroups (Table 1). We found that nurses aged between 45 and 54 years responded to the survey questions significantly different from their peers, yielding a mean well-being score of 2.89. On the other hand, nurses who had between 1.5 and 3.5 years of experience reported a higher degree of well-being than those who practice either long or short periods. Female nurses, which contributed to 80% of the participant population, did not demonstrate a significant average well-being score comparing to that of male nurses.

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Association Between Electronic Health Record Satisfaction and Well-Being

A significant association was found between satisfaction and well-being, where a higher EHR satisfaction was associated with high self-reported nurse well-being (correlation 0.35, $P<.001$). The mean EHR satisfaction score was 3.23 (SD 0.75), and the mean well-being score was 3.22 (SD 0.48). A wider range of scores was observed in EHR satisfaction (minimum of 1, maximum of 4.7) compared with well-being score (minimum of 1.8, maximum of 4.3).

The level of satisfaction with the EHR was significantly associated with the perceived well-being of nurses, such that higher EHR satisfaction led to higher well-being scores ($P=.002$; Table 2). A significant positive relationship was found between the perceived efficiency and time spent in the EHR with overall EHR satisfaction ($P=.001$ for both).

Table 2. Pearson correlation coefficients of correlations between each survey question and electronic health record satisfaction and nurse well-being scores.

Question	EHR[a] Satisfaction Items		Well-being Items	
	EHR satisfaction score	*P* value	Well-being score	*P* value
Rate level of satisfaction with EHRs	N/A[b]	N/A	0.29897	.003
EHRs have improved my efficiency	N/A	N/A	0.22655	.03
The amount of time I spend on EHR tasks related to direct patient care is reasonable.	N/A	N/A	0.33707	.007
I can manage the amount of my work well.	0.42326	<.001	N/A	N/A
After my work, I usually feel worn out and weary (reverse coding).	0.16846	.097	N/A	N/A
I can tolerate the pressure of my work very well.	0.20003	.048	N/A	N/A
One can become disconnected from this type of work (reverse coding).	0.20776	.04	N/A	N/A
I tend to think less at work and do my job almost mechanically (reverse coding).	0.28953	.004	N/A	N/A
I always find new and interesting aspects in my work.	0.01389	.89	N/A	N/A

[a]EHR: electronic health record.

[b]N/A: not applicable.

Findings From Subgroup Analysis

We used the Kendall test and the Fisher exact test to examine whether nurses of a certain demographic group tended to respond differently to any question (Table 3). We found 3 subgroup-question pairs to be correlated. Kendall test suggested that respondents with higher ages tended to consider the amount of time they spent on EHR tasks related to direct patient care as less reasonable ($P=.002$). Besides, higher age respondents held a stronger opinion against the EHR's positive effect on efficiency, supported by a *P* value of .03 and correlation coefficient −0.18. The last significant pair, subgroup *years of practice* versus question 4, suggested that respondents with more years of practice showed more agreement to the traceableness of their work.

Table 3. Kendall test for demographics and question responses.

Subgroup-question pairs	Correlation coefficient	*P* value
Age versus the amount of time spent on EHR[a] tasks related to direct patient care is reasonable.	−0.2566	.002
Age versus EHR have improved my efficiency.	−0.1838	.03
Years of practice versus I can manage the amount of my work well.	0.2403	.007

[a]EHR: electronic health record.

Analysis of Survey Questions

We calculated the average score of individual questions and compared them with the population average (Table 4). Among the 3 EHR-specific survey items, Question 1 to 3, participants responded most positively to *Question 1* (3.66), suggesting an overall satisfaction with the nursing EHR. However, the lower score received by *Question 3* (2.73) indicated that, on average, participants agreed that the balance between nursing EHR activities and direct patient care had not been achieved. The participants showed the highest agreement with *Question 4* and *Question 6*, which measured the non-nursing EHR-specific aspects of their work routine. In other words, the nurses were generally positive about their ability to managing workload and work-related stress. On the other hand, the lowest agreement was observed in *Question 5* and *Question 7*—participants reported feeling disconnected from the work and worn out.

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Table 4. Mean and mode score of survey questions.

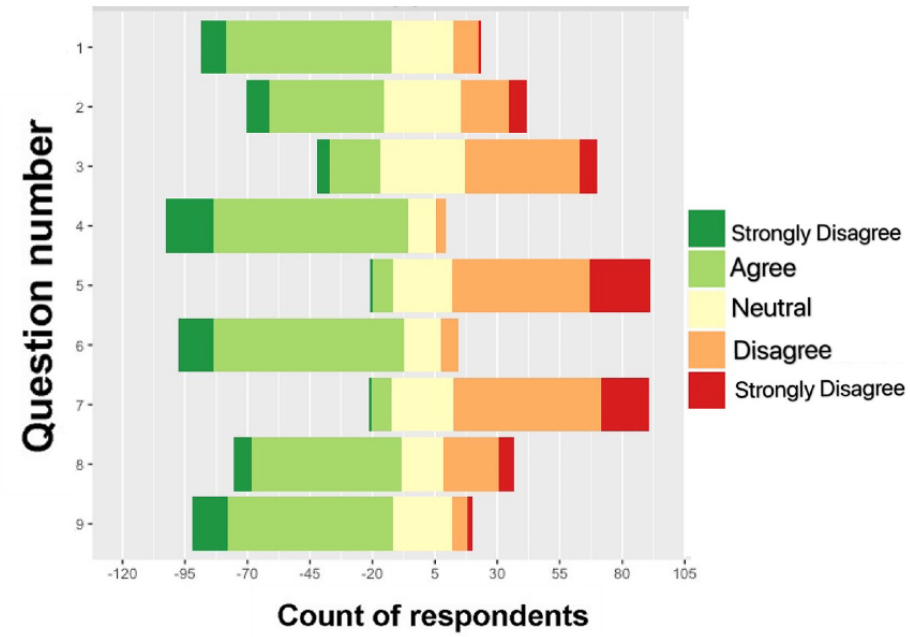
Question	Description	Mean score (SD)
1	Rate level of *satisfaction* with EHRs[a].	3.66 (0.80)
2	EHRs have improved my *efficiency.*	3.28 (1.040)
3	Amount of *time* I spend on EHR tasks related to direct patient care is reasonable.	2.73 (0.97)
4	Usually, I can *manage the amount of my work* well.	4.00 (0.64)
5	After my work, I usually *feel worn out* and weary.	2.18 (0.88)
6	I can *tolerate the pressure* of my work very well.	3.87 (0.70)
7	Over time, one can become *disconnected* from this type of work.	2.22 (0.85)
8	Lately, I tend to think less at work and *do my job almost mechanically*.	3.35 (1.03)
9	I always find *new and interesting aspects* in my work.	3.75 (0.81)
1-9	N/A[b]	3.22 (0.49)

[a]EHR: electronic health record.

[b]N/A: not applicable.

The dispersion of respondents' opinions on each question was captured using a diverging bar chart (Figure 1). The counts for each question are presented on the x-axis, such that 0 is neutral, green indicates agreement, and orange and red indicated disagreement. Among the 9 questions, only 3 received greater than 50% of negative feedback. On the other hand, the nurses did not appear predominantly neutral on any one of the questions. Concerns over the EHR's interference with direct patient care (Question 3) was the most reported issue among the 3 nursing EHR–related questions.

Figure 1. Diverging bar chart of responses of survey questions.



Interquestion Associations

Kendall test was applied to assess the response resemblances among Questions 1, 3, 5, and 7 (Table 5). Nurses who reported higher satisfaction with the balanced workload between the EHR and direct patient care (Question 3) also tended to report higher satisfaction with EHR in general (Question 1; $P<.001$). On the other hand, those who were dissatisfied with the time spent in the EHR compared with direct patient care reported higher levels of stress ($P<.001$) and isolation ($P=.009$).

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Table 5. Kendall test for question comparisons.

Comparison	Kendall test estimate	*P* value
Q1 versus Q3	0.3665	<.001
Q1 versus Q5	0.12	.15
Q1 versus Q7	0.0328	.69
Q3 versus Q5	0.337	<.001
Q3 versus Q7	0.1779	.03
Q5 versus Q7	0.216	.009

Discussion

Principal Findings

This study evaluated the relationship of EHR with satisfaction and well-being among ICU nurses across different units, age, clinical experience, gender, and EHR experience. We report that nurses were concerned regarding their EHR experience, in particular, the effect of EHR use on patient care. Nurses scored the highest satisfaction scores regarding their ability to manage the amount of assigned work. On the contrary, the proportion of time spent in the EHR compared with time on direct patient care was the lowest reported score, reflecting possible frustration.

Generational Differences in Perceived Electronic Health Record Use

We report that age was negatively associated with the perception of the EHR affecting direct patient care, whereas older nurses reported that EHR time was not reasonable compared with patient care time. The correlation between age and perceived improved efficiency as a result of EHR adoption showed a significant negative association, as the younger nurses agreed that EHRs improved their efficiency compared with older nurses. The study results also expressed that the years of clinical experience had a significantly positive relationship with the ability to manage the amount of work, where nurses with more clinical experience reported a higher ability to manage work. This finding supports similar studies investigating a difference in perceived EHR satisfaction among physicians [16,23].

Electronic Health Record Use and Nurse Well-Being

EHR satisfaction had significant associations with the overall well-being and feeling disconnected from work. ICU nurses' survey responses showed a strong association between their EHR satisfaction and the frustration of being taken away from patient care, feeling worn out and weary, and the loss of passion or disconnection with work. Moreover, a strong resemblance was found between the frustration of spending too much time in the EHR with feeling worn out and weary and being more disconnected from work. Strong indications can show that EHR satisfaction can lead to feeling overworked and burned out.

To the authors' knowledge, this is the first study to investigate the influence of EHR use on registered nurses' well-being. Findings from this study are consistent with similar studies conducted on physicians and APRNs, wherein EHR use was found to contribute to professional well-being [15,17,21]. In addition, our findings validate previous studies suggesting that professional experience and age affect the perceived EHR experience [16].

Findings From Previous Literature

Clinician well-being has been studied for decades [1,24]. However, contributing factors to well-being have been changing. In today's world, an important contributor to well-being is the use of EHRs [25]. Many studies that reported on the relationship between EHR use and well-being focused on physicians [16,20,26-28]. However, significantly fewer studies explored the relationship between the well-being of nurses and EHR use [21,29]. Hoff et al [29] reported the lack of robust research designs to study well-being and high dissatisfaction among nurses.

A key study investigating the association between EHR use and APRN demonstrated a high correlation between EHR-related factors and well-being [21]. The study reports that 50% of the participants agreed or strongly agreed that the EHR added to their daily frustration, and 32.8% reported an insufficient amount of time for documentation. Our study validates this finding, such that 33% (37/113) of nurses reported dissatisfaction with the current EHR system. Moreover, 75% (85/113) of nurses did not believe the time spent in the EHR was reasonable compared with time spent in patient care. In addition, 50% (57/113) of nurses reported that the EHR did not improve their efficiency. Those reasons may explain the frustration with EHR systems and calls for more research to study ways to improve EHR satisfaction through improved interface design that meets the expectations of nurses.

Limitations and Future Directions

This study was conducted as a single-site study, which may affect the generalizability of findings. Moreover, this study focused only on the perceptions of ICU nurses and assessed a single EHR system. Owing to the lack of a validated survey instrument to measure the impact of EHRs on the well-being of nurses, we designed a survey instrument on the basis of literature and domain experts' input.

Future directions will include conducting a large-scale, multisite study to investigate if and how EHRs contribute to the well-being of nurses. This study provides baseline metrics for future usability research. Future studies will include conducting formal usability testing to complement findings from this study. Finally, more studies and comparisons are needed around this problem beyond critical care settings to build a more holistic picture.

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Conclusions

A significant part of a health care provider's time is spent interacting with EHRs. We investigated the EHR satisfaction levels and the impact of EHRs on the well-being of nurses among ICU nurses at a tertiary medical center. Although nurses reported acceptable satisfaction scores with EHR use, deeper analysis suggests that EHR indirectly affects the well-being of nurses. We report a significant association between EHR satisfaction and nurses feeling burned out. More research is needed to improve the well-being of nurses through a better EHR interface design that meets the expectations of nurses.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Electronic health record (EHR)-burnout survey.
[DOCX File , 14 KB - nursing_v3i1e13996_app1.docx]

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Abbreviations

APRN: advanced practice registered nurse
EHR: electronic health record
ICU: intensive care unit

Edited by E Borycki; submitted 22.03.19; peer-reviewed by G Strudwick, P Jimenez, J op den Buijs; comments to author 05.06.19; revised version received 19.12.19; accepted 01.02.20; published 23.06.20.

Please cite as:
Khairat S, Xi L, Liu S, Shrestha S, Austin C
Understanding the Association Between Electronic Health Record Satisfaction and the Well-Being of Nurses: Survey Study
JMIR Nursing 2020;3(1):e13996
URL: https://nursing.jmir.org/2020/1/e13996/
doi:10.2196/13996
PMID:

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Original Paper

An Evidence-Based, Nursing Handover Standard for a Multisite Public Hospital in Switzerland: Web-Based, Modified Delphi Study

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Abstract

Background: Ineffective communication procedures create openings for errors when health care professionals fail to transfer complete, consistent information. Deficient or absent clinical handovers, or failures to transfer information, responsibility, and accountability, can have severe consequences for hospitalized patients. Clinical handovers are practiced every day, in many ways, in all institutional health care settings.

Objective: This study aimed to design an evidence-based, nursing handover standard for inpatients for use at shift changes or internal transfers between hospital wards.

Methods: We carried out a modified, multiround, web-based, Delphi data collection survey of an anonymized panel sample of 264 nurse experts working at a multisite public hospital in Switzerland. Each survey round was built on responses from the previous one. The surveys ended with a focus group discussion consisting of a randomly selected panel of participants to explain why items for the evidence-based clinical nursing handover standard were selected or not selected. Items had to achieve a consensus of ≥70% for selection and inclusion.

Results: The study presents the items selected by consensus for an evidence-based nursing handover standard for inpatients for use at shift changes or internal transfers. It also presents the reasons why survey items were or were not included.

Conclusions: This modified Delphi survey method enabled us to develop a consensus- and evidence-based nursing handover standard now being trialed at shift changes and the internal transfers of inpatients at our multisite public hospital in Switzerland.

(JMIR Nursing 2020;3(1):e17876) doi:10.2196/17876

KEYWORDS

Delphi survey; consensus; nursing; shift; nursing handover; standard; patient transfers; peripheral hospital

Introduction

Health care is complex. The processes necessary for communicating health care information are a continuous challenge for health care professionals and health care institutions. Deficient communication processes create the potential for errors when caregivers fail to transfer complete, consistent information [1]. Clinical handovers are practiced every day, in many ways, in all institutional health care settings [2,3]. The clinical handover of patients, according to the Australian Council for Safety and Quality in Health Care's 2005 clinical handover report [4], concerns and is defined as follows: *the transfer of professional responsibility and accountability for some or all aspects of care for a patient, or group of patients, to another person or professional group on a temporary or permanent basis*.

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The literature distinguishes three basic types of good practice in nursing handover: bedside, verbal, and nonverbal. Handovers at the bedside promote face-to-face interaction between patients and nurses and encourage patients to participate verbally, thus putting them at the center of the information exchange process [5,6]. Verbal communication usually takes place in an office setting, where the nurse responsible for a group of patients describes relevant documented information and perhaps gives their professional opinion. Nonverbal communication also usually takes place in an office setting, where nurses inform themselves by reading patients' health records, including progress notes, medication charts, observation charts, and nursing care plans. Finally, recorded communication can also be used in an office setting if the nurse in charge makes a recording describing the relevant information so that the oncoming shift can listen to it at a convenient time.

Deficient or absent clinical handovers, or failures to transfer information, responsibility, and accountability, can have severe consequences for hospitalized patients [7]. They have been shown to result in delays to diagnosis, treatment, and care; tests being missed or duplicated; and subsequent incorrect operationalization of care plans or drug follow-up [8].

More than a decade ago, the World Health Organization (WHO) collaborating centers on patient safety strongly recommended that their members improve communication during patient handovers by declaring the following: "Ensure that health-care organizations implement a standardized approach to handover communication between staff, change of shift and between different patient care units in the course of a patient transfer" [9]. Unfortunately, the world's countries were not universally proactive in addressing this recommendation and implementing structured, evidence-based handovers to improve patient safety and the continuity of care. Countries such as Australia, Belgium, China, Spain, the United Kingdom of Great Britain and Northern Ireland, the United States, and the Netherlands developed national and regional standards for nursing and interprofessional handovers [4,10-16]. Despite a recent systematic review by Bukoh and Siah, which demonstrated that structured handovers reduced incidences of patient complications, medication errors, and general adverse events, none of the handover standards examined had been designed using a robust evidence-based methodology. As a consequence of this lack of strong evidence, countries and health care institutions naturally hesitate to adopt standardized handovers. To the best of our knowledge, there are currently no national, regional, or local evidenced-based nursing handover standards in use in Switzerland [17]. Although some Swiss university hospitals are working hard to implement more structured nursing handover systems, no national policy is available as yet. This research is a first step toward the development of a more widespread nursing standard of evidence-based handover communication. It will support the nursing experts who are declaring that patient safety will be improved by the implementation of care delivery systems that effectively structure handover communication [8].

Nursing handover practices in our multisite hospital in Switzerland were highly variable, sometimes unreliable, and differed across medical specialties. This led to inconsistencies in the content and accuracy of handover information. Preceding studies have revealed multiple barriers to communication within health care organizations, including hierarchy, gender, ethnic background, primary health care education, and different communication styles [18,19]. Inconsistencies in communication may cause substantial risks to patient safety and care [20]. Other health care institutions have recently tried to uncover the specific risks and contributing factors to difficulties in handover communications [21]. In 2017, an internal survey of health care professionals at a multisite public hospital in Switzerland, concerning its culture of patient care safety, revealed that almost two-thirds of them (ie, nurses, physicians, and allied health care professionals) considered the quality of information transmission to be deficient and a risk to the safety of their patients [22]. Intervention studies have shown that information is poorly preserved if verbal or handwritten handovers are transferred across multiple shifts [23], rather like a game of broken telephone.

Validated causes at the root of handover communication failures include institutional cultures that fail to promote effective handovers (eg, lack of teamwork and respect); the different expectations of information givers and receivers; inadequate methods of communication, whether verbal, recorded, bedside, or written; ill-timed or badly coordinated physical transfers and patient handovers; interruptions to, or the lack of time allocated to, successful handovers; nonstandardized handover procedures; insufficient staff to ensure effective handovers at pertinent times of the day or week; and a lack of participation by patients during their handovers [24-26].

The web-based, modified, electronic Delphi (e-Delphi) survey presented here developed standardized solutions to these risks and then developed and implemented factors to improve the effectiveness of communication during transitions of care [27]. It has been proposed that efforts to standardize the content and processes of patient handovers (eg, shift reports) ensure consistency in the exchange of vital information and effectively improve communication and, thus, patient safety [28,29]. Despite few details about what the precise contents of any handover communication should be, standardizing processes (eg, describing the patient) could be a starting point for choosing the contents (eg, patient name, age, and current condition). To ensure that information transfer in complex care environments is safe and effective, specific information about each process should form a part of any two-way communication [30]. There is little empirical evidence in the current literature of any link between patient safety and the effective transfer of information during handovers [31].

We used the Delphi survey method as our framework for a handover content–selection process based on the results of several rounds of questionnaires sent to a selected panel of nurse experts [32]. This approach, according to Tong et al [33] and the World Medical Association [34], used the following: *structured anonymous communication between experts to gather consensus perspectives about an issue or topics that can then be used to inform decision making or to agree about methods of functioning*.

An e-Delphi study involves a number of rounds of web-based questionnaires in which experts are requested to provide their

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opinions on precise topics [35]. They do so independently, but after the first round, they are aware of the other participants' aggregated opinions when making their second-round decisions. The goal is to reach a consensus. The e-Delphi method's key features are iteration and anonymity, which were found to be particularly advantageous for a multisite hospital dealing with several medical specialties. The anonymous, web-based format encourages participation and honest opinion sharing by large numbers of panel members and prevents senior or influential individuals from monopolizing or influencing discussions. This is important in the hierarchical environment of a health care institution.

The higher the number of handovers, the more significant risks patients face, although little is known about the exact mechanisms by which handovers destabilize care. Information management at nursing shift changes has been highlighted as being particularly prone to mistakes [23,31]. The general themes involved in clinical nursing handover standards are affected by a range of factors that combine to define how smooth and safe they are for patients [26,36]. A nursing handover is a vital element in the continuity of care [37]. Transitions in care are notable periods of vulnerability in a patients' treatment journey [38]. Transferring responsibility for a patient's care to another health care professional increases the chances of an error occurring, especially if key information is communicated inaccurately and inefficiently [39]. Any inaccurate, unclear, or incomplete transfer of information increases the risks of potentially severe errors [40,41].

This study aimed to use a modified e-Delphi survey to design an evidence-based, nursing handover standard for inpatients for use at shift changes or internal transfers between the hospital wards of a multisite public hospital in Switzerland.

Methods

Design

Overview

Study design was based on a previously published protocol [42] describing the use of a multiround survey of a targeted panel sample of 264,300 nurse experts to build a consensus for the contents of an evidence-based nursing handover standard. A rounds-step Delphi technique documented by Keeney and al [30], Burchell and al [43], Slade and al [44], and Cole et al [31] was used for this study. Formal reporting on the qualitative data from responses to open questions and on the focus group was based on a checklist of the most common methods of data collection in qualitative health care research [33].

Comprehensive Scoping Review to Design the Components of a Web-Based Modified E-Delphi Survey

A comprehensive scoping review of the literature was made to find the components of effective, evidence-based, clinical nursing handovers. Predefined terms were used to search for published articles in the following electronic databases, from inception until September 30, 2018: MEDLINE (Medical Literature Analysis and Retrieval System Online) via PubMed (from 1946), Embase (from 1947), CINAHL (Cumulative Index to Nursing and Allied Health Literature) (from 1937), Web of Science (from 1900), ScienceDirect, and Wiley. The bibliographies of all relevant articles were hand-searched, and Google Scholar was used to search for unpublished studies.

Data Collection Process

Data collection was preceded by a comprehensive, systematic scoping review of the components of an evidence-based clinical nursing handover standard. This enabled us to draw up a list of potential handover items to be decided on using a web-based, modified e-Delphi survey. Data collection began in mid-September 2018 and ended in mid-December 2018.

Setting and Population

The study was conducted at a multisite public hospital that recorded over 40,000 individual hospitalizations in 2018; it is composed of two hospital centers in two linguistically and culturally different regions of a single Swiss canton [20]. Each hospital center has standard medical hospitalization wards to fulfil its mission of providing general public health care; however, the more complex medical specialties are only present at the French-speaking hospital center. The French-speaking hospital center has 39 acute care and eight psychiatric wards, with 1134 full-time-equivalent health care professionals. The German-speaking hospital center has 15 acute care and three psychiatric wards, with 390 full-time-equivalent health care professionals. Each acute care ward has a triad of nurse experts: a registered nurse clinical-educator, a student-success coach, and a nurse supervisor. Each hospital center's nursing managers and departmental supervisors supported and encouraged eligible staff to participate actively in the data collection process. We aimed for a targeted anonymized panel of nurse experts from both the French-speaking and German-speaking hospital centers.

Knowledge Synthesis for the Selection of Items for the Nursing Handover Standard

Investigators examined the review's findings at two item-selection meetings and chose the potentially relevant components of an evidence-based nursing handover standard to be included in the e-Delphi panel survey. Textbox 1 presents the main potential components. The questionnaire was made available in French and German; it was trialed with four clinical experts not involved in the study, who were asked to assess items for clarity, wording, and understandability.

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Textbox 1. Relevant components of an evidence-based nursing handover standard for inclusion in the electronic Delphi (e-Delphi) survey.

Culture and attitude for good handover practices:

- Respectful and collaborative attitude
- Proactive listening
- Positive, factual language adapted to patients, situations, and professionals
- Confidentiality
- The handover environment

Handover preparation, including coordination and sources of information:

- Clinical assessment before the handover
- Use different sources of information
- Updated patient records
- Reconsider and reanalyze information

Handover phases, including communication of patient-specific information:

- Mnemonic techniques to guide communication and format content chronologically
- Face-to-face handovers with the opportunity to ask questions
- Information technology to support data access to the patient's complete history and health status
- Patient records ensuring the traceability of decisions and follow-up
- Information technology to support data updates
- Flexible information technology to support adaptations for each specialized ward
- Handovers at the patient's bedside at the risk of reduced confidentiality
- Handovers at the patient's bedside for understanding their values and preferences

A minimum dataset should be transmitted:

- Summary of the patient's hospitalization history and care planning
- Assessment of the disease
- Prognosis of health status
- Allergies
- Reanimation status
- Medication treatment
- Laboratory results
- Vital signs
- Patient's activities and planned examinations

Eligibility of Nurse Experts

In collaboration with each center's director of nursing, investigators invited eligible, professionally active nurse experts from the general medicine, surgery, geriatrics and rehabilitation, intensive care, emergency, maternity and gynecology, and psychiatric wards to join our panel and express their opinions.

The eligible sample population was composed of 264 nurse experts. They were all highly qualified, very experienced, and recognized as such within their departments.

Inclusion criteria were as follows: (1) to have worked in their current specialty for at least three months before the start of the data collection process; (2) to have been employed as a registered nurse clinical-educator, student-success coach, or nurse supervisor with recognized knowledge and expertise in their field; and (3) to have the willingness and time to participate and the capacity to understand and give an opinion on clinical statements. In agreement with the two hospital centers' directors, all eligible nurse experts were invited to participate in the e-Delphi survey. Figure 1 presents the recruitment process.

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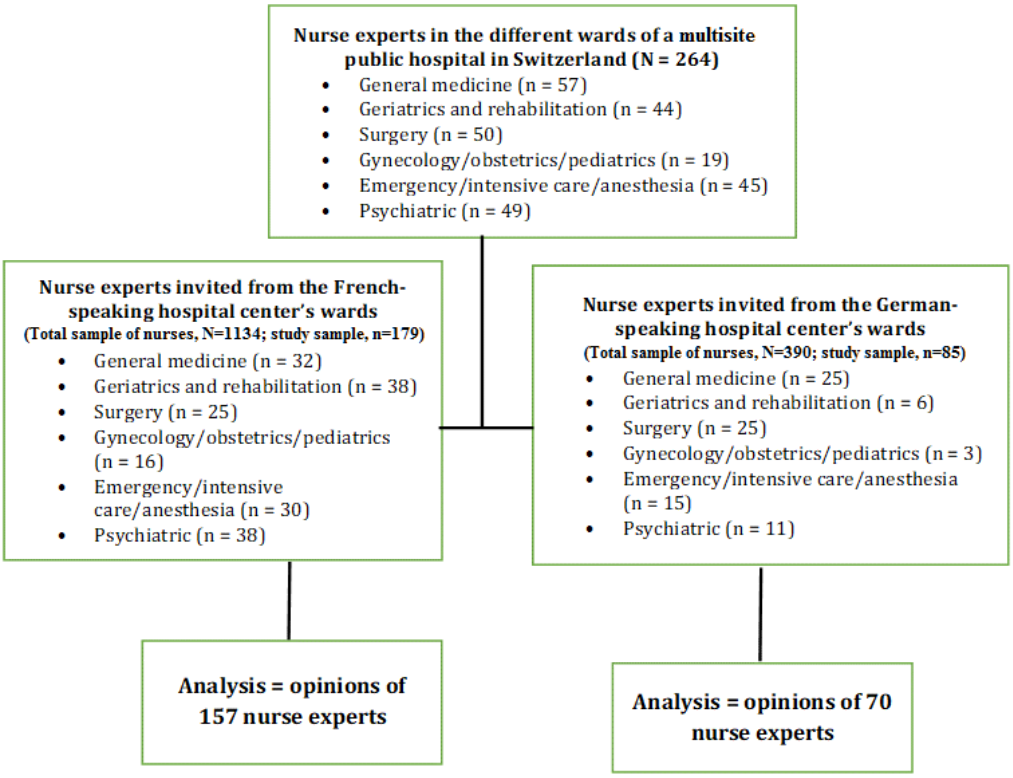
Figure 1. Selection of panels of all nurse experts from the hospital centers in the French- and German-speaking regions.



Survey Administration

The Human Research Ethics Committee of the Canton Vaud (CER-VD) (2019-00925) approved the study, participants' anonymity was ensured, and the standards of good research practice mentioned in the Declaration of Helsinki were respected [34]. The directors of both hospital centers approved the study [45]. Each round of the e-Delphi survey was transmitted using SurveyMonkey, a secure, commercial, web-based platform that ensures anonymous survey participation. Data were stored in Switzerland, protected using high-security firewalls, and treated confidentially. All eligible nurse experts were sent a personalized link to each round of the survey. Although a personalized link was used to access the survey, and sociodemographic and professional characteristics were stored, names and contact details were removed from the completed survey. Survey items had to reach a predetermined 70% rate of consensus for inclusion in the standard [30].

The E-Delphi Process

The modified e-Delphi data collection process was composed of three rounds. In round 1, potential nurse-expert panelists received an email asking them to give their opinions on 26 items in a structured questionnaire (see Figure 2). A cover letter described the study's aims, gave instructions on how to fill in the questionnaire, and provided assurances that participants' anonymity would be guaranteed. Filling in the online questionnaire was considered as a proxy for the nurse experts giving their written informed consent to participate. The survey used a 5-point Likert scale, ranging from *Strongly agree* (scoring 5) to *Strongly disagree* (scoring 1), to describe participants' opinions on whether items should be included in the evidence-based clinical nursing handover standard. A final, open-ended question asked, "What topic, not yet mentioned in these statements, should also be integrated into the handover standard?"

Respondents explained their choices or suggested items not listed in the first round, but which they believed were important. Two email reminders were sent out to nonresponders 1 and 2 weeks after launching the e-Delphi process. Round 1 closed after 30 days, and all the returned data were analyzed.

Round 2 was transmitted along with a second instructional cover letter asking participants to give their opinions on the 11 new items suggested by their peers via round 1's open question. Two email reminders were sent out to nonresponders 1 and 2 weeks after the start of round 2. Round 2 closed after 30 days, and all the returned data were analyzed.

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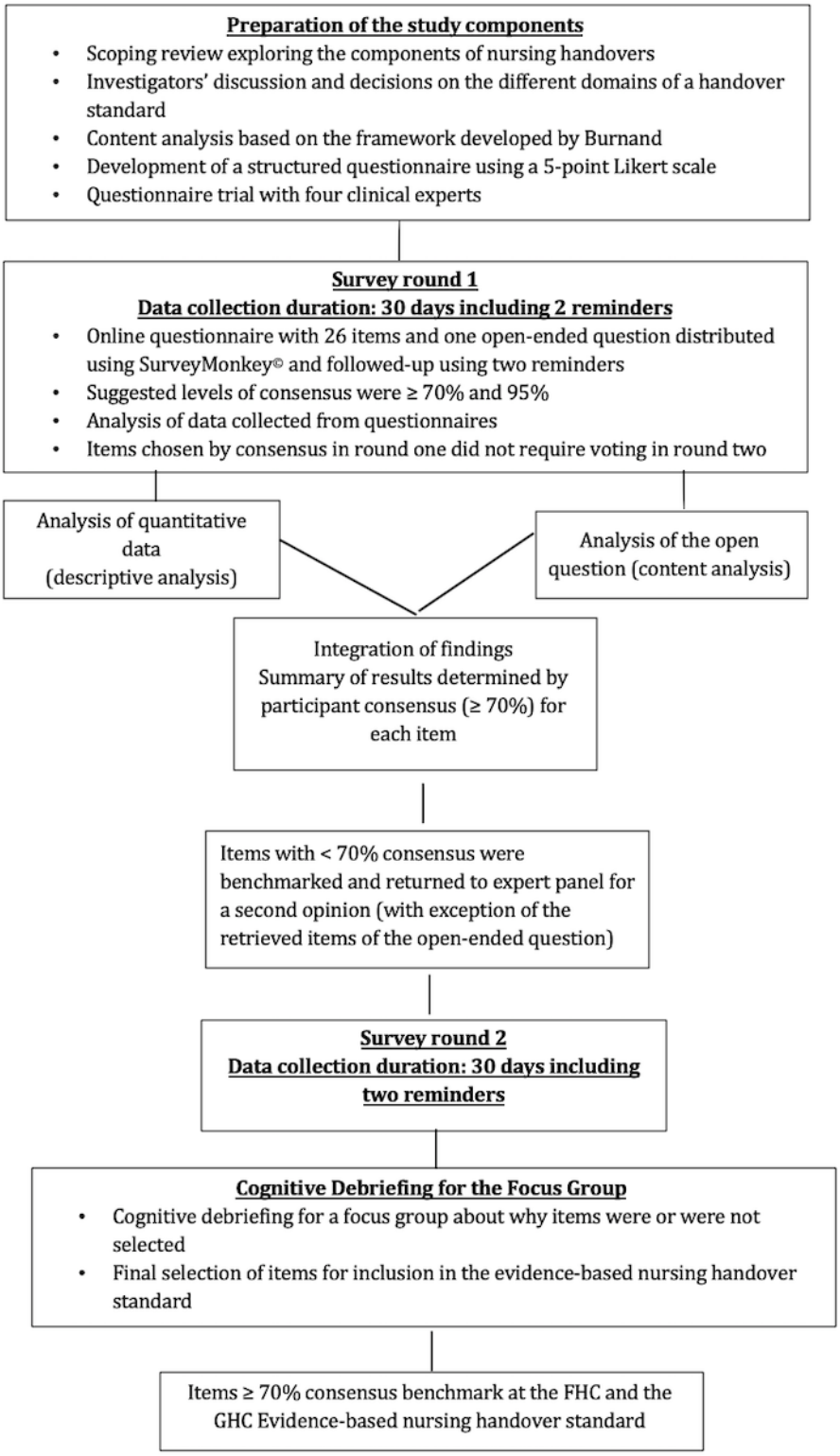
Figure 2. E-Delphi survey data collection process for designing an evidence-based nursing handover standard. FHC: French-speaking hospital center; GHC: German-speaking hospital center.



Cognitive Debriefing of the Focus Group

The study's third part was a cognitive debriefing. Patrick et al outlined how a cognitive debriefing process is structured around, and usually focused upon, the assessment of a specific clinical output; it should incorporate direct questions about participants' understandings of the measures leading to that output, as well as their relevance and comprehensiveness [46]. The cognitive debriefing's primary aim was to collect data from a focus group of volunteer participants who discussed and explained the findings and validated the consensus items to be used in the handover standard. A secondary aim was to better understand why some items had not reached the required level of consensus and to explore influencing factors.

Focus group participants were selected using a purposive sampling strategy aiming to represent different nursing roles,

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at different hierarchical levels, and in different languages at our multisite public hospital. They included registered nurses, nurse supervisors, registered nurse clinical-educators, student-success coaches, the directors of nursing from the French-speaking and German-speaking hospital centers, the nursing quality and risk manager, the nurse manager for electronic patient records, and lecturers in nursing sciences from the University of Applied Sciences in Nursing as facilitators. All the participants were directly involved in the implementation of evidence-based nursing handover standards in their respective environments. Cognitive debriefings have been documented as good research practice for gaining a better understanding of participants' agreements and disagreements about survey item statements [47].

The cognitive debriefing took place in December 2018 in an appropriate seminar room of our multisite public hospital's central administrative area. The room was large enough to enable all the participants to sit in a circle, ensuring visibility for everyone. All the participants had received prior verbal and written information about the session's aims, the data collection procedure, the focus group's principles, and the use that would be made of the data. Participants gave their written informed consent for the cognitive debriefing to be audio recorded for transcription. Participants received the results for the items voted on in the two-round survey. The cognitive debriefing was conducted by a moderator presenting item by item, accompanied by an observer, who began with the question, "Could you explain or hypothesize why a consensus was reached on some items but not others?"; this was used as a reminder throughout the debriefing to keep the participants focused. Figure 2 gives a schematic representation of the e-Delphi data collection process.

Data Analysis

The sociodemographic characteristics of the entire nurse-expert panel were also retrieved using SurveyMonkey, including age and years of experience in their professional role. All the items were available in French and German. Data were extracted onto a Microsoft Excel spreadsheet and subsequently imported into SPSS, version 25.0, statistical software (IBM Corp) [48].

The data collection process involved three rounds. Round 1 closed after 30 days, and the collected data were analyzed. Each item was described using descriptive statistics, such as frequency, distribution, mean (SD), and median (IQR-75). An appropriate exact test was used to compare means and percentages. A consensus agreement was defined using dichotomized *yes*/*no* answers for each item's statement, with *Strongly disagree*, *Partially disagree*, and *No opinion* recoded as *no* answers for that item, and *Partially agree* and *Strongly agree* recoded as *yes* answers. Round 2 was composed of the statements for which no consensus had been reached in round 1, plus additional statements that had arisen from the panel's suggestions in response to the open-ended question. Round 2 ended after a further 30 days, and the returned data were analyzed as mentioned previously.

The level of consensus chosen for accepting an item was set at ≥70% of *yes* answers. Questionnaires returned with more than 20% of their items unanswered were excluded from the analysis.

The third and final round involved the cognitive debriefing of a focus group made up of 15 randomly selected but highly motivated nursing experts. Qualitative data collected during the focus group were transcribed and analyzed using deductive thematic content analysis [49,50] in NVivo 12 software (QSR International) [51]. Transcripts were read, themes and subthemes emerging from the data were coded, and an analysis map was drawn to manage them. The coauthors approved this analytical process, and disagreements were resolved via discussion.

Results

Scoping Review

The systematic scoping review of the literature enabled the investigators to prepare 22 item statements that were classified into three domains of an evidence-based nursing handover standard: the handover environment, the handover preparation phase, and the handover phase itself. The overall handover process should have a structure, defined content for information or communication, be supported by information technology (IT) and electronic patient records, specify the type of handover, and include any pertinent education or training information (not treated in this study). Four extra items, not drawn from the scoping review, were integrated into the questionnaire; these related to the principles of collaborative practice considered in the charter of good practices in interprofessional health care collaboration, as edited by the Swiss Academy of Medical Sciences [52].

Response Rate

From the maximum potential eligible sample (N=264) of invited nurse experts, 245 returned their round 1 questionnaires (an excellent response rate of 92.8%), and 227 met the requirements for analysis (valid response rate of 86.0%). The round 1 response rates for the French-speaking and German-speaking hospital centers were 87.7% (157/179) and 82% (70/85), respectively. In round 2, 201 participants completed the study and met its requirements (valid response rate of 76.1%), with the response rates for the French-speaking and German-speaking hospital centers being 75.4% (135/179) and 78% (66/85), respectively.

Nurse Experts' Sociodemographic and Professional Characteristics

Most nurse experts were female (176/216, 81.5%), trained in clinical nursing, and working as registered nurse clinical-educators, student-success coaches, and nurse supervisors. The average respondent was 41.0 years old (SD 9.6) with a mean of almost 18 years of professional experience (SD 9.5). Two-thirds of invited nurse experts were working in the surgery and general medicine wards (see Table 1).

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Table 1. Participants' sociodemographic and professional characteristics.

Sociodemographic and professional characteristics	French-speaking region's hospital center (n=157)	German-speaking region's hospital center (n=70)	Multisite public hospital in Switzerland (N=227)
Sex[a], n (%)			
Men	32 (21.5)	8 (12)	40 (18.5)
Women	117 (78.5)	59 (88)	176 (81.5)
Age (years)			
Mean (SD)	42.0 (9.6)	38.9 (9.2)	41.0 (9.6)
Median	42	40	41
Min-max	27-60	26-61	26-61
Nurse expert's profession[b], n (%)			
Student-success coach	43 (30.5)	13 (19)	56 (26.9)
Registered nurse clinical-educator	47 (33.3)	25 (37)	72 (34.6)
Nurse supervisor	33 (23.4)	19 (28)	52 (25.0)
Other[c]	18 (12.8)	10 (15)	28 (13.5)
Years of experience			
Mean (SD)	18.4 (9.2)	16.2 (9.9)	17.7 (9.5)
Median	17.5	15	17
Min-max	4-42	4-40	4-42

[a]Number of respondents for this question was n=149 (French), n=67 (German), and n=216 (total).

[b]Number of respondents for this question was n=141 (French), n=67 (German), and n=208 (total).

[c]Professionals holding the official role of ward expert and educated to the level of Registered Nurse or Bachelor of Nursing Science.

First-Round Participants and Findings

Participants

Participants were registered nurse clinical-educators (72/208, 34.6%), student-success coaches (56/208, 26.9%), and nurse supervisors (52/208, 25.0%); 13.5% (28/208) were registered nurses or held a Bachelor of Nursing Science degree without postgraduate training. Table 1 presents the characteristics of participants in the French-speaking and German-speaking hospital centers.

Findings

Nurse experts had a high rate of agreement with regard to most of the items. However, the French-speaking hospital center's nurse experts did not reach a round 1 consensus of ≥70% on the following items: *Information technology support flexibility allows adaptability for each specialized unit*, *Handovers at the patient's bedside enable a better understanding of patient values and preferences*, *Handovers at the patient's bedside risk compromising confidentiality of patient health and nursing data*, *Provide a list of medication*, and *Present laboratory results*.

The German-speaking hospital center's nurse experts failed to find a round 1 consensus of ≥70% on two items, namely, *A mnemonic technique guiding patient transfer in a chronological way* and *Present laboratory results*.

Figures 3 and 4 present the participant ratings for the 26 statements by French-speaking and German-speaking hospital centers, respectively.

Table 2 presents the mean item scores and distributions of consensus agreement on the item statements submitted to the panel of nurse experts with the lead question, "To what extent do you agree that the following items should be an integral part of handovers?" Consensus required ≥70% agreement with the statement, taken as the sum of the *yes* Likert-scale options *Strongly agree* and *Partially agree*. The mean (SD) and median (IQR-75) was calculated for each item.

The open question enabled each respondent to propose supplementary items, not mentioned in round 1, for integration and submission to the panel of nurse experts in round 2. In round 2, the German-speaking hospital center failed to submit new topics proposed by the French-speaking hospital center to its staff, resulting in some heterogeneity in the choice of round 2 items (see Table 3).

Respondents from both the French-speaking and German-speaking hospital centers proposed second-round items to do with the patient's identity, their social context (eg, living alone or with relatives), their expectations and those of their families or relatives, and discharge planning. Additionally, respondents from the French-speaking hospital center suggested the following round 2 items: (1) handover duration should be chosen by the wards involved, (2) time of day should be chosen by the wards involved, (3) conditions of hospitalization (eg, elective or emergency and whether the patient was sectioned), (4) advanced health care directives, and (5) any identified clinical risks during hospitalization. Respondents from the

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German-speaking hospital center proposed adding a second-round item on the risks of transmitting infection.

Figure 3. Distribution of round 1 opinions on nursing handover items given by the panel of nurse experts from the French-speaking region's hospital center (n=179). The numbers of participants who rated each item according to the legend options are indicated within the respective colored portions of each bar. The 26 items, within their respective categories, are listed here. Good handover practices are carried out in a collaborative spirit: 1. Adopt a respectful and collaborative attitude; 2. Adopt proactive listening; 3. Use positive, factual language adapted to patients, situations, and professionals; 4. Respect confidentiality; and 5. Conduct the handover in a calm and quiet environment to prevent interruptions. The preparatory phase for handover includes the coordination of activities to gather the different sources of information to be communicated: 6. Make a clinical assessment before the handover; 7. Regroup different sources of information; 8. Update patient records; and 9. Reconsider and reanalyze information. The handover phase itself should include the communication of all patient-specific information: 10. Use a mnemonic technique to guide communication and format content chronologically; 11. Face-to-face handovers give nurses the opportunity to ask questions; 12. Information technology (IT) should support data access to patient's complete history and health status; 13. Patient records should allow the traceability of decisions and follow-up; 14. IT should support data updates; 15. Flexible IT support should allow for adaptability for each specialized unit; 16. Handovers at the patient's bedside risk breaching confidentiality; and 17. Handovers at the patient's bedside enable a better understanding of their values and preferences. A minimum dataset should be transmitted: 18. Provide a summary of patient's hospitalization history and care planning; 19. Provide an assessment of the disease, including severity; 20. Present a prognosis of health status; 21. Provide a list of allergies; 22. Present a reanimation status; 23. Provide a list of medication; 24. Present laboratory results; 25. Update vital signs; and 26. Provide a list of all patient activities.

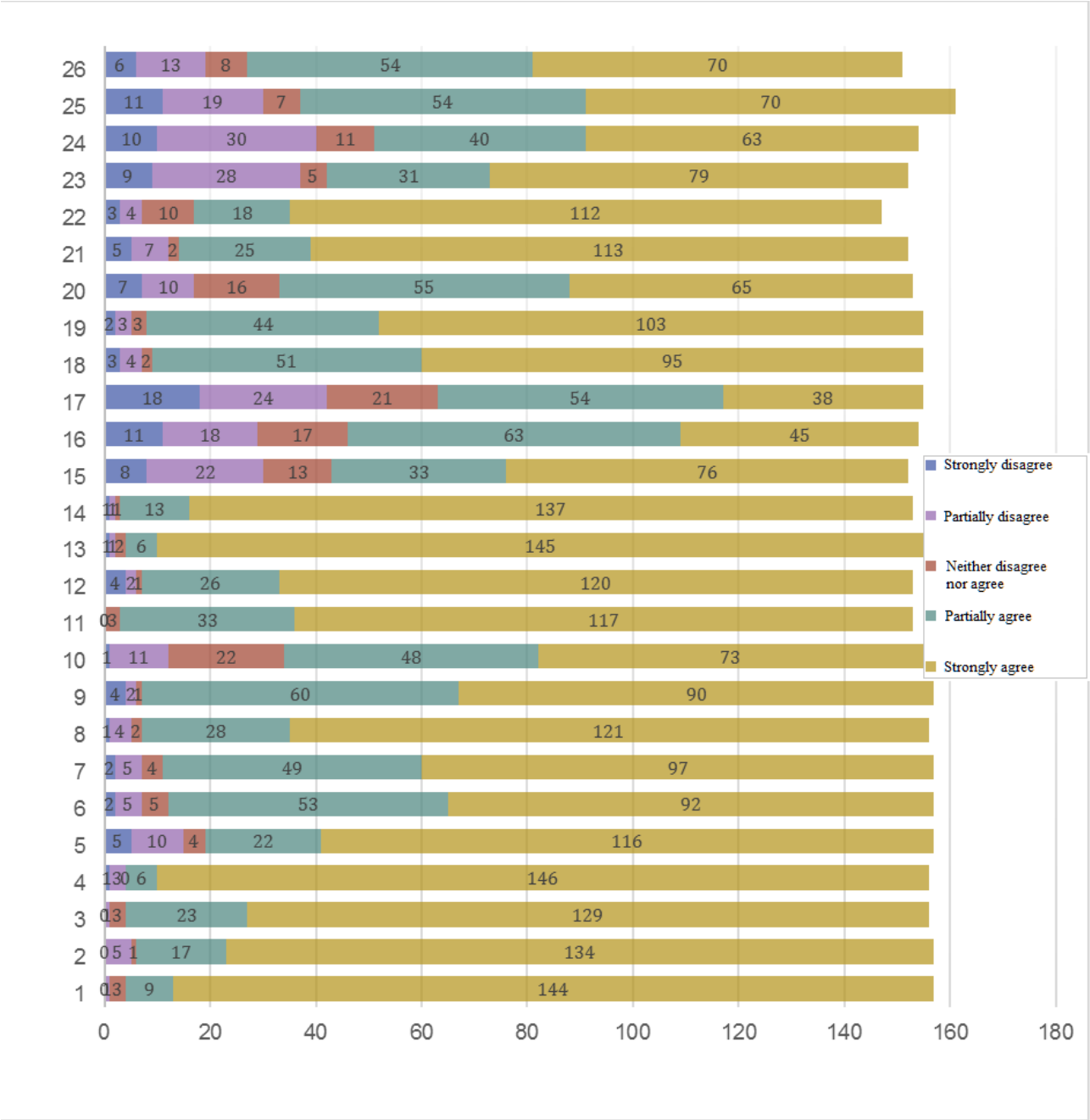

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Figure 4. Distribution of round 1 opinions on nursing handover items given by the panel of nurse experts from the German-speaking region's hospital center (n=85). The numbers of participants who rated each item according to the legend options are indicated within the respective colored portions of each bar. The 26 items, within their respective categories, are listed here. Good handover practices are carried out in a collaborative spirit: 1. Adopt a respectful and collaborative attitude; 2. Adopt proactive listening; 3. Use positive, factual language adapted to patients, situations, and professionals; 4. Respect confidentiality; and 5. Conduct the handover in a calm and quiet environment to prevent interruptions. The preparatory phase for handover includes the coordination of activities to gather the different sources of information to be communicated: 6. Make a clinical assessment before the handover; 7. Regroup different sources of information; 8. Update patient records; and 9. Reconsider and reanalyze information. The handover phase itself should include the communication of all patient-specific information: 10. Use a mnemonic technique to guide communication and format content chronologically; 11. Face-to-face handovers give nurses the opportunity to ask questions; 12. Information technology (IT) should support data access to patient's complete history and health status; 13. Patient records should allow the traceability of decisions and follow-up; 14. IT should support data updates; 15. Flexible IT support should allow for adaptability for each specialized unit; 16. Handovers at the patient's bedside risk breaching confidentiality; and 17. Handovers at the patient's bedside enable a better understanding of their values and preferences. A minimum dataset should be transmitted: 18. Provide a summary of patient's hospitalization history and care planning; 19. Provide an assessment of the disease, including severity; 20. Present a prognosis of health status; 21. Provide a list of allergies; 22. Present a reanimation status; 23. Provide a list of medication; 24. Present laboratory results; 25. Update vital signs; and 26. Provide a list of all patient activities.

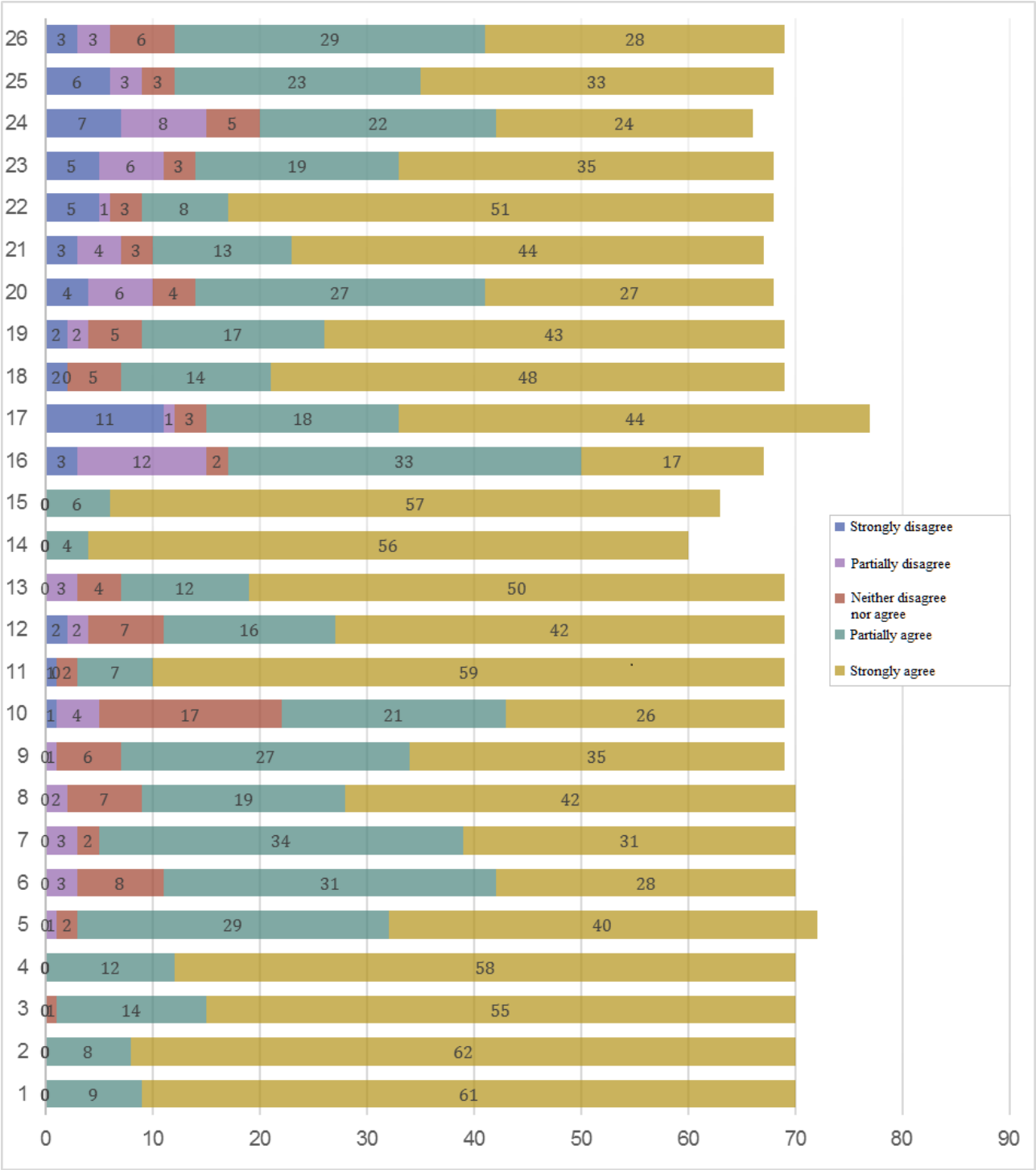

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Table 2. Analysis of the survey statement scores from the French-speaking and German-speaking hospital centers.

Statements and their categories	French-speaking hospital center (n=157)			German-speaking hospital center (n=70)		
	Mean (SD)[a]	Median (IQR-75)	Consensus, %	Mean (SD)	Median (IQR-75)	Consensus, %
Good handovers are carried out in a spirit of cooperation						
1. Adopt a respectful and cooperative attitude	4.9 (0.4)	5 (5)	97.5	4.8 (0.3)	5 (5)	100
2. Adopt proactive listening	4.8 (0.6)	5 (5)	96.2	4.9 (0.3)	5 (5)	100
3. Use positive, factual language adapted to patients, situations, and professionals	4.8 (0.6)	5 (5)	96.8	4.7 (0.4)	5 (5)	98.6
4. Respect confidentiality	4.9 (0.6)	5 (5)	96.8	4.8 (0.4)	5 (5)	100
5. Conduct the handover in a calm, quiet environment to prevent interruptions	4.5 (1.0)	5 (4)	87.9	4.5 (0.5)	5 (5)	98.6
The preparatory phase for handover includes the coordination of activities to gather the different sources of the information to be communicated						
6. Make a clinical assessment before handover	4.4 (0.8)	5 (4)	92.4	4.0 (0.8)	4 (4)	84.3
7. Gather different sources of information	4.5 (0.8)	5 (5)	93.0	4.3 (0.7)	4 (4)	92.9
8. Update patient records	4.6 (0.7)	5 (5)	95.0	4.4 (0.8)	5 (4)	87.1
9. Reconsider and reanalyze information	4.4 (0.7)	5 (4)	95.5	4.4 (0.8)	5 (4)	88.6
The information transmission phase should include the communication of all patient-specific information						
10. Use a mnemonic technique to guide communication and format content chronologically	4.4 (1.1)	5 (4)	77.1	4.0 (1.1)	4 (4)	67.1[b]
11. Use face-to-face handovers, which give nurses the opportunity to ask questions	4.8 (0.8)	5 (5)	95.5	4.8 (0.8)	5 (5)	94.3
12. Information technology should support access to data on the patient's complete history and health status	4.7 (1.0)	5 (5)	93.0	4.4 (1.1)	5 (4)	82.9
13. Patient records should enable the traceability of decisions and follow-up	4.9 (0.6)	5 (5)	96.2	4.6 (0.9)	5 (5)	88.6
14. Information technology should support data updates	4.9 (0.8)	5 (5)	95.5	5.0 (1.2)	5 (5)	85.7
15. Flexible information technology support should allow for adaptability by each specialized unit	4.1 (1.5)	5 (4)	69.0[b]	4.9 (1.0)	5 (5)	90.0
16. Handovers at the patient's bedside risk breaching confidentiality	3.8 (1.3)	4 (4)	68.8[b]	4.0 (1.5)	4 (4)	71.4
17. Handovers at the patient's bedside enable a better understanding of their values and preferences	3.5 (1.4)	4 (4)	58.6[b]	4.7 (1.1)	4 (5)	88.6
A minimum dataset should be transmitted						
18. Provide a summary of the patient's hospitalization history and care plans	4.5 (0.9)	5 (4)	93.0	4.6 (1.0)	5 (5)	88.6
19. Provide an assessment of the disease, including severity	4.6 (0.9)	5 (5)	93.6	4.4 (1.1)	5 (4)	85.7
20. Present a prognosis of health status	4.1 (1.3)	4 (4)	76.4	4.3 (1.4)	5 (4)	77.1
21. Provide a list of allergies	4.6 (1.2)	5 (5)	87.9	4.5 (1.4)	5 (5)	81.4
22. Present the patient's reanimation status	4.8 (1.3)	5 (5)	82.8	4.6 (1.3)	5 (5)	84.3
23. Provide a list of medication	4.1 (1.6)	5 (4)	69.0[b]	4.2 (1.5)	5 (4)	77.1
24. Present laboratory results	3.8 (1.5)	4 (4)	65.6[b]	4.0 (1.8)	4 (4)	65.7[b]
25. Provide an update on vital signs	4.2 (1.5)	4 (4)	73.2	4.2 (1.4)	4.5 (4)	80.0
26. Provide a list of all patient activities	4.3 (1.4)	4 (4)	79.0	4.1 (1.1)	4 (4)	81.4

[a]The survey used a 5-point Likert scale, ranging from *Strongly agree* (scoring 5) to *Strongly disagree* (scoring 1), to describe participants' opinions on whether items should be included in the evidence-based clinical nursing handover standard.

[b]Nonconsensus: <70% of the nurse experts accepted the item as a necessary, evidence-based, nursing standard for patient handovers.

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Table 3. Analysis of scores of survey statements failing to reach consensus and items suggested from the open question from the French-speaking and German-speaking hospital centers.

Items from open question and their categories	French-speaking hospital center (n=135)			German-speaking hospital center (n=66)		
	Mean (SD)[a]	Median (IQR-75)	Consensus, %	Mean (SD)[a]	Median (IQR-75)	Consensus, %
Resubmitted item[b]						
28. Handovers at the patient's bedside ensure continuity, quality, and safety of care	3.4 (1.3)	4 (3)	62.2[c]	4.3 (0.8)	4 (4)	71.4
A minimum dataset should be transmitted (complement by expert, round 1)						
29. Identify the patient	4.8 (0.5)	5 (5)	95.6	4.0 (1.2)	5 (4)	78.8
30. Present the patient's social context	4.4 (0.8)	5 (4)	89.6	3.5 (1.2)	4 (4)	71.2
31. Present the patient's expectations	4.4 (0.8)	5 (4)	89.6	3.8 (1.2)	4 (4)	73.8
32. Present the patient's discharge plan	4.6 (0.6)	5 (5)	94.1	4.4 (0.8)	5 (4)	90.9
33. Risk of transmitting infections[d]	N/A[e]	N/A	N/A	4.2 (1.2)	4 (4)	83.1
36. State of hospitalization[f]	4.2 (1.1)	5 (4)	80.7	N/A	N/A	N/A
37. Advanced care directives[f]	4.4 (1.1)	5 (4)	87.4	N/A	N/A	N/A
38. Present identified clinical risks[f]	4.6 (0.8)	5 (5)	92.6	N/A	N/A	N/A
The organization provides the right framework for transfer situations and handovers (complement by expert, round 1)						
35. Decide on the time of day for handover to ensure continuity of care[f]	4.5 (0.9)	5 (5)	91.1	N/A	N/A	N/A
34. Define the time required for handover, depending on the situation[f]	4.1 (0.9)	4 (4)	83.0	N/A	N/A	N/A

[a]The survey used a 5-point Likert scale, ranging from *Strongly agree* (scoring 5) to *Strongly disagree* (scoring 1), to describe participants' opinions on whether items should be included in the evidence-based clinical nursing handover standard.

>[b]Handovers at the patient's bedside ensure continuity, quality, and safety of care was the only resubmitted item that failed to reach the consensus level of agreement of ≥70% from the French-speaking hospital center's nurse experts.

[c]Nonconsensus: <70% of the nurse experts accepted the item as a necessary, evidence-based, nursing standard for patient handovers.

[d]For the French-speaking hospital center, the Risks of transmitting infections was integrated into item 38, Present identified clinical risks.

[e]N/A: not applicable.

[f]The German-speaking hospital center's organizers, investigators, or management failed to transmit the suggestions in round 1's open question made by the French-speaking hospital center.

Second-Round Participants and Findings

Participants

As already mentioned, not all of the additional topics proposed in answer to the open question were submitted to participants at both hospital centers. Second-round respondents had all participated in the first round, and the second-round response rate was 76.1% of all the originally invited participants (201/264). Second-round sociodemographic and professional characteristics were similar to those of the first round (see Table 1).

Findings

Table 3 presents the mean second-round item scores for respondents in the two hospital centers. As already mentioned, round 2's list was composed of the items that failed to reach the overall consensus level in round 1 as well as items suggested in round 1's open question (ie, question 27) , but the German-speaking hospital center's organizers, investigators, or management failed to transmit the suggestions made by the French-speaking hospital center.

Cognitive Debriefing Using a Focus Group

The cognitive debriefing was done with a focus group composed of a purposive sample of participants chosen to discuss the study's findings.

Participants and Duration

Of 18 nurse experts invited to participate in the focus group, 15 (83%) attended the session, including 4 men (27%) and 11 women (73%). The session, including the introduction and conclusion, lasted 60 minutes.

Findings

Survey Perceptions

The nurse experts gave the survey an encouraging response overall, expressing positive expectations for the study's final goal and their willingness to create safe, standardized, evidence-based, communication practices for use during

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shift-to-shift nursing handovers. The following quote illustrates that positive attitude:

> *A handover standard would reduce the differences in practice caused by each professional's level of experience and sensitivities.*

The survey's high response rate was testament to its favorable reception from frontline nursing staff. Its results also gave them a base from which to subsequently adapt the standard by adding the content necessary for nursing shift handovers within specific wards or transfers between particular specialties.

The Institution's Role in the Handover Process

Participants expressed the important role of organizational issues (enough time, suitable staffing levels, appropriate environments, etc) in well-functioning nursing handovers, as shown in the item list. Organizational issues are always present in hospital systems, but health care professionals often perceive them to be obstacles. Designing new nursing handover standards was viewed as an opportunity to align the visions of management and clinicians. Participants also mentioned the limitations and risks related to changes in practice. The following quote illustrates this:

> *Organizational limitations meant that, in general, professionals had not adopted a consensus on how to carry out handovers at the patient's bedside.*

Diversity of Medical Specialties

The nurse experts showed a very high level of consensus, despite the diverse background of clinical settings and medical specialties. Some participants mentioned that it would have been interesting to detail the results by type of ward; however, the research team justified aggregating the data because guaranteeing participants' anonymity required not being able to recognize them from their professional backgrounds.

Breaking data down by type of ward or clinical setting might have had a negative influence on items that did not reach consensus, such as dealing with handovers at the patient's bedside or presenting their medication list.

Consensus Reached

The item relating to staff attitudes during handovers—hopefully in a spirit of cooperation—was very favorably received, and had been chosen with regard to the hospital's declared aims toward collaborative practices, which are part of its strategy and philosophy.

An overview of all the statements accepted by the entire panel was presented to the 15 attending nurse experts. Participants reaffirmed the important role of organizational issues (enough time, suitable staffing levels, appropriate environments, etc) in well-functioning nursing handovers, as shown in the item list. Organizational issues are always present in hospital systems, but health care professionals often perceive them to be obstacles. Designing new nursing handover standards was viewed as an opportunity to align the visions of management and clinicians. Participants also mentioned the limitations and risks relating to changes in practice. The following quote illustrates this:

> *Organizational limitations meant that, in general, professionals had not adopted a consensus on how to carry out handovers at the patient's bedside.*

The focus groups offered the opportunity to discuss each statement that had reached a consensus. All the participants, no matter their age, sex, or nursing specialty, were enthusiastic about the consensuses found. The following quotes illustrate their positive mindsets:

> *I'm happy that these topics found a formal consensus. This will be a great help in formalizing communication between our nurses during shift changes: it will reduce the time spent and hopefully prevent some of the endless disagreements between nurses about which information is pertinent or not...*
>
> *...Communication on our ward is poorly structured and not always considered as a potential trigger for errors or even conflicts. Standardizing will be a great help...*
>
> *...this will be an excellent starting point from which to construct our own, adapted, standardized handovers at shift changes on our ward...*

Consensus Not Reached

Providing a medication list at handover failed to reach the required level of consensus, giving rise to quite heterogeneous opinions among focus group participants. Some stated that it would be difficult to remove this item from standard handover procedures. Others explained that a fraction of the nurse experts replied negatively because a list of medication has little meaning without parameters such as the mode of administration, effects, or follow-up. This is in line with the survey subheading of environmental diversity (ie, different wards and specialties), which mentioned the following:

> *A more detailed handover may be required, depending on the specialties.*

The following was also mentioned:

> *Perhaps in some wards we don't need to transmit that information verbally since it's in the written part of the file.*

Several participants speculated on the different causes of medication errors that are not the result of handover processes:

> *It would be interesting to see what medication errors are related to, and I don't know if there really is a link, at that time, to the handover. I think there are other problems with medication errors; I don't really think that they are linked to handovers.*
>
> *I agree. I think that you have to be very strict on procedures—double-checking, not giving medication without consulting the paperwork. I think that errors come from the huge amount of paperwork most of the time.*

Suggestions on whether to transmit all medication information were also explored:

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> *It's more focused on clinical problems, problems they have—patients' problems—and nurses make the connections to the drugs.*

This degree of detail will be defined in the handover standard's different sections, including priorities related to time management, mission, and risk management failures:

> *We clearly want safety, but we cannot afford to make extremely time-consuming reports. Indeed, if we set ourselves a framework at the beginning, and imagine that we have half an hour to do the handover, we will also have to adapt our priorities.*

Handovers at the Patient's Bedside

Participants' understanding of the concept of handovers at the patient's bedside may have been different according to their different work settings, and this could have influenced our findings. Handover at the patient's bedside refers to the patient's presence during that handover. The concept also highlighted professionals' uncertainties regarding potential breaches of confidentiality versus developing a better understanding of patients' values and preferences during a handover at their bedside. One focus group participant mentioned that her colleagues gave such handovers a lot of thought, stating the following:

> *...we should try, actually, but there are a lot of questions still to sort out...*

Information Technology Support

IT support is essential to ensuring the continuity of information transfer. A handover can be summarized using written documentation, allowing professionals guaranteed access to an overview of the data. There was a unanimous consensus on complete data transparency, making it possible to answer any questions that arose during the handover. Currently, however, not all the hospital's wards have the tools that correspond best to their specialty. Participants agreed that knowing the medication's precise formulation was a guarantee of safety and continuity. Although there is a recognized risk of errors, paper notes are increasingly used to compensate for the lack of precision or flexibility in electronic patient records.

Discussion

Principal Findings

In addition to selecting which items should be included in an evidence-based, shift-to-shift nursing handover standard, this study sought to find a consensus about information flows, best practices, and patient involvement. The significant number of nurse experts involved in our survey determined the need for an electronic data collection method [30,53,54].

The potential benefits arising from this study are due to its combined use of clinical and applied research skills to solve a patient safety issue. Indeed, the study will have a direct impact on future patient safety and the quality and continuity of care in our multisite public hospital in Switzerland. The hospital-wide standard for shift-to-shift nursing handovers will enable frontline nurses in the French-speaking and German-speaking hospital centers to build their own consensus positions on the content necessary for nursing shift handovers and patient transfers within and between different regional care units. Nevertheless, after two rounds of online investigation, some of the nursing professionals would have preferred a single, immediately implementable, nursing handover standard applicable to all the hospital's care units.

It is also very likely that some item responses were influenced by a reluctance to change, because changing well-established practices could initially induce handover errors. Items that did not reach a hospital-wide consensus could be reconsidered by individual care units or even by hospital centers. Indeed, Flemming and Hübner reported that the inaccurate transmission of medication prescriptions was a frequent type of error [55]. According to the WHO position, more than 40% of prescription and administration errors occur during handovers and transfers—mistakes that could be avoided by medication reconciliation at those moments. This process compares the patient's list of usual drugs with a new list including deprescriptions and new prescriptions, modified following medical decisions [56]. This item may, therefore, have to be reconsidered at the French-speaking hospital center in the future—but not at the German-speaking hospital center—as may the nurse experts' feelings about bedside handovers, which allow patients to express their decisions, opinions, and expectations, and validate their latest clinical data and medication. This is especially relevant, since the French-speaking hospital center's nurse experts did not perceive potential breaches of confidentiality during bedside handovers to be a risk. About two-thirds of the French-speaking hospital center's nurse experts were not convinced that this item needed to be included in the nursing handover standard; however, the German-speaking hospital center's nurse experts were interested in adopting it. These contrasting results might be explained by differences in the proportions of managers and full-time employees at the two centers, or by differences in understanding or training about the concept of bedside handovers. Use of a mnemonic tool did not achieve consensus at the German-speaking hospital center, despite mental models in the form of acronyms being encouraged as a strategy to improve handover process safety, especially in situations where large amounts of sometimes disparate information are communicated [19]. Despite the differences in the second-round items resubmitted to participants at the two hospital centers, the findings presented here will be a significant contribution to our multisite public hospital's overall strategy of seeking continual improvements in the quality and safety of care via evidence-based practices [57]. As Klee et al and McFarlane stated, creating a consensus handover standard is a way to change the daily practices of all the nurses involved in this nursing process, and its results are not limited to those who accepted the item statements [58,59]. This e-Delphi survey process should not be considered as a generalizable method for creating clinical nursing handover standards in other hospitals. However, the approach could be a starting point for developing good clinical research practice in large samples. The final consensus position will be decisive in implementing our hospital's new nursing handover strategy at ward level. Encouraging a high survey participation rate will contribute to motivating nursing teams to really change their practice. Nursing

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management teams should nevertheless reflect on how to support and supervise nursing professionals as they attempt to adapt items to the specificities of their own care units.

Strengths and Limitations

This study's greatest strength was its high participation rate from among the potential sample of experts. There was a positive response to the survey because it addressed a theme of concern to nursing teams' daily practice and its results might benefit them directly and rapidly. Another explanation could be that developing a participative consensus, giving experts the opportunity to express themselves and submit proposals concerning their working environment, meant that their expertise was recognized by the management of their multisite public hospital. The work's added value probably lies in its scientific rigor, particularly questionnaire development using an evidence-based scoping review. Giving clinical experts, who are active in so many disciplines, the opportunity to critically analyze the standard may have contributed to the high level of consensus reached. This high level of consensus, communicated to the participants during the focus group presentation, made the methodology clear to everyone. The reflection period before the adoption of the handover standard by the different care units could be considered a strength and a limitation.

Our study's first limitation concerns the probability that some item results were influenced by a reluctance to change, thus inducing more positive or negative responses, depending on the item. A second limitation was that all the hospital's clinical specialties were involved, making it likely that the consensus was biased toward those specialties represented by the greatest numbers of nurse experts. We did not analyze the collected data by medical specialty in order to ensure participant anonymity. Information is also more difficult to coordinate across a multisite hospital with centers relatively distant from one another. It should also be noted that an online survey makes it impossible to ensure that participants gave their responses autonomously and without peer influence. Another limitation concerned the discrepancy in round 2's e-Delphi items—resulting from answers to the open-ended question—which were not all resubmitted to the two different hospital centers.

A more organizational limitation to constructing standardized handovers is that there is no guarantee of its implementation and optimal use. Nurses will have to be trained on how to use a standardized handover tool, with a tailored implementation strategy for each ward and department. Future research should examine the effectiveness of the standardized handover's introduction, using quasi-experimental intervention studies (ie, before and after), completed with postimplementation satisfaction surveys: qualitative surveys among nurses (ie, focus groups) and quantitative surveys among patients (ie, online surveys and questionnaires at the end of hospitalization). Finally, error rates (eg, medication, clinical follow-up of unstable patients, and so on) before and after the implementation should also be compared.

Conclusions

A standardized, hospital-wide, shift-to-shift nursing handover process encourages nursing care teams to conscientiously share information that is essential to the continuity of care. This participative study enabled us to reveal a high level of consensus on a large majority of the items proposed for such a nursing handover standard. Effective compliance with the new standard will be the expression of its successful implementation. However, further dimensions of nursing handovers have yet to be explored, particularly on the causes of the risks of error and on the interprofessional sharing of information that enables the coordination of patient-centered care. Proactive leadership from hospital management and appropriate staff training will be the next crucial steps toward the successful implementation of our institution-wide standard for evidence-based nursing handovers between shifts and care units.

Acknowledgments

We thank the nurse experts and other professionals from the Valais Hospital for their participation in this study. This study was funded by the Valais Hospital and by the Department of Nursing Sciences, HES-SO (Haute École Spécialisée Suisse orientale, University of Applied Sciences and Arts Western Switzerland), Valais-Wallis, Sion, Switzerland. The sponsors declare no conflict of interest.

Authors' Contributions

All the authors contributed to the development of the study design and drafting of the manuscript. They all approved the manuscript's final version and agreed to be held accountable for all aspects of the work.

Conflicts of Interest

None declared.

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Abbreviations

CER-VD: Human Research Ethics Committee of the Canton Vaud
CINAHL: Cumulative Index to Nursing and Allied Health Literature
e-Delphi: electronic Delphi
HES-SO: Haute École Spécialisée Suisse orientale
IT: information technology
MEDLINE: Medical Literature Analysis and Retrieval System Online
WHO: World Health Organization

Edited by G Eysenbach; submitted 17.01.20; peer-reviewed by JKH Pun, S Sarbadhikari; comments to author 14.03.20; revised version received 10.04.20; accepted 19.04.20; published 15.06.20.

Please cite as:
Tacchini-Jacquier N, Hertzog H, Ambord K, Urben P, Turini P, Verloo H
An Evidence-Based, Nursing Handover Standard for a Multisite Public Hospital in Switzerland: Web-Based, Modified Delphi Study
JMIR Nursing 2020;3(1):e17876
URL: https://nursing.jmir.org/2020/1/e17876/
doi:10.2196/17876
PMID:

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Original Paper

Influence of Organizational Issues on Nurse Administrators' Support to Staff Nurses' Use of Smartphones for Work Purposes in the Philippines: Focus Group Study

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Abstract

Background: Studies show that nurses use their own smartphones for work purposes, and there are several organizational issues related to this. However, it is unclear what these organizational issues are in the Philippines and the influence they have on nurse administrators' (ie, superiors) support to staff nurses' (ie, subordinates) use of smartphones for work purposes.

Objective: Drawing from the Organizational Support Theory (OST), this study aimed to identify organizational issues that influence nurse administrators' support to staff nurses' use of smartphones for work purposes.

Methods: Between June and July 2017, 9 focus groups with 43 nurse administrators (ie, head nurses, nurse supervisors, and nurse managers) were conducted in 9 tertiary-level general hospitals in Metro Manila, the Philippines. Drawing from OST, issues were classified as those that encouraged or inhibited nurse administrators to support nurses' use of smartphones for work purposes.

Results: Nurse administrators were encouraged to support nurses' use of smartphones for work purposes when (1) personal smartphones are superior to workplace technologies, (2) personal smartphones resolve unit phone problems, and (3) policy is unrealistic to implement. Conversely, issues that inhibited nurse administrators to support nurses' use of smartphones for work purposes include (1) smartphone use for nonwork purposes and (2) misinterpretation by patients.

Conclusions: Nurse administrators in the Philippines faced several organizational issues that encouraged or inhibited support to staff nurses' use of smartphones for work purposes. Following OST, the extent of their support can influence staff nurses' perceived organizational support on the use of smartphones for work purposes, Overall, the findings highlight the role and implication of organizational support in the context of smartphone consumerization in hospital settings, especially in developing countries.

(JMIR Nursing 2020;3(1):e17040) doi:10.2196/17040

KEYWORDS

BYOD; IT consumerization; nurse administrators; organizational support; Philippines; smartphone

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Introduction

Background

It is now common for employees to use their personal digital devices to accomplish work-related tasks. Harris et al [1] attribute this situation as information technology (IT) consumerization or the "adoption of consumer devices and applications in the workforce." Among personal digital devices, it is not surprising to see the adoption of smartphone use for work purposes, considering that its portability blurs the boundaries between personal and professional use [2,3]. Instead of using company-issued devices for accomplishing work-related tasks, organizations have observed that employees prefer to use their own devices such as smartphones. For instance, a survey shows that 67% of IT employees are using personal devices in the workplace [4]. Similarly, Intel reported that the number of their employees using their own smartphones for work purposes increased from 3000 in 2010 to 17,000 in 2011 [5]. Although there are organizations that would support their employees' use of smartphones, there are others that would not support such an initiative [6].

Take the case of health care organizations. A 2015 survey found that 73% of health care organizations across North America allowed their health care staff to bring their own devices (primarily smartphones) for work purposes, but only 51% allowed their nurses to use personal devices for work compared with 91% of medical doctors [7]. Likewise, a recent study in Saudi Arabia showed that although 97% of surveyed health care workers owned a smartphone, only 42% used it for clinical work [8]. It is important to note that about 77% of the respondents in that study were nurses, which suggests the possibility of such restrictions being placed on nurses. Currently, much of the literature focuses on medical doctors' use of smartphones [9-12]. However, more studies are needed to understand the perspectives of nurses—the largest group of health care professionals in a hospital [13]—as they tend to experience low support on using mobile devices [14,15] despite the potential benefits it could bring to enhancing clinical work and improving patient care [16-22].

Considering that IT consumerization in health care organizations is a pertinent issue faced by several levels of hospital administrators [23], it is crucial to understand specific issues encountered by nurse administrators when their staff nurses use their smartphones for work purposes. To date, studies that present issues related to nurses' use of smartphones for work purposes (eg, distraction, potential for medical errors, reduced quality of care, privacy and confidentiality issues, and nomophobia) were derived from surveys or interviews with bedside nurses [20,22] or nursing students [15,24-27]. Thus, there is a need for studies that focus on the perspectives of nurse administrators. More importantly, there's a need for studies that put forth the point of view of nurse administrators because nurse administrators are in the best position to provide insights on how to appropriate implicit or explicit *bring your own device* (BYOD) policies for staff nurses given the manpower and technological constraints in their area of assignment.

This study aimed to identify organizational issues related to staff nurses' use of smartphones for work purposes and examine whether such issues influence nurse administrators to support such practice in the Philippines. As a developing country in Southeast Asia, the Philippines is an interesting context for this study because most hospitals in the Philippines do not have sufficient health information technologies that can support health care professionals' clinical work [28]. Moreover, the country is currently facing a decline in its nursing workforce [29]. Considering that most hospitals in the Philippines lack basic health information technologies and are working under manpower constraints, it is interesting to evaluate the extent to which nurse administrators in the Philippines support smartphone use for mitigating such challenges.

Overall, this study is another contribution based on a series of studies examining the implications of personal smartphone use of nurses in clinical settings in the Philippines [16,18,30]. On a practical note, the findings of this study can help guide health care organizations in developing appropriate BYOD policies for health care staff in the era of IT consumerization.

Organizational Support Theory

This study draws on the Organizational Support Theory (OST) as its theoretical foundation. OST posits that employees develop beliefs on how organizations support their actions [31]. These beliefs are based on the actions acted upon by organizational agents (ie, top management, immediate superiors, rank and file employees) who exert power over employees. Therefore, employees tend to have perceptions of organizational support, and this can influence their actions, including the use of technology [32,33]. In the context of this study, a recent work in the Philippines that also draws on OST suggests that staff nurses' perceived organizational support (ie, staff nurses' perception of organizational support on the use smartphones for work purposes as derived from the hospital management, immediate nursing superiors, fellow staff nurses, and medical doctors) had an indirect effect on their use of smartphones for work purposes [18]. Clearly, this finding shows how crucial organizational support is when IT consumerization occurs in the clinical setting.

In addition to the perceived organizational support, OST also posits that the support exhibited by organizational agents constitutes actual organizational support [31]. According to Rhoades and Eisenberger [34], supervisors are one of the key organizational agents who directly influence employees' perception of organizational support. This can be attributed to the fact that supervisors have the responsibility to direct and evaluate subordinates [34]. Therefore, the extent of support conveyed by supervisors (ie, actual organizational support) can influence employees' perceived organizational support. For the purposes of this research, supervisors will be referred to as nurse administrators, who are nurses with supervisory function [35]. In the Philippines, nurse administrators typically include head nurses (entry-level supervisory position; sometimes referred to as charge nurses), nurse managers (midlevel supervisory position), and nurse supervisors (midlevel supervisory position) [16].

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Although the link between actual and perceived organizational support is established by meta-analyses that show that supervisor support is a strong positive predictor of perceived organizational support [34,36], the influence of organizational issues on supervisors' support to employees' use of technology is currently unclear. The rationale of exploring this aspect in this study is that certain issues might influence nurse administrators' support to staff nurses' use of smartphones for work purposes, which then influences staff nurses' perceived organizational support. Although previous studies have presented several issues related to nurses' use of smartphones for work purposes (ie, blanket ban of smartphones at work, reduced professionalism, and hospitals not providing smartphones and credits for nurses) [14-16,19-22], it is unknown whether these issues influence nurse administrators' support to nurses' use of smartphones for work purposes. For instance, if a hospital implements a blanket ban on smartphones, would a nurse administrator prohibit a staff nurse to use a smartphone if this is the only means possible to contact a physician given that there is no other hospital device to use? As one of the hospital's organizational agents, nurse administrators need to deal with balancing the risks (eg, privacy and confidentiality concerns) [14,15] and benefits (eg, opportunity to enhance quality of care to patients, faster communication, and information seeking) [16-19] associated with using smartphones for clinical work, especially in low-resource settings. Overall, this study aimed to answer the following research question: *What are the organizational issues that influence nurse administrators' support to staff nurses' use of smartphones for work purposes?*

Methods

Study Design and Ethics Approval

This study used a qualitative research design because it allows the collection of rich descriptions of organizational issues related to the use of a health information technology [37]. The institutional review board of Nanyang Technological University gave ethical clearance for the study (IRB 2016-09-003). In addition, the administrators or ethics committees of the hospitals where the focus groups were conducted approved the study. All participants provided written and verbal consent to participate in the study. Participants were given Philippine Peso (PHP) 200 (approximately US $4) worth of gift vouchers for their participation.

Selection and Profile of Focus Group Sites

Overall, 9 of 19 hospitals in Metro Manila, Philippines, that were part of an earlier study [18], were randomly selected using a hospital matrix (Figure 1). The hospital matrix was developed based on data collected for that study (Table 1). To identify hospitals that are within the same quadrant, cutoff values were used as markers in the scatterplot.

Although there is no consensus on the required number of focus group sites [38], at least 2 hospitals per quadrant were selected. To select hospitals, half of the hospitals from each quadrant were randomly selected. Figure 1 shows the hospitals where the focus groups were conducted, and Table 2 provides a summary of the selected hospital's characteristics. Subsequently, focus groups were conducted in 6 private and 3 government hospitals.

Figure 1. Hospital quadrants and focus group sites (hospital codes are reflected in each dot or triangle; dots represent actual focus group sites).

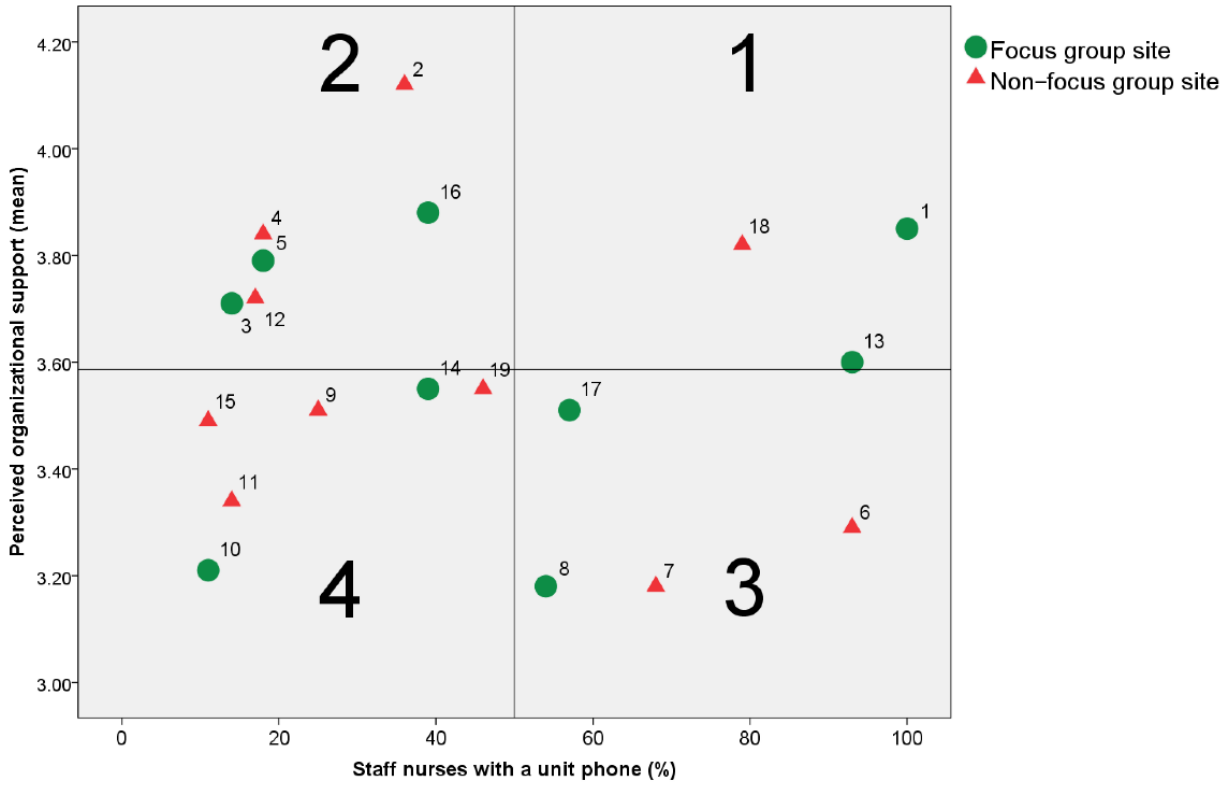

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Table 1. Hospital matrix data.

ID	Staff nurse respondents, n	Perceived organizational support[a]	Staff nurses with unit phone, n (%)[b]	Focus group site[c]
H1	28	3.85	28 (100)	Yes
H2	26	4.12	9 (35)	No
H3	27	3.71	4 (15)	Yes
H4	27	3.84	5 (19)	No
H5	28	3.79	5 (18)	Yes
H6	27	3.29	25 (93)	No
H7	28	3.18	19 (68)	No
H8	28	3.18	15 (54)	Yes
H9	28	3.51	7 (25)	No
H10	28	3.21	3 (11)	Yes
H11	26	3.34	3 (12)	No
H12	30	3.72	5 (17)	No
H13	27	3.60	25 (93)	Yes
H14	28	3.55	11 (39)	Yes
H15	26	3.49	3 (12)	No
H16	27	3.88	10 (37)	Yes
H17	27	3.51	15 (56)	Yes
H18	27	3.82	21 (78)	No
H19	24	3.55	11 (46)	No

[a]Mean score for perceived organizational support. Maximum score of 5. See items for perceived organizational support in Bautista et al [18].
[b]Each respondent was asked if the hospital provides their work area with a unit phone (ie, hospital-provided mobile phone).
[c]Refers to the hospitals that eventually became focus group sites.

Table 2. Characteristics of hospital sites for focus group (N=9).

Quadrant number and code	Location[a]	Ownership	Bed capacity
1			
H1	South	Private	>300
H13	Central	Private	<300
2			
H3	South	Government	<300
H5	North	Private	<300
H16	Central	Government	>300
3			
H8	North	Private	<300
H17	Central	Private	>300
4			
H10	North	Private	>300
H14	South	Government	>300

[a]Location within Metro Manila, the Philippines.

Selection and Profiles of Participants

Consistent with qualitative research design, purposive sampling was used to recruit participants [39]. Eligibility criteria were as follows: (1) aged 21 years or older, (2) have worked for at least a year in their current hospital, and (3) currently working as a nurse administrator. Participants were recruited by coordinating with each hospital's nursing department. Having nurse

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administrators from various areas of the hospital ensured maximum variation sampling [40].

Overall, 43 nurse administrators participated in the focus groups (Table 3). They included 22 head nurses, 10 supervisors, 9 nurse managers, and 2 infection control nurses (a supervisory position in the hospitals where they were employed). A total of 9 focus groups were conducted, and each session had 4 to 5 participants. Although focus groups are usually composed of 6 to 12 participants per group [40], it should be small enough for all participants to contribute but large enough to share various opinions [41]. Therefore, having 4 to 5 participants per focus group was enough to obtain rich data [42,43].

In general, participants were mostly female (36/43, 84%), and their median age was 45 years. The median length of service was 16 years, and the median number of nurses supervised was 17. Maximum variation sampling [40] was achieved because the participants represented several general (eg, wards and outpatient department) and specialty (eg, intensive care, operating theater, and emergency department) areas.

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Table 3. Profiles of focus group participants (N=43).

Quadrant number and code	Hospital ownership	Sex	Age	Work experience (years)	Position	Staff nurses supervised (n)	Area
1							
H1P1	Pvt[a]	F[b]	44	13	HN[c]	17	Intensive care unit
H1P2	Pvt	M[d]	45	17	HN	13	Medical surgical ward
H1P3	Pvt	F	46	10	HN	17	Emergency department
H1P4	Pvt	F	45	14	NS[e]	8	General nursing ward
H1P5	Pvt	F	48	13	NS	26	Training and research
H13P1	Pvt	F	57	15	HN	12	Pediatric ward
H13P2	Pvt	F	52	13	HN	26	Operating/delivery room
H13P3	Pvt	M	42	8	HN	11	Intensive care unit
H13P4	Pvt	M	44	10	NS	50	Nursing department
H13P5	Pvt	F	51	15	HN	10	Neonatal intensive care unit
2							
H3P1	Gov[f]	F	38	17	NM[g]	13	Obstetrics/gynecology ward
H3P2	Gov	F	49	7	NM	7	Hemodialysis unit
H3P3	Gov	F	44	24	NM	9	Surgical ward
H3P4	Gov	F	45	15	NM	13	Pediatric ward
H3P5	Gov	F	52	20	NM	20	Delivery room
H5P1	Pvt	F	48	6	NM	100	General nursing units
H5P2	Pvt	M	32	7	HN	18	Operating theater
H5P3	Pvt	M	29	5	HN	12	Medical surgical ward
H5P4	Pvt	M	30	9	HN	20	Intensive care/medical unit
H5P5	Pvt	F	40	18	NM	100	Special nursing units
H16P1	Gov	F	34	26	HN	11	Pay ward
H16P2	Gov	F	35	16	HN	22	Neurology/ear/nose/throat unit
H16P3	Gov	F	36	41	NS	60	Medicine ward
H16P4	Gov	F	37	37	NS	29	Emergency department
H16P5	Gov	F	38	22	HN	16	Outpatient department
3							
H8P1	Pvt	F	29	5	HN	38	General nursing unit
H8P2	Pvt	F	50	26	HN	9	Neonatal intensive care unit
H8P3	Pvt	F	45	14	HN	3	Ambulatory care
H8P4	Pvt	F	39	15	NS	70	Acute and critical care units
H17P1	Pvt	F	64	41	NS	9	Outpatient department
H17P2	Pvt	F	43	17	NS	9	Nursing department
H17P3	Pvt	F	50	25	HN	9	Outpatient department
H17P4	Pvt	F	39	15	ICN[h]	258	All nursing areas
H17P5	Pvt	F	28	6	HN	13	Critical care unit
4							
H10P1	Pvt	F	49	28	NM	45	Operating theater
H10P2	Pvt	F	36	12	HN	30	Newborn services unit

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Quadrant number and code	Hospital ownership	Sex	Age	Work experience (years)	Position	Staff nurses supervised (n)	Area
H10P3	Pvt	F	38	19	HN	16	Pediatric/medical surgical unit
H10P4	Pvt	F	45	22	HN	24	Delivery room
H10P5	Pvt	F	53	32	HN	11	Obstetrics/gynecology ward
H14P1	Gov	M	51	29	NS	100	Operating/delivery/emergency
H14P2	Gov	F	58	32	ICN	50	All nursing areas
H14P3	Gov	F	58	34	NS	88	Nursing department
H14P5	Gov	F	59	35	NM	15	Emergency department

[a]Pvt: private.
[b]F: female.
[c]HN: head nurse.
[d]M: male.
[e]NS: nurse supervisor.
[f]Gov: government.
[g]NM: nurse manager.
[h]ICN: infection control nurse.

Data Collection Procedure

Focus groups were conducted from June to July 2017 by JB. These were held in a time and location arranged by each hospital's nursing department. Focus groups were conducted during or after the participants' shift in their respective hospital's nursing training office or vacant hospital room. To allow freedom of expression, the rooms were closed, and only the study participants were present inside the rooms during focus groups. An interview guide was used during the focus groups. This interview guide was developed based on the relevant literature on nurses' use of smartphones at work [16,44-47]. Although there were preset questions, probing questions were also asked for clarification or exploration [48].

The focus groups were conducted using a mix of English and Tagalog languages so that participants could clearly express their sentiments. Aside from verbal responses, nonverbal cues (eg, body language and group dynamics) were recorded in the field notes. To allow greater discussion during focus groups, participants were arranged to sit in a circular pattern [49]. Each focus group lasted about 40 min on average. To uphold privacy and confidentiality, participants were asked not to state their name and workplace during the audio-recorded focus groups. Instead, participants were assigned participant numbers for identifying themselves or others during the focus groups. Moreover, all potentially identifiable information was removed from the transcripts.

Data Analysis

Audio recordings of each focus group underwent verbatim transcription. The transcription was performed by JB because he moderated the focus groups and could identify each participant's voice in the recordings. All completed transcripts and field notes were imported in NVivo 11 (QSR International, Melbourne, Australia) for data analysis. To analyze the data, a primary-cycle coding was first conducted to break down the data into smaller pieces [40]. This was performed by conducting an extensive line-by-line open coding in which codes were assigned freely to the data [50]. After primary-cycle coding, a secondary-cycle coding was performed by immersing and reflecting on the existing codes. Subsequently, related codes were categorized into conceptual bins from which organizational issues emerged [40]. Eventually, the issues were grouped based on OST [31] by classifying those that encouraged or inhibited nurse administrators to support staff nurses' use of smartphones for work purposes. Multimedia Appendix 1 shows the coding table. Discussions among the authors helped identify how themes varied from one case to another in consideration of the participants' characteristics (eg, hospital type and area). Considering the depth of results, focus group data from 43 participants reached data saturation. To enhance qualitative rigor, steps were taken to enhance its trustworthiness by applying the principles of credibility, transferability, dependability, and confirmability [51]. The following sections present the findings along with relevant quotes.

Results

Issues That Encouraged Support

This theme refers to organizational issues that encouraged nurse administrators to support staff nurses' use of smartphones for work purposes. Textbox 1 provides an overview of this theme.

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Textbox 1. Issues that encouraged support.

Personal smartphones are superior than workplace technologies.

- Landline telephones are unable to contact mobile phones.
- Intercom system is unreliable.
- Incomplete feedback loop with the desktop-based text messaging software.

Personal smartphones resolve unit phone problems

- Absent unit phones.
- Insufficient unit phones.
- Insufficient unit phone credits.

Policy is unrealistic to implement.

- Making exemption.
- Ban on smartphone use only for nonwork purposes.

Personal Smartphones Are Superior Than Workplace Technologies

Generally, nurses should use technologies provided by their hospitals for work. Although technologies were limited in most hospitals where the focus groups were conducted, participants shared that their hospital provided a few technologies that they could use to facilitate communication with colleagues. However, such technologies were deemed unreliable and inferior compared with the smartphones that nurses possess. Therefore, nurse administrators were inclined to allow their nurses to use their personal smartphones for work purposes.

Landline Telephones Are Unable to Contact Mobile Phones

Every private and government hospital had landline telephones considering that it is one of the most fundamental communication technologies one would have. However, most participants reported that although their hospitals provide landline telephones, staff nurses cannot use them to call mobile phones because these are limited to communication with other landline telephones within the hospitals. As a result, most of the participants allowed nurses to use their smartphones to communicate with members of the health care team:

> *The options for us to call cellphone, overseas calls, and NDD [national direct dialing] is restricted [in the landline]. It is restricted to all [making out-of-hospital calls].* [H5P3, Head Nurse]

Hospital 8 was an exception because participants shared that their staff nurses could make mobile phone calls by using hospital landline telephones that connected them to mobile phones through the operator. This is generally useful, but a participant from Hospital 8 noted that when operators were unavailable, nurse administrators would allow their nurses to use smartphones to contact doctors:

> *My staff has Globe [a service provider] and if we need to inform a Smart [refers to a doctor that is subscribed to another service provider], we will call to the operator. Now, if Smart is not available to the operator, I have one staff [nurse] that has an unli [unlimited call] to Smart. One of my staff is unli to Globe. We just borrow [each other's smartphone].* [H8P3, Head Nurse]

Intercom System Is Unreliable

Participants from Hospital 3 and Hospital 5 described their intercom system as a local two-way communication system in which a microphone and a loudspeaker were installed in every nursing area. Although this was deployed to help facilitate communication among health care staff within the hospital, some of them noted several problems when using the intercom system that consequently reduced its usefulness. For instance, one participant noted that "it is difficult to use" the intercom system (H3P3, Nurse Manager), and another shared that "sometimes it is busy" (H3P1, Nurse Manager). Conversely, a participant stated that such technology "is actually good" but lamented that it was also an inefficient form of communication technology as it is an indirect means of communication:

> *With the number of patients being catered by the hospital [many patients] including the number of resident doctors that is rotating in the hospital [few doctors], doctors would not receive our message. So, our requests would take time.* [H5P3, Head Nurse]

Consequently, the problems experienced by the participants with their intercom system served as a cue for them to allow staff nurses to use their smartphones for work purposes. For instance, one participant stated that they could "directly call the doctors for a referral" using their staff nurses' smartphone and they "need not bother to press anything on our intercom" (H3P3, Nurse Manager). Similarly, when the intercom system was busy, one participant was relatively fine when her nurses "made calls or texted" (H3P1, Nurse Manager) using their smartphones just to contact their patients' doctors. Conversely, one participant explained that communication via mobile phones is faster than an intercom system, to the extent that they requested their management to provide them with a unit phone:

> *For us to mobilize and facilitate information and updates, it is much easier on our phones. It is not*

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> *because we want to remove the paging [intercom] system but there are times that we need a much faster means of communication. That is why we are requesting a [unit] phone.* [H5P3, Head Nurse]

Incomplete Feedback Loop With the Desktop-Based Text Messaging Software

Participants described the desktop-based text messaging software as a software that allowed nurses to send and receive text messages to and from mobile phones regardless of the service provider. In most situations, staff nurses used them to send patient referrals to doctors. In Hospital 1, participants mentioned that their hospital installed *Maxxtext* in each desktop computer. Similarly, Hospital 17 also has a similar software called *Infotext*.

Despite being an alternative to mobile phones for sending text messages, a major problem with this technology is the difficulty in receiving replies. For instance, one participant shared that her staff nurses in the intensive care unit used *Infotext*, but they were bothered because "the problem with Infotext is we cannot immediately receive the reply" (H17P5, Head Nurse). She also noted that doctors were familiar with this problem, and "it is not guaranteed that they will reply [in the Infotext]" considering that there was a "feedback problem" (H17P5, Head Nurse).

The feedback problem associated with this technology was a strong concern because a patient's life in the intensive care unit depends on the speed of coordination among the health care team. Considering this problem, one participant shared that instead of using *Infotext*, she allowed her staff nurses to use their smartphones when making referrals to doctors, especially during emergencies:

> *If there were emergency cases, you cannot avoid not to use your personal phone because residents and consultants send their replies to us. We do not have a cellphone [in the area]. We just use our own cellphone.* [H17P5, Head Nurse]

Participants in Hospital 1 also noted the feedback problem with *Maxxtext* and why it became unpopular among staff nurses and doctors. According to one participant, *Maxxtext* was quite useful until it had the same feedback problem, and this led to the termination of the software and the deployment of mobile phones in their hospital:

> *...[T]hey placed Maxxtext, so we did not bother using the cellphones because it was a much better form of communication with the doctors. However, there was a time that Maxxtext had a [feedback] problem, so the [software] contract was not renewed. What they did instead was to give cellphones per unit.* [H1P4, Nurse Supervisor]

Personal Smartphones Resolve Unit Phone Problems

During the focus groups, most participants were highly vocal about unit phone problems, which suggested their importance and relevance. This is understandable as most of the participants came from hospitals where unit phones were mostly not provided to staff nurses. In situations where unit phones were not provided, they were insufficient, or credits were lacking, nurse administrators were inclined to allow their nurses to use their smartphones for work purposes.

Absent Unit Phones

Focus groups with the participants revealed that all government hospitals (ie, Hospital 3, Hospital 14, and Hospital 16) did not provide unit phones, and a few private hospitals provided them (eg, Hospital 1 and Hospital 13). Considering that most of the hospitals did not provide mobile phones to their nurses, participants from those hospitals shared that the smartphones of their staff nurses were very useful, and they allowed their use for work purposes. For instance, one participant shared that she allowed her nurses to use their smartphones "to do research on the case of the patient" because she believed that it is "the fastest way for them to look for information regarding the case of the patient that they are handling" (H5P1, Nurse Manager). Similarly, another participant shared that her area was not provided with a unit phone; as a result, she allowed her nurses to use their smartphones considering their usefulness for communication purposes:

> *From the ambulatory care, I allow the use of their personal mobile phone because a unit phone is not provided by our hospital. They use it to inform doctors if there are admissions.* [H8P3, Head Nurse]

Apart from the usefulness of smartphones, some participants also shared that smartphones contributed to improving the quality of care rendered to patients. This occurred when smartphones helped nurses to immediately cater to their patients' needs. As a result, the absence of a unit phone served as a cue for the participants to support their staff nurses' use of smartphones for work purposes. For example, one participant stated that "the patient benefits from it because they [staff nurses] can facilitate immediate interventions to the patient" (H14P2, Infection Control Nurse). Moreover, one participant shared that although mobile phones can be "a double-edged sword," he argued that:

> *From a clinical standpoint, if you will use it in the interest of caring for patients, it will be very beneficial and efficient.* [H5P4, Head Nurse]

Nurses would need to find ways to provide the best possible service to their patients despite resource constraints. This meant even using their smartphones just to accomplish their task. According to some participants, their staff nurses' use of smartphones for work purposes is a manifestation of their capability to adapt in a situation where such technology is not provided by their hospitals. For one participant, the absence of a unit phone made him decide to allow its use because it is a way for staff nurses "to gather technical or clinical information outside of our norm or usual routine" (H5P4, Head Nurse). Moreover, another participant explained how nurses adapt to perform their work in the absence of unit phones:

> *If the organization is unable to provide their needs [like unit phones], it talks about the adaptability of the people working under them. So, of course, if you want to finish your task immediately, you [would] opt to use your own cellular phone.* [H5P5, Nurse Manager]

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Although most participants supported their staff nurses' use of smartphones for work purposes because of the absence of unit phones in their workplace, a few of them recognized that, in the long term, hospitals should provide unit phones so that nurses would not use their smartphones. This sentiment is best described by a participant from Hospital 5 as he believed that his nurses need a unit phone and having it would result in an outcome where "the personal phone [of the nurses] can be kept away and the unit phone is the one outside to be used" (H5P3, Head Nurse). More importantly, another participant expressed that providing her staff nurses with unit phones would be "for the good of the patient" (H16P1, Head Nurse). She added:

> *It will save us since we can verify and clarify [doctors' orders] much faster. Patients would not get angry with us that we are not doing anything for them.* [H16P1, Head Nurse]

Interestingly, the participants also provided details on what mobile phone should hospitals provide to as a unit phone. However, participants were divided on whether a smartphone or a feature phone (nontouchscreen) should be provided. For some participants, providing a feature phone was ideal because it is more durable than a smartphone, and it is not susceptible to theft considering its low value. For instance, one participant shared that her area in the operating room needs "just a keypad cellphone. Like this [points to a feature phone]. It would not get easily destroyed or lost" (H10P1, Nurse Manager). In addition, feature phones could cover most of the staff nurses' needs because they only frequently used their smartphones to make calls and send text messages to colleagues:

> *A good situation is for each unit to have one [unit phone]. Just only a keypad phone [refers to feature phone], just for text and call. No camera. No applications. Just a keypad [phone].* [H3P1, Nurse Manager]

More importantly, feature phones are less likely to be used for nonwork purposes. According to one participant, she preferred a feature phone because this cannot be used to access social media or play mobile games:

> *Maybe we just need the ones with just keypads [feature phone]. You cannot really avoid that others might use it for FB [Facebook] or games. If it its only keypads, its only for call and text. They are limited to that because it's the only thing they need in the ward. That should be for all [areas].* [H17P3, Head Nurse]

On the contrary, some participants indicated a preference to have a smartphone as their unit phone because they intended to use it for documentation purposes. For these participants, being able to take pictures as a means of documentation can reduce their workload and provide visual evidence of certain conditions or events that need to be shown to colleagues as evidence. For instance, one participant shared that "we prefer a touchscreen [smartphone unit phone] because we have referrals that involve pictures and we send them" (H17P5, Head Nurse). Moreover, a participant shared the importance of having a smartphone for documentation in the emergency room:

> *We need something for documentation because it is important for us. For instance, the patient comes from ER [emergency room]. We endorse the patient in the [other] unit without any bedsore; it needs to be documented, so we need to take a picture of it.* [H1P3, Head Nurse]

Insufficient Unit Phones

Among the focus group sites, only 2 private hospitals (ie, Hospital 1 and Hospital 13) provided most of their staff nurses with a unit phone. These phones were all feature phones that were limited to making voice calls and text messages. However, despite the presence of unit phones in these hospitals, some participants shared that there were occasions on which their staff nurses needed to use their smartphones because not all of them can use the unit phone at the same time. For example, one participant shared that she has more than 17 staff nurses in the telemetry unit, and "nurses could not use the unit phone at the same time. That's why they use their personal phone" (H1P1, Head Nurse). Likewise, another participant argued that staff nurses' smartphones are much more accessible to use than the hospital's unit phones:

> *We need not share it [refers to their own smartphone]. If the doctor responded, you can easily respond to it without going back to the unit [nurses' work station] to answer the call from the doctor that you contacted.* [H1P2, Head Nurse]

Considering that Hospital 13, a private hospital, also had problems with insufficient unit phones in their hospital, one participant suggested that 3 staff nurses can share a unit phone:

> *It depends on how many are on duty. Sometimes there are three of them because two [staff nurses] plus the charge nurse, so three [nurses per unit phone].* [H13P1, Head Nurse]

Likewise, when asked how many unit phones might be sufficient for staff nurses in government hospitals, one participant indicated the "three nurses per one unit phone" ratio when she stated that:

> *Every shift, we are six [staff nurses and nurse administrators]. Maybe have two cellphones.* [H16P4, Nurse Supervisor]

Insufficient Unit Phone Credits

Although Hospital 1 and Hospital 13 provided unit phones as a strategy to reduce staff nurses' reliance on their own smartphones, participants from these hospitals noted that their hospitals do not necessarily provide them with sufficient credits to use the unit phone. In most cases, unit phones were under prepaid subscription, and credits should be added if consumed completely. Without any credits, unit phones become useless to contact colleagues. As a contingency, participants from Hospital 1 and Hospital 13 allowed their staff nurses to use their own smartphones when their unit phones ran out of credits:

> *There are times that our load [credits of the unit phone] is already used up, so I allow my nurses to use their own [smartphone].* [H13P1, Head Nurse]

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Similarly, another participant shared that as they are working in the emergency department, they need an immediate response from doctors. Unfortunately, their unit phone "does not always have a load [credits]. It is seldom that it has a load. So, we use our own cellphone" (H1P3, Head Nurse).

Some participants who had unit phones also noted that their hospitals only provided credits through prepaid cards every start of the month, and all of them expressed that this arrangement is not feasible because they can easily consume the credits within a couple of weeks. In most situations, some participants used their own money to purchase credits for the unit phone:

> *I shoulder the load [credits] for unlicalls [unlimited calls]. I use 95 pesos [About USD 2] per unlicall and text' that is valid for seven days. After seven days, need to load again. Like that. Really expensive.* [H1P3, Head Nurse]

An important reason on why credits are consumed quickly is that they often called a member of the health care team (mostly doctors) who had a different service provider. According to one participant, "It is expensive if you are subscribed in Globe to call someone who is subscribed to Smart" (H1P2, Head Nurse). In the Philippines, service providers charge more when users make voice calls to other service providers. For example, Globe Telecom [52] and Smart Communications [53] charge PHP 6.50 (about US $0.13) per minute for calling those with the same service provider and PHP 7.50 per minute (about US $0.15) to others. To avoid potential costs, some participants would ask who among their staff nurses has a smartphone with the same service provider as the one used by the intended recipient of the message or voice call. For example, one participant shared that they "use the cellphone provided by the management but sometimes we use our own cellphone because the line [service provider] is different" (H13P2, Head Nurse).

Policy Is Unrealistic to Implement

All 9 hospitals had policies on the use of mobile devices, which were written in hospital memos. Accordingly, hospitals can be divided based on the level of restriction placed on mobile devices. The first group is composed of 4 hospitals (ie, Hospital 5, Hospital 10, Hospital 13, and Hospital 17) that implemented a ban on the use of any mobile devices (whether for work or nonwork purposes) during working hours. It is interesting to note that all these hospitals were private institutions, and only Hospital 13 provided most of their nurses with unit phones. Conversely, the second group comprised 5 hospitals (ie, Hospital 1, Hospital 3, Hospital 8, Hospital 14, and Hospital 16) where the use of smartphones is banned for nonwork purposes but is allowed for work purposes.

Making an Exemption

Although Hospital 5, Hospital 10, Hospital 13, and Hospital 17 placed a ban on the use of any mobile devices, participants from these hospitals stated that they make an exemption by allowing staff nurses to use their smartphones for work purposes. This could be attributed to the fact that such policy was unrealistic considering that their hospitals did not provide staff nurses with relevant work-related technologies, such as mobile phones. According to one participant, although their hospital banned the use of any mobile devices, she shared that "you cannot avoid not to use it [smartphones] because it is a big help for nurses in terms of communication, especially when the doctors are not here" (H13P1, Head Nurse). Similarly, another participant shared that "we allow [the use of smartphones] if [it is] related to work, but it is not allowed if you would just use Instagram" (H17P5, Head Nurse).

For most participants, a blanket ban on smartphone use is difficult to implement as these devices were useful and necessary at work. One participant argued that "it is not absolute that we cannot use our phone" considering that "there is a need for us to use the phone [for work purposes]" (H5P3, Head Nurse). Moreover, another participant shared that a blanket ban on smartphones "is not realistic even there is a memo because it is difficult to enforce it" (H17P2, Nurse Supervisor). In Hospital 10, although they strictly implemented a ban on using mobile devices at work (this hospital has one of the lowest mean scores for perceived organizational support), a participant from that hospital argued that:

> *You cannot avoid not to use [smartphones for work purposes] especially during emergency cases. The ban for us is mostly for personal use.* [H10P3, Head Nurse]

Overall, there was a consensus among participants that the only time that they can implement a blanket ban on the use of mobile devices is when hospitals can provide sufficient technologies for staff nurses. An indication for this is when staff nurses need not use their smartphones completely for work purposes:

> *We need more [unit] phones so that they [nurses] can avoid using their personal phone. That is the time that they can fully implement a policy about no use of personal phone in the unit during duty hours.* [H1P1, Head Nurse]

Ban on Smartphone Use Only for Nonwork Purposes

On the contrary, 5 hospitals (ie, Hospitals 1, Hospital 3, Hospital 8, Hospital 14, and Hospital 16) had memos where the use of smartphones is banned for nonwork purposes but is allowed for work purposes. Of these hospitals, 2 are private (Hospital 1 and Hospital 8) and 3 are government hospitals (Hospital 3, Hospital 14, and Hospital 16).

Interestingly, although private hospitals such as Hospital 1 and Hospital 8 provided most of their nurses with unit phones, participants noted that their hospital still allowed staff nurses to use their smartphones for work purposes. Even though the participants described that their memos do not provide a definite list on how it should be used for work purposes, nurses could use their smartphones when there is an urgent need to communicate with colleagues (eg, sending text messages or making calls to colleagues). For example, one participant noted that their hospital issued a *Doctor's Notification Protocol* (H8P1, Head Nurse) as a basis for them to use their smartphones for work purposes. A colleague of that participant clarified that this protocol allowed nurses to use their smartphones to "inform doctors thru text [messages]" as the hospital had revised the old protocol "by including SMS messaging" as part of the protocol (H8P3, Head Nurse).

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In Hospital 1, although unit phones were provided, a participant expressed that their staff nurses can still use their smartphones "if there are important calls or emergencies" related to work (H1P4, Nurse Supervisor). Furthermore, another participant from Hospital 1 shared a policy that allows them to use their smartphones aside from unit phones in the emergency room:

> *The hospital requires that our referral needs to be answered [by the doctors] within 15 minutes. So, it is important to for us to call [using their own smartphone]. Texting is not reliable because sometimes it [the referral] is received late.* [H1P3, Head Nurse]

Considering that government hospitals lack adequate technologies for nurses to use, participants from Hospital 3, Hospital 14, and Hospital 16 noted that their hospital allowed the use of smartphones for work purposes and only prohibits their use for nonwork purposes. Although some participants noted that this is not an ideal policy and is the result of their hospitals' lack of health information technologies, they noted that it is a policy that enables health care staff to properly perform their duty despite resource constraints:

> *Actually, we have a memo from our chief nursing officer that using cellphone is prohibited particularly for personal use. But, definitely, our nurses can use the cellphone in referring our patients particularly in emergency cases. Now, let us say we caught them using their cellphone, we know that they are not using it for their personal consumption but definitely for referring our patients.* [H14P1, Nurse Supervisor]

Issues That Inhibited Support

This theme refers to organizational issues that inhibited nurse administrators from supporting staff nurses' use of smartphones for work purposes. Textbox 2 provides an overview of this theme.

Textbox 2. Issues that inhibited support.

Smartphone use for nonwork purposes

- Feelings of frustration and unprofessionalism
- Negative outcomes
- Disciplinary actions

Misinterpretation by patients

Smartphone Use for Nonwork Purposes

Although the participants allowed staff nurses to use their smartphones for work purposes, they were equally concerned that some were abusing such considerations by secretly using their smartphones for nonwork purposes. This eventually led them to inhibit support to staff nurses' use of smartphones for work purposes.

Feelings of Frustration and Unprofessionalism

When participants discussed details on staff nurses' use of smartphones for nonwork purposes, most of them showed a facial expression akin to frustration. This is expected because participants mostly shared statements that reflected frustration when discussing this issue. For instance, one participant shared her frustration over the non–work-related use of smartphones by staff nurses:

> *If you allow them to use cellphone [for work purposes], some are abusive. Sometimes they will tell you that they are trying to contact the doctor, however, what they are really doing is using it for FB [Facebook], playing games, [or] Instagram.* [H17P2, Nurse Supervisor]

Apart from feelings of frustration, some participants felt that such behavior did not look like what a staff nurse ought to be doing during the performance of his or her duty. As mentioned by one of the participants, although it is fine for staff nurses to use smartphones for work purposes, its use for nonwork purposes "does not look professional" (H14P1, Nurse Supervisor).

Negative Outcomes

Staff nurses' use of smartphones for nonwork purposes can lead to negative outcomes. Some participants shared that there were times that they did not want their nurses to use their smartphones because they become distracted. This sentiment is described by one participant:

> *There are times that I do not want them to use their phone because, in just a moment, they have time to chat and [play mobile] games.* [H13P5, Head Nurse]

Another outcome that participants were concerned regarding the use of smartphones for nonwork purposes is reduced work productivity. This concern was reasonable because all of them believed that smartphone use for nonwork purposes is highly distracting and can result in productivity loss:

> *When you see [them], you will think that they are just looking for something [that is related to work] but they are just playing games. It is not very good when it comes to work. Of course, if we are in the ward, we need to work. That is one bad impact of it. That is true because it slows down their work.* [H3P2, Nurse Manager]

For some participants, its use for nonwork purposes also reduced the quality of care because smartphones take away the attention that should have been given to patients. One culprit for this is the use of social media during working hours:

> *Today, they are not sleeping anymore, but they are using social media, [like] Facebook, during graveyard shift [10pm-6am]. Later, you do not realize that you*

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enjoy browsing and that you forgot that the patient has a due [order]. The work gets delayed, other routines for the patient get delayed. So, the quality of care is affected. [H1P1, Head Nurse]

Disciplinary Actions

Participants noted that they enforced disciplinary actions when they caught staff nurses using their smartphones for nonwork purposes. For most of the participants, the first thing that they did was to give verbal reminders that included some counseling. For instance, one participant shared that "if I caught them playing games, I remind them that we have a memo that using cellphone is not allowed in the operating theatre" (H10P1, Nurse Manager). Similarly, another participant mentioned that she usually calls the attention of her nurses and reminds them that they "have a policy that cellphones are not allowed during their tour of duty" (H17P2, Nurse Supervisor).

Consequently, some participants shared that they implemented preventive measures, such as asking nurses to place their smartphones inside lockers or cabinets. By asking the nurses to put it inside lockers prevented them from placing it in their pockets, which then reduced the tendency for it to be used for nonwork purposes. For instance, one participant mentioned that "their phone should not be even in their pockets. It should be in the locker" (H1P1, Head Nurse). In situations that there is a need for nurses to use their smartphones, they can get it from their locker:

We do not allow their own cellphone inside the OR [operating theatre]. They need to place it inside the locker. But sometimes, their phone rings and they need to pick it up, then they go to pick it up. [H13P2, Head Nurse]

To some extent, some participants shared that their hospital ordered nurse administrators to implement harsh disciplinary actions. Accordingly, if verbal reminders were not enough for repeat violators, nurse administrators could confiscate the smartphone as the next step:

I usually call their attention [upon seeing nurses using smartphones for non-work purposes]. Then I ask them to work on our stocks [materials in the operating theatre]. To some extent, for repeat violators, we confiscate their cellphones and we give it back after duty. [H5P5, Nurse Manager]

Aside from confiscation, participants in Hospital 10 asked violators to pay a fine when caught using smartphones for nonwork purposes. As mentioned by a participant from Hospital 10, "We have a fine of 100 pesos [about USD 2] then we confiscate the cellphone. They can get that after duty" (H10P1, Nurse Manager). Nonetheless, the hospital also made a record of such violations by asking staff nurses to file an incident report. For instance, another participant from Hospital 10 shared that "in our area, there is [a need to file] an incident report" (H10P2, Head Nurse). These findings somewhat indicate why Hospital 10 had one of the lowest perceived organizational support scores among all hospitals. Finally, there were instances that staff nurses were suspended from work as they were caught using smartphones for nonwork purposes:

There was an instance where the chief nurse caught some of our nursing staff watching something on their mobile phone and disciplinary action was given. It was work suspension. Three days for each [nurse]. [H5P4, Head Nurse]

Misinterpretation by Patients

Most of the participants shared that they cautioned staff nurses when using smartphones in front of patients as there is a tendency for patients to interpret that staff nurses use their smartphones for nonwork purposes. This issue was expressed mostly by participants from private hospitals because they cater to *pay patients*. Accordingly, pay patients tend to expect a higher standard of service than patients admitted in government hospitals where most are subsidized. This means that patients in private hospitals are relatively observant on how staff nurses conduct their work. For instance, a participant from Hospital 17 (a private hospital) shared that:

It is normal in my ward that a patient becomes angry because they thought that our staff [nurses] are texting [for personal use]. However, in that case, the nurse was only using it to count the drops of the IV [intravenous] fluids. [H17P2, Nurse Supervisor]

On the contrary, patients who are sick or in pain are generally sensitive, and they may easily complain when they feel neglected, especially when staff nurses use their smartphones, regardless of whether it is for work or nonwork purposes. For example, one participant shared that her patients in the delivery room "are in labor...in pain, so they are really sensitive," as a result, "if they see that you are holding your cellphone and you did not immediately address their need, these result in complaints" (H5P5, Nurse Manager).

Although it is difficult for the participants to oblige their staff nurses not to use their smartphones considering how necessary it is in their work, they advised them to use it discreetly and outside the view of patients. The aim of this advice is to ensure that patients do not feel neglected when staff nurses use their smartphones even it is for work purposes. For instance, one participant advised her staff nurses to use their smartphones "not in front of the patient" and should there be a need to use it, "they should hide so that the patient would not see them" (H14P3, Nurse Supervisor). In addition, another participant shared a vivid explanation of some considerations when staff nurses use their smartphones for work purposes:

What I advise them is to use it discretely and not obvious especially when there are other people walking and you look like doing nothing but just using the cellphone. If there are [work-related] calls, I would ask them to hide either in the CR [comfort room] or in our dressing room. Sometimes, nurses are doing work then the phone rings. They are not allowed to answer it since they are in front of other people. So, they need to hide. [H10P5, Head Nurse]

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Discussion

Issues That Encouraged Nurse Administrators to Support Nurses' Use of Smartphones for Work Purposes

One of the key findings is that a hospital's lack of adequate health information technologies can drive (or force) nurse administrators and staff nurses to be resourceful in using an existing technology that they can use in their work regardless of policy constraints. This is somewhat expected in most, if not all, hospitals in the Philippines because the deployment and implementation of even the most basic forms of health information technologies (eg, electronic health records) are lagging [28].

In the context of this study, problems encountered by nurse administrators with existing hospital communication technologies (eg, landline telephones and intercom) served as a justification for them to allow their nurses to use smartphones for work purposes. As a result, this led nurse administrators to support the use of smartphones for work purposes to overcome problems associated with existing workplace technologies. This is expected considering that nurses have a moral responsibility to take care of patients, and technologies, such as smartphones, can serve as a bridge to address health care gaps, especially in low-resource settings [21,54].

Apart from problems with existing workplace technologies that made personal smartphones more superior, the absence of unit phones, and its credits, served as another reason for nurse administrators to allow staff nurses to use smartphones for work purposes. Similarly, when unit phones lack the necessary credits to be functional, nurse administrators have no choice but to allow their staff nurses to use their smartphones. Although the issue regarding the absence of unit phones is expected in most hospitals in developing countries [54], it is interesting to note that studies conducted in locations where health information technologies are expectedly robust, such as in Australia [55] and Taiwan [19], also showed that nurses used their smartphones for work purposes because it is not provided to them by the hospital. Overall, the findings indicate that smartphones are now essential in the work of staff nurses, and nurse administrators would allow their use, especially when hospitals do not provide adequate unit phones and credits to their nurses.

Another key finding of this study is that a blanket ban policy on mobile devices did not deter nurse administrators' decision to allow staff nurses to use smartphones for work purposes because such policy was perceived to be unrealistic. In general, the findings are contrary to previous studies in which nurse administrators tend to be unsupportive of nurses' use of smartphones [14,15], considering that nurse administrators in this study were generally supportive of smartphone use as long as it was used solely for work purposes. Although allowing staff nurses to use smartphones for work purposes contradicts a hospital's blanket ban policy on mobile devices, this policy can only be implemented realistically if a hospital provides nurses with adequate technologies. Unfortunately, this is not the case for most hospitals in the Philippines considering that deployment of health information technologies is relatively low [28].

Recognizing the limitations present in their workplace, nurse administrators tend to take a pragmatic approach to BYOD policies by implementing the ban only for smartphone use for nonwork purposes. Therefore, hospitals that implement a blanket ban on mobile devices and do not provide adequate technologies to their nurses will have a difficulty in implementing such a policy, and it is expected that there will be a disconnect between policy and practice [14]. As argued by Johansson et al [56], the use of smartphones by nurses is a means to support their practice and is not primarily an outcome of policies implemented by hospitals. Although the findings are generally reflective of circumstances in developing countries [8,21], the disconnect between policy and practice regarding smartphone use among nurses is also a concern in developed countries, such as in the United States [14,57], the United Kingdom [46], Canada [58], Australia [55], and Italy [22]. As argued by Flynn et al [57], the disconnect between policy and practice implies that hospital administrators should develop and implement realistic policies that recognize the increasing role of smartphones in clinical practice.

Issues That Inhibited Nurse Administrators to Support Staff Nurses' Use of Smartphones for Work Purposes

Although staff nurses generally used their smartphones for work purposes, it is inevitable that some would use it for nonwork purposes, such as playing mobile games, making personal calls and text messages, and accessing social media [14-16,18,20,22,44,58]. This tends to result in feelings of betrayal and perceptions of unprofessional behavior. According to researchers [14,15], the prospect of nurses using their smartphones for nonwork purposes is unprofessional because it does not align with the ethical and legal standards that define the profession.

Nonetheless, for nurse administrators, the use of smartphones for nonwork purposes is a concern because it is a prime source of distraction that can reduce productivity and the quality of care rendered to patients [20-22,44,45]. This finding is consistent with a recent study in which non–work-related use of smartphones was found to be negatively associated with perceived quality of care and perceived work productivity [18]. Given these negative outcomes, it is expected that some nurse administrators may not support nurses' use of smartphones, whether it is for work or nonwork purposes.

The negative outcomes resulting from nurses' use of smartphones for nonwork purposes also led nurse administrators to enforce disciplinary actions against offenders. Similar to the findings of the study by Brandt et al [14], most nurse administrators tend to use verbal reminders and counseling as first-level interventions. Other disciplinary actions were also implemented, such as placing smartphones inside the locker, confiscation, and, to a certain extent, suspension [14]. However, what is novel in this study was the implementation of fines as no previous study has documented this form of disciplinary action. Although a fine of PH*P* 100 (about US $2) might seem little, this is a significant amount of money for staff nurses in the Philippines because it can constitute about one-fifth of their daily wage. In general, the results show that nurse administrators do not tolerate the use of smartphones for nonwork purposes,

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and they implement various forms of disciplinary actions to deter non–work-related use of smartphones.

Another issue found in this study was that nurse administrators were conscious of patients misinterpreting nurses' use of smartphones. Such a concern was reflected in studies in the United States [59], Canada [58], and Sweden [56]. Although this issue did not prompt nurse administrators to completely ban the use of smartphones among their nurses, they advised the nurses not to use it in front of patients to reduce the chances of receiving complaints. A potential reason for giving such advice is that nurse administrators must maintain a good nurse-patient relationship. According to Pullen and Mathias [60], an essential aspect of this relationship is the preservation of mutual respect between the nurse and the patient. Considering that nursing is a patient-facing work [59], it is important for nurse administrators to make sure that nurses give patients the highest possible level of respect.

Limitations

This study recognizes that the organizational issues were limited to focus groups with nurse administrators. Ideally, these issues should come from interviews with a variety of hospital stakeholders (eg, health care professionals, hospital administrators, and patients). As a recommendation, future studies can be geared toward including other health care professionals when it comes to identifying organizational issues related to nurses' use of smartphones for work purposes.

Conclusions

This is one of the few studies to use OST as a framework to examine the influence of organizational issues on organizational support within the context of IT consumerization in clinical settings. Therefore, future studies can incorporate this theory when examining organizational issues brought upon by IT consumerization. Apart from theoretical insights, the study can be used as a basis for developing appropriate BYOD policies in organizations where IT consumerization is an organizational issue. Although the findings are in the context of health care, these can also be applicable to non–health care organizations where IT consumerization is prevalent.

Acknowledgments

This study was supported by a research grant from the Wee Kim Wee School of Communication and Information, Nanyang Technological University (M4081905.060).

Conflicts of Interest

None declared.

Multimedia Appendix 1
Coding table.
[DOCX File , 17 KB - nursing_v3i1e17040_app1.docx]

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Abbreviations

BYOD: bring your own device
OST: Organizational Support Theory
PHP: Philippine Peso

Edited by G Eysenbach; submitted 12.11.19; peer-reviewed by F Cagayan, M Pandey; comments to author 05.12.19; revised version received 06.12.19; accepted 16.12.19; published 10.01.20.

Please cite as:
Bautista JR, Lin TTC, Theng YL
Influence of Organizational Issues on Nurse Administrators' Support to Staff Nurses' Use of Smartphones for Work Purposes in the Philippines: Focus Group Study
JMIR Nursing 2020;3(1):e17040
URL: https://nursing.jmir.org/2020/1/e17040
doi:10.2196/17040
PMID:

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Original Paper

The mPOWERED Electronic Learning System for Intimate Partner Violence Education: Mixed Methods Usability Study

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Abstract

Background: Nurse practitioners are a common resource for victims of intimate partner violence (IPV) presenting to health care settings. However, they often have inadequate knowledge about IPV and lack self-efficacy and confidence to be able to screen for IPV and communicate effectively with patients.

Objective: The aim of this study was to develop and test the usability of a blended learning system aimed at educating nurse practitioner students on topics related to IPV (ie, the mPOWERED system [Health Equity Institute]).

Methods: Development of the mPOWERED system involved usability testing with 7 nurse educators (NEs) and 18 nurse practitioner students. Users were asked to complete usability testing using a speak-aloud procedure and then complete a satisfaction and usability questionnaire.

Results: Overall, the mPOWERED system was deemed to have high usability and was positively evaluated by both NEs and nurse practitioner students. Respondents provided critical feedback that will be used to improve the system.

Conclusions: By including target end users in the design and evaluation of the mPOWERED system, we have developed a blended IPV learning system that can easily be integrated into health care education. Larger-scale evaluation of the pedagogical impact of this system is underway.

(JMIR Nursing 2020;3(1):e15828) doi:10.2196/15828

KEYWORDS

intimate partner violence; domestic violence; nursing education; learning

Introduction

Background

Violence in interpersonal relationships is a substantial health and social problem in the United States, with approximately 1 in 4 women and 1 in 7 men in the United States reporting being a victim of intimate partner violence (IPV) at least once in their lifetime [1]. This is particularly concerning given that IPV victimization often results in adverse psychological problems (eg, posttraumatic stress, depression, and low self-esteem) [2]; harmful health behaviors (eg, substance abuse) [3]; risky sexual behaviors [4]; and physical injuries that range from relatively minor injuries to disfigurement, permanent disability, life-threatening injuries, and death.

Although IPV affects everyone regardless of age, socioeconomic status, sexual orientation, gender, race, religion, or nationality,

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research has demonstrated that lesbian, gay, bisexual, transgender, or queer (LGBTQ) individuals experience IPV at rates that are similar to or higher than heterosexual individuals [5,6]. Similarly, ethnic minority women are affected disproportionately by IPV [7], with further disparities noted when individuals are of low socioeconomic status and of foreign-born status [7]. However, the reasons why LGBTQ individuals and ethnic minority women do not seek formal help from health care providers differs. LGBTQ individuals state that they are often reluctant to seek formal help when services tailored to LGBTQ individuals are not available, when health care providers are not sensitive to LGBTQ issues, when they distrust providers, when they fear *coming out* to their provider, and when they believe that the abuse would not be taken seriously [5]. In contrast, perceived discrimination, immigration status, and mistrust of medical professionals are barriers to ethnic minority women reporting or seeking support for IPV [7]. There is strong evidence that persons with a history of IPV have higher health care utilization rates than persons with no history of IPV [8], even if their visit is unrelated to the abuse [9]. In addition, the increased use of health care resources by abuse survivors does not end when IPV ends, but it continues for up to 16 years after the abuse ends [10].

More than 75% of practicing nurse practitioners provide care in primary care settings [11] and are in the unique position to play a vital role in identifying and evaluating IPV, providing assistance and support to victims, and linking victims to specialized support services [12,13]. Unfortunately, the extant literature indicates that many nursing professionals exhibit poor levels of content knowledge and competence that negatively influence their ability to broach the topic with patients and respond in an appropriate manner [14-16]. Although the US Preventive Services Task Force recommends that women of childbearing age be screened for IPV by their clinician at each visit and that interventions or referrals should be provided as indicated by screening results [17], clinicians identified lack of IPV knowledge and confidence as barriers to screening [18,19].

An effective method by which nurses' skills and knowledge about IPV screening and intervention can be improved is to educate them on the dynamics of IPV and the importance of intervention and appropriate care [20,21]. IPV is included to some degree in all prelicensure registered nursing programs in the United States to prepare students for their National Council Licensure Examination. The extent of education, method of education (didactic, simulation, and Web-based modules), and where in the curriculum (psychiatry/mental health and foundations of nursing) it is included are not standardized, resulting in students enrolled in postmasters nurse practitioner certificate programs having varying degrees of IPV knowledge.

The blended learning approach that is becoming an increasingly widespread approach in higher education institutions might provide a useful way to augment face-to-face nursing education regarding IPV. In addition to improving learning satisfaction, communication self-efficacies [22], and knowledge [23,24], blended learning environments also promote flexible student learning [25]; learner autonomy [26]; and self-reported reasoning, decision making, and metacognition [24]. Completion of Web-based education on falls risk assessment resulted in undergraduate nursing students' (NSs) increased knowledge and report of increased self-efficacy when performing a falls risk assessment on an older adult [27], suggesting the effectiveness of Web-based education on NSs' ability to translate theory into practice.

In summary, there is good evidence to support the integration of Web-based modalities to augment face-to-face nursing education. However, successful implementation of a blended learning system requires careful thought about how the course content will be delivered [28,29], how instructors and students can successfully use the technology, and how the system will support different learners within various learning contexts. To ensure that the system can achieve these goals, electronic learning (e-learning) products should undergo evaluation to identify usability problems and measure product usability. A pedagogical usability framework integrates aspects of standard usability testing (ie, effectiveness, efficiency, and satisfaction) [30], while also addressing the usability features specific to the design of e-learning systems (eg, learner control, motivation, flexibility, and feedback). Thus, usability in the context of e-learning systems concerns whether the elements and content of the system enable students to achieve learning goals with positive learning experiences [31]. In this study, we conducted a pedagogical usability testing [32] of the mPOWERED system for comprehensive health care provider–focused IPV education (Health Equity Institute) and to determine the acceptance of the system and its features in United States–based nurse educators (NEs) and NSs.

The mPOWERED System

Existing literature indicates that interventions and treatments focused on reducing IPV must address myths and misconceptions and provide IPV-related training that is based on up-to-date and geographically and culturally contextualized empirical evidence. Using the most current empirical evidence and input from NEs and IPV health care providers, the current version of the mPOWERED system comprises 4 modules (Figure 1).

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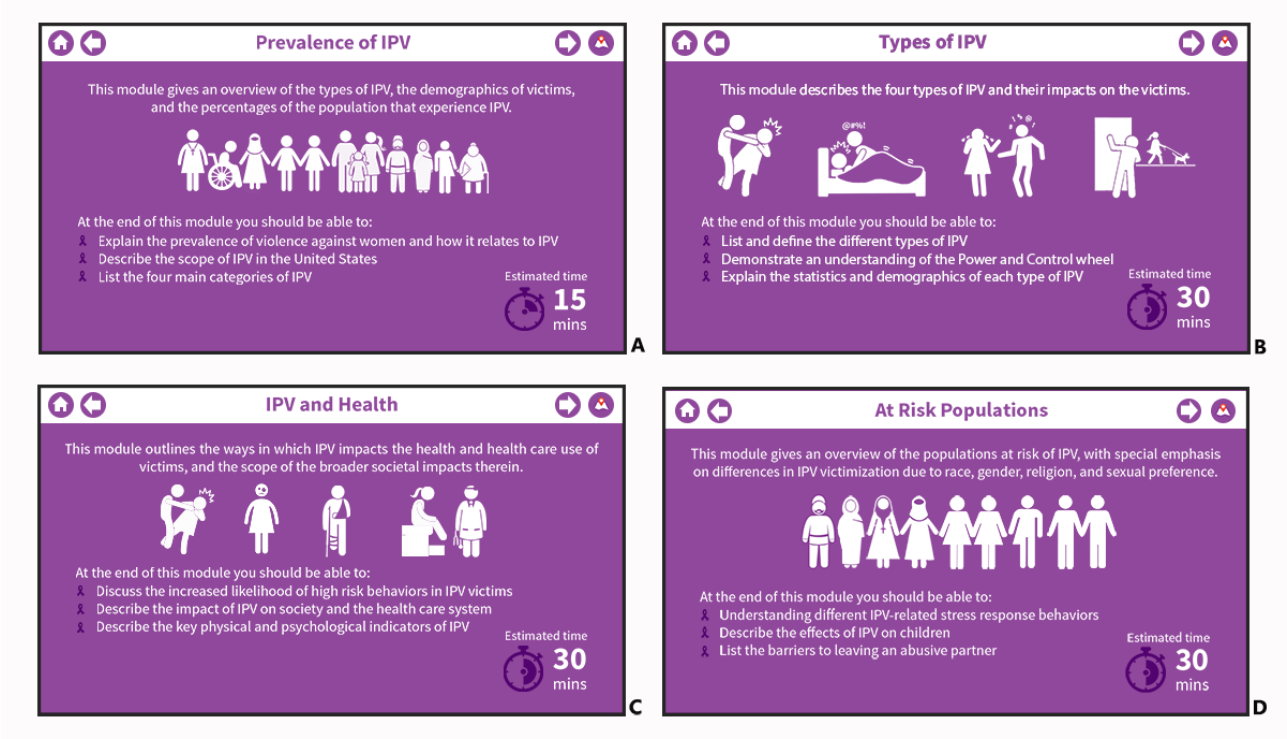
Figure 1. Screenshot of the 4 mPOWERED system modules: (A) Prevalence of Intimate Partner Violence (IPV), (B) Types of IPV, (C) IPV and Health, and (D) At-Risk Populations.



The first module (*Prevalence of IPV*) focuses on definitions of abuse and violence, distinguishing between IPV myths and facts, and acknowledges preexisting values, attitudes, beliefs, and experience held by nurses and how these influence a nurses' interaction with patients. The second module (*Types of IPV*) defines the 4 types of IPV (ie, physical violence, sexual violence, psychological violence, and stalking), explains the statistics and demographics of each type of IPV, and presents the multicultural power and control wheel [32] to help the NSs and NEs understand how an abuser uses power and control to establish and maintain control over a partner. The third module (*IPV and Health*) discusses the increased likelihood of stress-response behaviors in IPV victims and describes the impact of IPV on society and the health care system as well as the key physical and psychological indicators of IPV. The last module (*At-Risk Populations*) introduces vulnerable populations who are at higher risk of IPV victimization (eg, LGBTQ people and ethnic minorities), describes the effects of IPV on children, and lists the barriers to leaving an abusive partner.

The graphical components of the mPOWERED system were designed using Adobe Creative Suite in accordance with Mayer's principles of multimedia design [33]. InVision prototyping software was used to transform the static design into a clickable and interactive prototype. Participants completed the usability testing on the interactive InVision prototype using a 7-inch Android tablet (Samsung Galaxy Tab A), where they were able to click on custom-built hotspots to navigate the prototype.

Methods

Sampling and Recruitment

To gain the necessary insight into the needs, requirements, and expectations of the mPOWERED system, semistructured interviews were held with NEs and NSs from the San Francisco Bay Area. To be eligible to participate, NEs needed to have experience of working in clinical settings and sufficient experience of teaching in nurse education programs. NSs were eligible to participate if they were currently enrolled in a nurse practitioner certificate program at a US university. Research from the field of usability testing indicates that 80% of usability issues that can be identified in wider implementation will be identified with samples as small as 4 to 5 participants [28]. With that in mind, we used purposive sampling to recruit a maximum variation sample of *key informant* NEs and NSs with nursing experience and clinical practice, as this method provides rich insights into the research topic. Before data collection, ethics approval was granted by the San Francisco State University Institutional Review Board.

Data Collection and Analysis

Method triangulation was used to increase the validity of findings and gain a more comprehensive understanding of pedagogical usability issues [34]. Specifically, the usability of the mPOWERED system was evaluated utilizing cognitive walkthrough using a concurrent think-aloud method [35], semistructured one-on-one interviews, and a questionnaire with Likert scale and open-ended questions.

At the start of testing, participants were familiarized with the mPOWERED system for approximately 5 min. The participants then performed 4 tasks of varying levels of complexity that

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covered the full range of functions offered by the mPOWERED system: (1) log in to the system and read through the introduction to the system, (2) work through the first module (*Prevalence of IPV*) and complete the interactive quiz, (3) access the system settings and go to the help center, and (4) work through the fourth module (*At Risk Populations*) and periodically check your progress via the roadmap.

As participants were navigating their way through these tasks, they were encouraged to vocalize anything that crosses their mind (eg, thoughts about any aspect of the system that they liked or disliked, found easy or difficult to understand, or found confusing or contradictory and when they encountered technical difficulties). In addition, participants could receive help from the moderator if they encountered problems or could not manage to go further in the system.

Immediately following usability testing, participants were asked a series of semistructured questions on the perceived usefulness, ease of use, and clarity of information of each system module as well as their experiences and perceptions of the mPOWERED system. The goal of this process was to obtain the participants' immediate interpretation of a given task scenario and system design and to facilitate the elaboration of usability issues and increasing insight and design suggestions [36]. During this phase, participants were encouraged to discuss the situations where they encountered problems or expressed concerns and then discuss the possible causes of the situation or possible design changes that could be implemented to address the identified issues.

After testing, participants completed a Web-based survey implemented using Qualtrics Web-based survey software that contained questions about the perceived usability of the system, participant demographics (age, gender, position title, and prior experience with IPV), and technology use. The perceived usability of the system was evaluated by the 39-item e-learning usability questionnaire [37] and open-ended questions. The e-learning usability questionnaire measures respondents' perception regarding the usability of e-learning apps along 7 dimensions of usability (content, learning and support, visual design, navigation, accessibility, interactivity, and self-assessment and learning). The statements were rated on a 5-point Likert scale, with statements ranging from strongly disagree (1) to strongly agree (5), and open-ended questions related to usability. The e-learning usability questionnaire has demonstrated high Cronbach alpha values (>.94), indicating an excellent internal consistency that is adequate for usability testing. Open-ended questions provided participants with the opportunity to write freely about mPOWERED features they found the most/least useful and the barriers to using the system to augment IPV education. Example questions included "What are your opinions (visual design, navigation, etc) of the mPOWERED system" and "What problems did you experience while using the mPOWERED system."

To evaluate respondent's prior experience with IPV, we first provided the Centers for Disease Control and Prevention's definition of IPV and then asked "With this definition in mind, please mark all of the following categories in which (to your knowledge) intimate partner violence has occurred, or is currently occurring," with the following categories: (1) in your personal experience, (2) immediate family members, (3) close friends, (4) extended family and friends, (5) coworkers or clientele in a work environment, and (6) no instances of IPV. If the participants responded in the affirmative to categories (1) to (6), they answered a follow-up Likert scale question regarding the cumulative number of instances of IPV that occurred in each selected category. Response options for this question were (1) never, (2) once, (3) more than once, (4) a few times, and (5) many times.

With prior approval of the participants, the interviews and focus groups were video recorded using Morae usability and analytics software. All participant and moderator comments along with feedback were independently transcribed using qualitative content analysis [38,39] by 2 members of the research team. Themes generated from the content analysis were mapped to usability heuristics for e-learning systems [30,37]. The usability heuristics are (1) content, (2) consistency and mapping, (3) visual design, (4) navigational fidelity, (5) accessibility, (6) interactivity, (7) self-assessment and learnability, (8) match with the curriculum, and (9) understandable and meaningful symbolic representations. Interresearcher consistency was evaluated by exchanging coded sections of the transcripts, with initial codes and themes reviewed for a second time. When disagreements arose, the researcher made comments on the codes/themes and suggested changes to the coding classification. Disagreements around themes were resolved by an in-person research team discussion until consensus was reached and a final theme was agreed upon [39].

Results

Participants

The participants' characteristics are reported in Table 1. Overall, 7 NEs from San Francisco State University and 18 NSs participated in this study. The mean age of NEs was 58.4 (SD 10.6) years, with 1 individual self-identifying as a man, 5 individuals self-identifying as a woman, and 1 individual self-identifying as genderqueer. The mean age of NSs was 37.0 (SD 6.6) years, with most of the students self-identifying as female (3 men and 16 women). The respondents self-reported a high level of computer use and literacy and diverse personal experiences with IPV.

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Table 1. Participants' demographics, clinical and teaching experience, electronic learning, and intimate partner violence experience.

Characteristics	Nurse educators	Nursing students	Overall
Age (years), mean (SD)	58.4 (11)	37 (7)	47.7 (15)
Gender, n (%)			
Male	1 (14)	3 (16)	4 (15)
Female	5 (71)	16 (84)	21 (81)
Genderqueer	1 (14)	0 (0)	1 (4)
Ethnicity, n (%)			
Caucasian	2 (29)	5 (28)	7 (28)
Black/African American	1 (14)	__[a]	1 (4)
Asian/Asian American	3 (43)	9 (50)	12 (48)
Hispanic/Latino	1 (14)	2 (11)	3 (12)
Hawaiian or Pacific Islander	—	1 (6)	1 (4)
Other	—	1 (6)	1 (4)
Clinical experience (years), n (%)			
<1	—	4 (22)	4 (16)
1-5	—	4 (22)	4 (16)
5-10	1 (14)	6 (33)	7 (28)
>10	7 (100)	4 (22)	11 (44)
Teaching experience (years), mean (SD)	12 (3)	N/A[b]	—
Mobile devices to facilitate learning, n (%)			
Daily	4 (57)	13 (72)	17 (68)
Twice weekly	2 (29)	3 (17)	5 (20)
Twice monthly	1 (14)	2 (11)	3 (12)
IPV [c] experience, n (%)			
No instances of IPV	—	2 (11)	2 (8)
Current or past relationships	2 (29)	6 (33)	8 (32)
Immediate family members	1 (14)	8 (44)	9 (36)
Close friends	2 (29)	6 (33)	8 (32)
Coworkers or clientele in a work environment	3 (43)	6 (33)	9 (36)

[a]No respondents.

[b]N/A: not applicable.

[c]IPV: intimate partner violence.

System Usability

Overall, 3 themes emerged from the data to describe NEs' and NSs' views about the usability of the mPOWERED system. These were (1) ease of use, (2) usefulness, and (3) aesthetics. Selected ad verbatim quotations from the interviews are presented to illustrate these themes.

Ease of Use

This theme included the subthemes content presentation and navigational fidelity. The general opinion among respondents was that IPV content was presented in small understandable chunks (NE mean 4.86; NS mean 4.71) and in a way that supports learning (NE mean 4.86; NS mean 4.65):

I like that you guys broke it down into modules, like small little chunks. And that you can do the quiz and see the answers right away. Yeah, full of rich information. [NE3]

I would say this was put forth very well, because you don't overwhelm in a module. I have modules for nursing where there's 27 topics just in one, in one go- so it's really hard to remember some of that stuff. But here, you've outline- to me the most important things that you've highlighted is the prevalence of IPV, who are the victims- so we know that it's pretty much all ages, um all socioeconomic um demographics. And you've included statistics as well,

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and the types of IPV. So I think that it's presented very straightforward, not too much. [NS18]

An important facet of e-learning and blended learning is enabling the learner to control the amount of material they consume as well as when they learn the material. Usability testing indicated that most respondents found that the mPOWERED system enabled them to control the pace of learning (NE mean 4.43; NS mean 4.71), with 1 NS reporting:

I like that this whole system is very simple and straight forward. It makes it easier. I think any students who are using this will enjoy it, and it's not really a looong, dry, or boring lecture. It's actually quite interesting. It keeps it very simple to the point. [NS5]

Participants felt that content was presented in a consistent manner (NE mean 4.71; NS mean 4.59) but mentioned that integrating audio narration into the system would emphasize the organization of key points in the material and reduce the overall cognitive demands placed on the user:

There is a lot of statistics and a lot of information, like minute information. So I would say having this presentation narrated it's gonna be helpful. And forcing the reader to stop and look at the different types of x, y, and z. [NE6]

Usefulness

Aspects of usefulness included consistency with the curriculum and system interactivity. Overall, both NEs and NSs expressed liking the mPOWERED system, finding that the content was congruent with the manner in which IPV content is taught in the classroom setting (NE mean 4.86; NS mean 4.65):

I thought this was an excellent way to present IPV to students. It was informational, provided interaction with the module, and user friendly. [NS5]

Participants were of the view that the mPOWERED system could augment classroom learning of IPV (NE mean 4.86; NS mean 4.45), with all NEs stating that the system added flexibility in the teaching and learning environment, and would allow them to have deeper and richer teacher-student interactions during in-person classroom meetings:

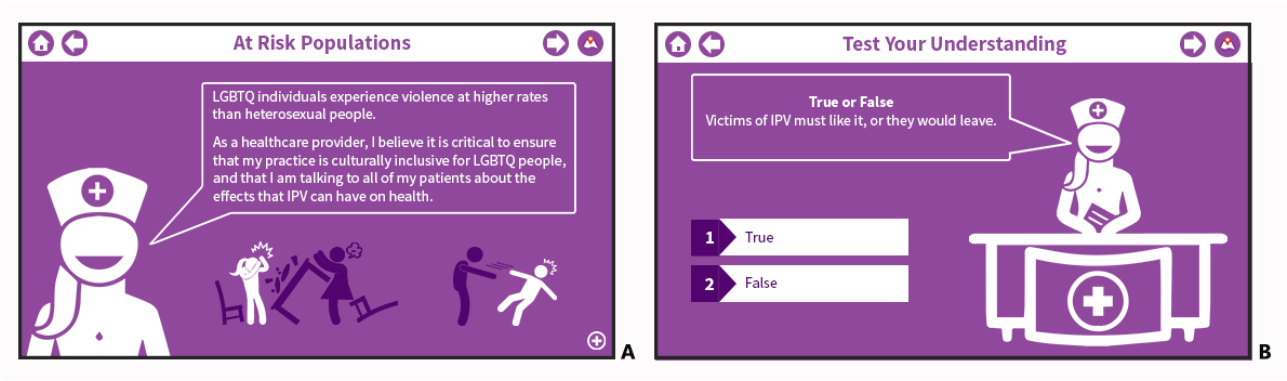
I would use it to do, like before going to class for the lecture. Cos [Because] that will have them primed to start conversations and share stories about IPV, whether they know about it, or heard about it, or seen it, in a clinical setting. [NE4]

Participants also stated that the mPOWERED system engaged the user (NE mean 4.71; NS mean 4.61) and motivated them to learn about IPV (NE mean 4.43; NS mean 4.71). This was especially true for the short multiple-choice quizzes at the end of each module. Both NSs and NEs unanimously felt that quizzes encouraged active learning and especially appreciated that the system provided adaptive feedback on students' answers after each question:

I like the quiz because it's interactive and you click on it and it gives you the answer right away. As opposed to answering the questions and then having the answers at the end. So I like this format. So keep that definitely. [NE3]

One facet of the mPOWERED system that NSs particularly liked was the health care provider slides (see Figure 2) that students believed helped reinforce the content of the mPOWERED system:

Figure 2. Exemplar screenshots of a (A) health care provider slide and (B) interactive quiz question.



My favorite thing is the doctor/nurse speaking to you at various junctions of the program. This strengthens the messages. [NS15]

Love the use of "I," and the communicative approach. [...] She's telling you this. That's what I first thought at the beginning, I really like that you've kept it going throughout. [NS18]

In contrast, many NEs did not like the health care provider slides, with respondents expressing a dislike for the first-person perspective:

It was distracting and it made me think "oh well ok, they are trying to plant the seed in my head that I'm supposed to think this way." I see it as a distraction and the way I perceived it in my head is that they were trying to subconsciously make me think that way. [NE4]

In general, participants were satisfied with the mPOWERED system, finding that it improved their understanding of the content material. However, both NSs and NEs stated that the system content should be expanded to include information regarding identifying and evaluating IPV and how to offer first-line support for IPV:

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Well this just says how it impacts, it doesn't tell me what I can do. [NE5]

This tells me about it [IPV], but not what we do about it. I'd want to know what to do. [NS18]

Aesthetics

The theme aesthetics explored aspects including visual design and understandable and meaningful symbolic representations. First, there was a high level of satisfaction among the NSs and NEs regarding the balance between text and graphics on each slide (NE mean 4.78; NS mean 4.82), with participants reporting that the IPV-related icons were easy to interpret (NE mean 4.57; NS mean 4.18):

I think the size of the icons are good here, they are clear as to what they represent...These as well. So without the words I could likely put together a lot of>what's going on here. [NS4]

The icons are good. They're pretty straightforward, in terms of like if you took away the titles you could probably deduce what they're meaning. [NE5]

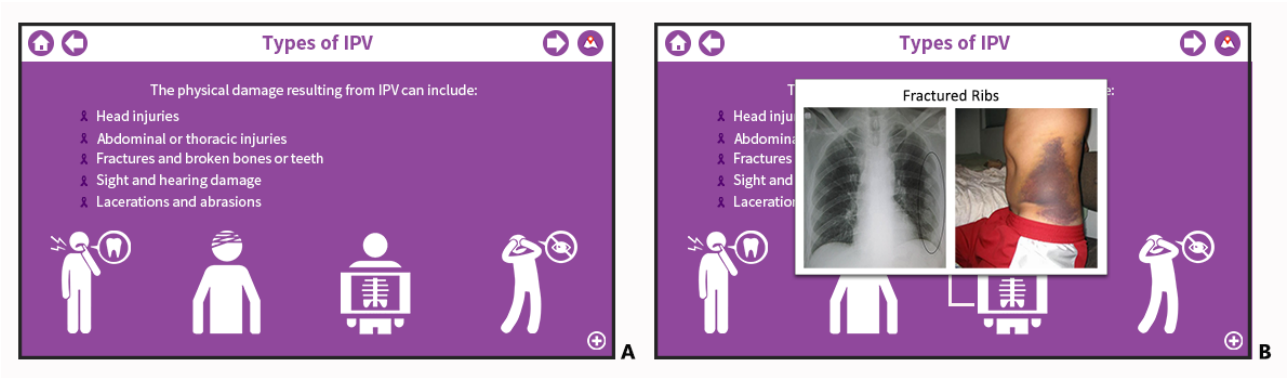
In addition to comments about the symbolic representations, the use of icons to illustrate IPV-related scenarios was well received by participants and conveyed the seriousness of the issue in a compelling fashion (NE mean 4.71; NS mean 4.18):

I do really like the pictures. Yeah, those are good. I think it shows distress in a sense that, I guess it's just a matter of visualizing the significance of violence, you know? And kind of seeing what someone is going through in the intimacy of their home and just kind of seeing it as a kind of significant thing. It has this emotional thing where you are more connected to the content. You think it could come off as cheesy, or minimizing it, like characters getting beaten up. But I think it helps you just understand the importance of "this is what someone is going through." And especially in this particular way, and seeing the way the body is contorted, it doesn't make it so graphic. But it still is kind of like "ohhh". [NE3]

I like the fact that its pictures, and not real people. Cos [Because] that doesn't sit well with me when I watch actors screaming at each other. [NE4]

That said, others suggested the use of real graphics to improve the graphical depiction of scenarios. For example, 1 NS recommended adding actual photos to the system to complement the existing icons (see Figure 3):

Figure 3. Screenshots of (A) initial and (B) modified intimate partner violence (IPV) and health module slides revised to medical images and radiologic findings of physical injuries associated with IPV.



You know, actually, for healthcare professionals or people that you want to show this information to I think real photos would probably really hit home. In terms of like drawing them into the emotional side, the magnitude of what's going on. [NS18]

In general, participants felt that the system avoided reinforcing negative stereotypes (NE mean 4.43; NS mean 4.59), with icons portraying diverse demographics and numerous situations in which IPV can manifest itself. However, 1 NE with expertise in LGBT issues felt that some of the icons were too stereotypical and outdated:

Here's another thing to think about. Its binary, it's always women and men. I think that's something that we are having to look at when we are discussing things now. Is it important to say women and men, or people who identify as women, or people who identify with me. Because I would say this number shoots up when it is a transwoman. And actually a transman. Actually they are really vulnerable in relationships. [NE2]

In general, this is men on women, which I think for nurses I think that they should understand that there are different types of violence. Like slashing his tire wheels, cutting up his clothes that are in his closet...I would want to see it if we are teaching all sorts of health professionals for it to be more broader. [NE2]

Discussion

Principal Findings

The aim of this study was to conduct usability testing of the mPOWERED system of IPV education and to determine the acceptance of the system and its features among NEs and NSs. Overall, the mPOWERED system was well accepted by most respondents as an alternative teaching/learning modality. Participants' comments suggest that the ease of navigating the system and amount of content were appreciated and that the e-learning system provides a user-friendly, visually appealing

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means that can alleviate the difficulty of adding IPV education in already content-heavy nursing program curriculums [40].

Positive user experience is of prime importance to educators and educational systems. As adult learners, students are more engaged when learning directly relates to their professional career [41]. Framing information from the perspective of a health care professional, and including audio case studies in the mPOWERED system, provides context to the IPV education and its relevance to the participant's role in the nursing profession. The inclusion of statistical information with direct links to the empirical evidence enables educators to easily update content, thus ensuring that the users can directly access current information. The ability to review information and receive immediate feedback on each test question were positive aspects of the mPOWERED system that participants specifically commented on and felt meet the needs of the self-directed adult learners.

The usability of e-learning software products is a key characteristic to achieve the acceptance of academic users [42] and health care professionals regardless of their background, experience, or orientation [43]. The usability testing and semistructured interviews uncovered aspects of the mPOWERED system that can be improved and expanded in future developments. First, our original intent during icon development was that the icons should be quickly recognized and processed, while at the same time avoiding sensationalizing and trivializing this serious public health issue. Although both NSs and NEs liked the icons and thought that they were easy to interpret, 1 NE with expertise in LGBT issues felt the mPOWERED system could be improved by updating the "too stereotypical and outdated" icons. There is evidence that the interpretation of health-related icons is influenced by interrelating factors (eg, culture and literacy) [44], and as such, we will employ user-centered design methods to evaluate user's responses to the health information visualization icons when modifying the current modules and developing additional modules of the mPOWERED system.

Second, participants expressed that adding medical images and radiologic findings to the mPOWERED modules would provide users with realistic images that could facilitate the identification and evaluation of IPV. Cognizant of the fact that 25% of women and 10% of men in the United States have been a victim of IPV during their lifetime [45] and that realistic images may trigger extreme emotions, we decided to implement the realistic images via a modal window (ie, a window element that sits on top of an app's main window) that users could access by clicking on the relevant icons (see Figure 3) rather than having the medical images appear directly in the lesson content pages.

Third, participants commented that the mPOWERED system should include a module providing evidence-based information on how to (1) identify and evaluate IPV and (2) offer first-line support for individuals experiencing IPV. The expressed desire for this specific additional information is consistent with the literature indicating that the lack of education and training poses a significant obstacle to IPV screening and support [18,19], and the next mPOWERED system modules to be developed will focus on first-line responses. This is especially relevant for nurse practitioner students who will be practicing in primary care settings. In addition, our future plans include integrating modules focusing on the root causes of IPV (ie, power and control) using an empowerment and gender equality framework.

This study makes a number of unique contributions to the development of blended learning systems for health care–related topics. Using a purposive sample methodology, we were able to get feedback from participants who would likely use this technology, both from the perspective of the educator and the student. After implementation of suggested changes, we plan to evaluate the pedagogical impact of the mPOWERED IPV education system to improve IPV knowledge, attitudes, and skills in students enrolled in our nurse practitioner program and then expand its use in our prelicensure nursing program. In addition, we will explore the ability of the system to educate other health care professionals (eg, physical therapists, occupational therapists, and physician assistants) on this serious public health topic.

Conclusions

NEs need to ensure that students are adequately prepared and competent to identify and evaluate IPV, are able to provide adequate assistance and support to victims, and can refer victims to specialized support services. A usability test conducted to explore users' experiences with the mPOWERED system indicated that the system was useful, usable, and satisfying. Furthermore, participants proposed that the mPOWERED system would be a useful tool to augment traditional education and were keen to see more blended learning in their program curriculum. Both NEs and NSs identified design issues that will provide direction in the next stages of product development. The mPOWERED system has considerable potential to augment traditional classroom learning about health topics such as IPV.

Conflicts of Interest

None declared.

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Abbreviations

e-learning: electronic learning
IPV: intimate partner violence
LGBTQ: lesbian, gay, bisexual, transgender, or queer
NE: nurse educator
NS: nursing student

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Edited by E Borycki; submitted 09.08.19; peer-reviewed by AM Almeida, N Metheny, T Hebda; comments to author 09.10.19; revised version received 01.11.19; accepted 25.11.19; published 03.01.20.

Please cite as:
Hughes C, Musselman EA, Walsh L, Mariscal T, Warner S, Hintze A, Rashidi N, Gordon-Murer C, Tanha T, Licudo F, Ng R, Tran J
The mPOWERED Electronic Learning System for Intimate Partner Violence Education: Mixed Methods Usability Study
JMIR Nursing 2020;3(1):e15828
URL: https://nursing.jmir.org/2020/1/e15828
doi:10.2196/15828
PMID:

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Original Paper

Education Into Policy: Embedding Health Informatics to Prepare Future Nurses—New Zealand Case Study

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Abstract

Background: Preparing emerging health professionals for practicing in an ever-changing health care environment along with continually evolving technology is an international concern. This is particularly pertinent for nursing because nurses make up the largest part of the health workforce.

Objective: This study aimed to explore how health informatics can be included in undergraduate health professional education.

Methods: A case study approach was used to consider health informatics within undergraduate nursing education in New Zealand. This has led to the development of nursing informatics guidelines for nurses entering practice.

Results: The process used to develop nursing informatics guidelines for entry to practice in New Zealand is described. The final guidelines are based on the literature and are refined using an advisory group and an iterative process.

Conclusions: Although this study describes the development of nursing informatics guidelines for nurses entering practice, the challenge is to move these guidelines from educational rhetoric to policy. It is only by ensuring that health informatics is embedded in the undergraduate education of all health professionals can we be assured that future health professionals are prepared to work effectively, efficiently, and safely with information and communication technologies as part of their practice.

(JMIR Nursing 2020;3(1):e16186) doi:10.2196/16186

KEYWORDS

informatics; nursing; education

Introduction

Focus of Study

Health professionals work with people of all ages and stages of life; across primary, secondary, and tertiary care; and in a variety of settings, from hospitals to the community [1]. Modern health care often includes the use of technology, which is frequently mirrored in health strategy [2]. For example, the New Zealand Health Strategy calls for health care professionals to work "smarter" using technology to enhance the health and well-being of New Zealanders [3]. There is a general consensus that people will continue to be at the center of any successful digital health initiative [4,5]. This is particularly pertinent for nursing because nurses make up the largest component of the health workforce [6]. Focusing and investing in nursing is thought to improve health and gender equality and support the economic growth of a country [7]. Williamson and Muckle [8] considered technology an integral part of current nursing practice and therefore suggested the use of technology being integrated into the nursing curriculum for students. Although a systematic review suggests that learning mediated by technology may not be better than traditional approaches to teaching and learning, exposure to technology may help develop information and communication

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technologies (ICT) skills that can be transferred to the clinical setting [9].

The focus of this case study was nurses working in New Zealand. New Zealand is a small country situated deep in the South Pacific with a population of less than 5 million [10]. There are 52,700 practicing nurses or 1106.9 practicing nurses per 100,000 New Zealanders [1]. Nurses are recognized as the largest regulated health workforce in New Zealand, and because of having a generalist scope, diversity, flexibility, and demographic spread, they are the health professionals who are best able to provide a rapid response to emerging health needs [11]. Although historically New Zealand was an early leader in considering how to prepare nurses to work with technology, nursing informatics has not been consistently addressed in nursing curricula across the country's 17 schools of nursing, meaning that New Zealand nurses may not be well prepared in this area [12-15]. Therefore, a project was established to address this gap.

Background

There are many terms concerning the use of ICT in health care, but in this instance, the term health informatics, or when specifically for nursing—nursing informatics, has been selected. Health informatics is defined as the discipline focused on the acquisition, storage, and use of information in a specific setting or domain, in this case health care [16]. Within nursing, the term nursing informatics is preferred, and this is defined as a "science and practice [which] integrates nursing, its information and knowledge, and their management, with ICT to promote the health of people, families and communities worldwide" [17]. Or more simply, we are talking about the use of computers and ICT to support health care.

Including health informatics within health professional educational preparation was noted in the literature from the early 1970s; however, there seems to have been a surge of articles from 1999 [18]. In 2010, the International Medical Informatics Association (IMIA) revised the earlier (2000) international recommendations for health informatics or medical informatics education with the hope that these would help to establish courses and perhaps lead to sharing of courseware [18]. The revised 2010 recommendations were designed to meet the educational needs of health professionals from medicine, nursing, health care management, dentistry, pharmacy, public health, health record administration, and informatics/computer science and for dedicated programs in biomedical and health informatics [18]. This indicates a broad health professional reach. Despite the direction provided in the IMIA recommendations, there is still evidence that embedding informatics within a health professional education program is not commonplace [19].

A survey of medical schools in the United Kingdom identified that 17% of the 76% of medical schools that responded had little or no health informatics included in their curricula, and this is despite the General Medical Council's curriculum requirements [20]. Similarly, in pharmacy schools in the United States, it was noted that little "progress had been made in pharmacy school curricula in response to the increasing importance of informatics to the profession" [21]. A global approach was suggested to provide flexible, Web-based, and standards-based medical informatics education, but this does not seem to have been well accepted [22]. A common issue has been the lack of suitably prepared faculty to teach health informatics [18,20-22].

For more than 30 years, nursing has had an interest in nursing informatics competencies [23]. However, early publications often described the use of computers by nurses and focused on computer skills and what should be included in nursing education [24]. An international initiative, driven from the United States, the Technology Informatics Guiding Education Reform (TIGER) developed competencies to guide the nursing profession, but these are not widely used [25]. Many countries have considered nursing informatics competencies for their nurses [26-29], recognizing that their context and needs may be particular to their country. More recently, the IMIA Nursing Informatics Special Interest Group focused on nursing informatics competencies at a postconference meeting of world leaders [30]. The aim of this meeting was to "publish a set of informatics competency recommendations for nurses educated in the next decade that cover the informatics skills required for improved, innovative and even transformative health and health care delivery" [23]. A comprehensive scope was set by including information management and the use ICT for aspects such as electronic health records, medical devices, telemedicine, patient portals, electronic health, and mobile apps, with the hope that the competencies would also help prepare nurses for future developments.

Despite the use of ICT in health care practice becoming increasingly commonplace in developed countries, nursing education has lagged in providing the preparation needed for new nurses to be aware and have the opportunity to develop the knowledge, skills, and attitudes they will need in practice. As Murphy and Goosen state, "After almost 25 years it is still problematic how few schools of nursing offer education on how the values of patient focused care can be mixed with careful application of health informatics tools and good professional information management" [23].

New Zealand as a Context

New Zealand provides a context for this project, and this section includes some of the New Zealand health informatics history that helped to shape the current informatics landscape. Despite early recognition of the need for nursing informatics competencies and guidelines to inform practice and undergraduate nurse education in New Zealand, the embedding of nursing informatics within the nursing curricula did not occur [13,31].

In 1989, a nurse educator, Jan Hausman, was seconded by the Ministry of Education to develop New Zealand guidelines for teaching nursing informatics [14]. However, this early initiative saw little change in the nursing curricula. Nevertheless, a growing interest in nursing informatics started around this time, and by 1991, a national nursing informatics group (Nursing Informatics New Zealand [NINZ]) was formed [31]. In the mid-1990s, this group developed and published Standards for Nursing Informatics with the notion that these guidelines would

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guide nursing practice [13]. Unfortunately, these guidelines were not widely adopted.

In 2000, NINZ joined the New Zealand Health Informatics Foundation to form Health Informatics New Zealand (HiNZ), a not-for-profit organization that supports the field of health informatics, with a focus on events and professional development in New Zealand. HiNZ members include health professionals (including nurses), health sector managers, ICT experts, industry managers, academics, students, and government personnel [32].

In 2006, a report identified that more people, particularly those already in the health workforce, needed to be trained in health informatics [33]. Subsequently in 2012, based on this work and that of IMIA [18], a cross-institutional group of New Zealand informatics educators collaborated to develop "Core Competencies for Health Informatics" under the umbrella of HiNZ [34,35]. These competencies were designed for the existing workforce and were directed to health professionals, managers, and technical experts in health care. An outcome was government recognition and funding of *primer* workshops based around introductory health informatics concepts that were delivered around the country to local health care organizations. It was hoped that in providing the *primer* workshops, more health care workers would be informed and engaged in health informatics, and this would, in the longer term, address the shortage of health professional champions and interdisciplinary team members trained in health informatics [34,35].

However, these efforts and the core competencies, although they included health professionals, were focused toward those already in practice and not those in training. A project to address this gap, specifically for nurses, commenced in 2016.

Methods

To identify the nursing competencies needed for New Zealand nurses, a project was initiated in 2016 by a team of 3 nurse educators from 3 different schools of nursing. The objective of this project was to use a case study approach to develop nursing informatics guidelines specific for the New Zealand context that were based on principles encompassing key knowledge, skills, and behaviors for student nurses to attain over the time of their undergraduate education to be ready to begin practice as a registered nurse (RN). A case study approach was selected as it allowed for descriptive and exploratory analysis [36]. In addition, any nursing informatics guidelines needed to align with the New Zealand Nursing Council competencies for RNs [37]. Over the next 2 years, evidence-based Guidelines for Nursing Informatics Competencies for Undergraduate Nurses in New Zealand were developed, and this work is now published and ready for dissemination [38]. Preceding this, in 2015, a study mapping the TIGER competencies [25] against the current legislation and practice in New Zealand was conducted, but the feeling was that the US-centric competencies did not suit the New Zealand health care and educational context [15,39]. This work was presented at the national nursing informatics conference in New Zealand, which identified other interested nurses and resulted in a collaboration to consider what nursing informatics competencies were needed for New Zealand nurses. The first stage of the collaboration was between nurse lecturers from 3 different schools of nursing and consisted of mapping their respective school's existing undergraduate nursing curricula against the Australian nursing informatics standards [26]. This work identified gaps in the existing undergraduate curricula for each school [12,40]. To address this gap and identify the nursing competencies needed for New Zealand nurses, a review of literature and then iterative consultation with an advisory group and key stakeholders was undertaken. The project team met regularly (usually virtually) and collaboratively created the foundation for the guidelines for nursing informatics competencies for undergraduate nurses in New Zealand, which were shaped by feedback received from the advisory group and key stakeholders until the final product was developed: *Guidelines: Informatics for nurses entering practic*e [38].

Results

The *Guidelines: Informatics for nurses entering practice* (hereafter called The Guidelines) identify 5 health informatics principles for nurses at the end of their undergraduate nursing education program as they enter practice as level 1 or novice RNs [38] (Textbox 1).

The Guidelines identify the key knowledge, skills, and behaviors toward nursing informatics for nurses as they enter practice as an RN, and as such, they have been developed and articulated to inform undergraduate nursing education. The principles are explicitly aligned to the Nursing Council of New Zealand (NCNZ) Competencies for RNs [37] (Figure 1).

Background literature that informed The Guidelines included reports from international nursing informatics initiatives including from Australia (the Australian National Informatics Standards for Nurses and Midwives) [26], from the initiative driven from the United States (TIGER) [25], from the Royal College of Nursing in England (Every nurse an e-nurse: Digital capabilities for 21st century nursing) [29], and from Canada (Nursing informatics entry to practice competencies for RNs) [27].

This project was informed by an advisory group of 12 nurse leaders from practice, education, policy, the nursing regulatory body, and industry. Drafts of The Guidelines were distributed, and feedback was sought using an iterative process. In addition, 4 nursing organizations were asked to be kept informed: The Office of the Chief Nurse in the Ministry of Health at the government level; the regulatory body, NCNZ; and The Council of Deans and Nurse Educators in the Tertiary Sector, from the education sector.

In addition, the formatting was considered, and alongside each principle, examples were provided. The inclusion of examples from everyday practice in the New Zealand health system adds a local context (Figure 1). Finally, a glossary was added so that terms are defined, providing a common understanding.

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Textbox 1. The 4 principles.

Principle 1: Professional practice

Nurses are accountable and responsible for their use of information and communication technologies (ICT)

Principle 2: Information management

Use of information to inform and manage patient care

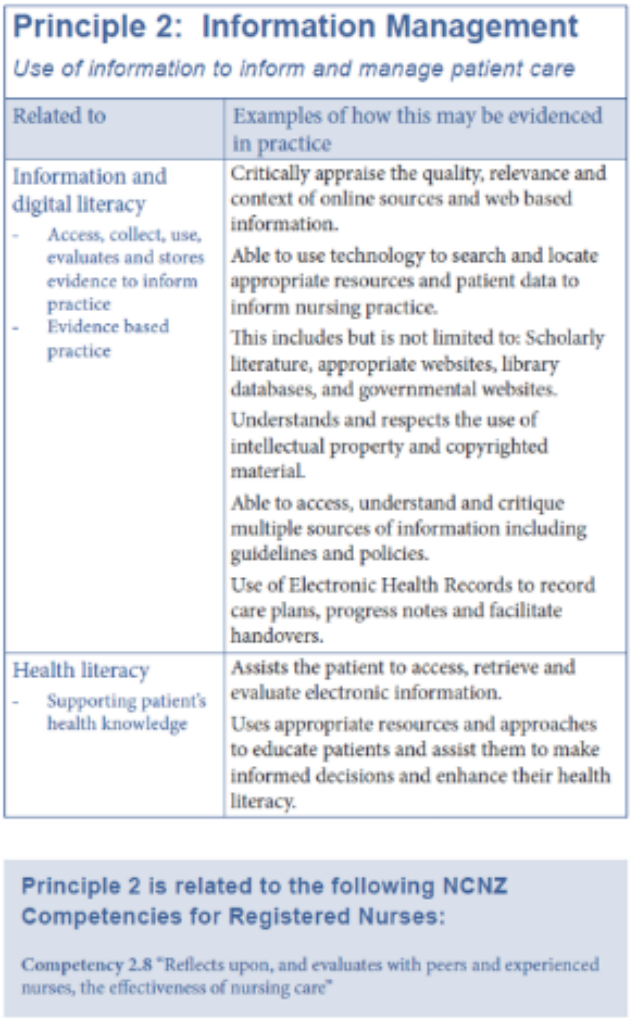
Principle 3: ICT to enhance the health of New Zealanders

Nurses effectively use ICT to assist with the delivery of quality nursing care to improve patient outcomes

Principle 4: General computer and ICT skills

The nurse is adaptable in different health care environments through transferrable ICT skills

Figure 1. The Guidelines showing principle 2. NCNZ: Nursing Council of New Zealand.



Principle 2: Information Management

Use of information to inform and manage patient care

Related to	Examples of how this may be evidenced in practice
Information and digital literacy - Access, collect, use, evaluates and stores evidence to inform practice - Evidence based practice	Critically appraise the quality, relevance and context of online sources and web based information. Able to use technology to search and locate appropriate resources and patient data to inform nursing practice. This includes but is not limited to: Scholarly literature, appropriate websites, library databases, and governmental websites. Understands and respects the use of intellectual property and copyrighted material. Able to access, understand and critique multiple sources of information including guidelines and policies. Use of Electronic Health Records to record care plans, progress notes and facilitate handovers.
Health literacy - Supporting patient's health knowledge	Assists the patient to access, retrieve and evaluate electronic information. Uses appropriate resources and approaches to educate patients and assist them to make informed decisions and enhance their health literacy.

Principle 2 is related to the following NCNZ Competencies for Registered Nurses:

Competency 2.8 "Reflects upon, and evaluates with peers and experienced nurses, the effectiveness of nursing care"

Discussion

Principal Findings

This project aims to inform, influence, and potentially change professional nursing practice and policy through providing clear guidelines for nursing informatics competencies. The Guidelines align with the NCNZ competencies for RNs [37], which all schools of nursing in New Zealand work with the development of their curricula. Furthermore, this project supports the national health strategy as nurses provide health care service to support people in New Zealand to "Live well, Stay well, Get well," which is a key component of the 2016 New Zealand Health Strategy [3].

By considering the past and previous attempts to introduce nursing informatics competencies in New Zealand, there is an opportunity to learn and to improve on earlier endeavors. A common problem faced by earlier efforts includes moving from the creation of guidelines to a position where competencies are recognized and inform policy to where they are embedded in education. This project supports actively building connections

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between the tertiary education providers within the schools of nursing, thereby crossing perceived divisions between universities, polytechnics, and institutes of technology. By demonstrating engagement within the nursing communities, specifically nurse lecturers and the key nursing regulatory and policy stakeholders, The Guidelines may be acceptable to all and are more likely to be accepted and influence policy.

In terms of policy impact, this project has the potential to influence the NCNZ to explicitly address the inclusion of nursing informatics within undergraduate nursing curricula. The implementation of these guidelines nationally would impact all 17 schools of nursing in New Zealand by ensuring that present and future RNs are consistently prepared for working in a technological age. This will likely have flow-on effects for patient care, potentially improving safety and efficiency within the health care system and improving quality of care for recipients, while acknowledging the role of nurses in health maintenance and health promotion as well as providing health care for those who are sick or dying. Technology is used in all aspects of health care, and ensuring that our workforce is adequately prepared for its use in health care has the potential to assist all recipients of care, including Māori—the indigenous people of New Zealand—and those from neighboring Pacific Islands, who are overrepresented in New Zealand's worst health statistics [3].

The impact of policy in terms of education will affect nursing students, who remain predominantly women (9% of the current nursing workforce is male) [1]. Understanding the use of technology in health care will better prepare them to be competent and effective future nurses. The Guidelines form a bridge between the theory of nursing informatics, education of nurses, and clinical practice.

Next Steps

The challenge is to now disseminate this work to the New Zealand nursing education community so that The Guidelines can be incorporated into nursing curricula. The first step is to share The Guidelines across all schools of nursing in New Zealand so that nurse educators can consider how The Guidelines can be implemented into their undergraduate programs of nursing, which will facilitate effective knowledge transfer and uptake of The Guidelines into practice. Furthermore, there is a need to identify and then address the concerns, barriers, and facilitators to using The Guidelines in nursing education. In addition, from a New Zealand perspective, where the indigenous people are Māori, there is a need to understand any issues specifically from the perspectives of Māori as concerns related to data guardianship and nurses acting as kaitiaki/guardians of the data may apply [41].

Conclusions

Despite local and international efforts to include health informatics as part of the curricula for preparing health professionals for practice in the 21st century, there remains inconsistency in achieving this. This case study illustrates the development of heath informatics competencies and guidelines for one profession, in one country. The challenge is moving from educational rhetoric to practice and policy to ensure that health informatics is embedded into the educational preparation for all health professionals. The importance of learning from past initiatives is highlighted. The process used to develop the "Guidelines: Informatics for nurses entering practice" for use in New Zealand is expected to guide undergraduate nursing education and as such form a bridge between theory, education, and practice.

Conflicts of Interest

None declared.

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Abbreviations

HiNZ: Health Informatics New Zealand
ICT: information and communication technologies
IMIA: International Medical Informatics Association
NCNZ: Nursing Council of New Zealand
NINZ: Nursing Informatics New Zealand
RN: registered nurse
TIGER: Technology Informatics Guiding Education Reform

Edited by E Borycki; submitted 09.09.19; peer-reviewed by D Marshall, P Procter, T Hebda, P Sousa; comments to author 08.10.19; revised version received 17.11.19; accepted 25.11.19; published 09.01.20.

Please cite as:
Honey M, Collins E, Britnell S
Education Into Policy: Embedding Health Informatics to Prepare Future Nurses—New Zealand Case Study
JMIR Nursing 2020;3(1):e16186
URL: https://nursing.jmir.org/2020/1/e16186
doi:10.2196/16186
PMID:

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Original Paper

Utilization of Nursing Education Progressive Web Application (NEPWA) Media in an Education and Health Promotion Course Using Gagne's Model of Instructional Design on Nursing Students: Quantitative Research and Development Study

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Abstract

Background: Previous studies have proven that web-based learning media that offer interesting features with *the learning management system* concept could support the learning processes of nursing students. Nonetheless, it is still necessary to conduct further research on its potential as an information media that supports learning using 1 of the mobile learning methods.

Objective: This study aims to develop and use the Nursing Education Progressive Web Application (NEPWA) media in an education and health promotion course for nursing students.

Methods: This is a research and development study aimed at developing the NEPWA media using the Analyze, Design, Develop, Implement, and Evaluate approach and a quantitative research with descriptive and pre-experimental 1-group pretest-posttest design conducted in the Study Program of Nursing Sciences, Faculty of Health Sciences, Muhammadiyah University of Surakarta. A total of 39 nursing students in their second year of undergraduate studies participated in this study. A pretest-posttest design was used to measure any changes in the dependent variable, whereas a posttest design was used to measure any changes in the independent variables.

Results: After using the NEPWA media, there was a significant increase in the student knowledge variable (N=39; knowledge: $P<.001$; 95% CI 23.88-33.14). In terms of student satisfaction with the learning process using Gagne's model of instructional design, most of the students were satisfied, with a mean score of ≥3. In addition, the results of the measurement using the System Usability Scale on the NEPWA media showed that NEPWA has good usability and it is acceptable by users, with a mean score of 72.24 (SD 8.54).

Conclusions: The NEPWA media can be accepted by users and has good usability, and this media is designed to enhance student knowledge.

(JMIR Nursing 2020;3(1):e19780) doi:10.2196/19780

KEYWORDS

mobile application; nursing students; blended learning; knowledge; satisfaction; system usability; mobile phone

Introduction

Learning in the age of digital transformation has different characteristics compared with that in the past decades. The learning model in the digital age has created a new trend that uses electronic media known as mobile learning (m-learning), which offers many benefits such as flexible and portable learning designed without space-time constraints [1].

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In general, the majority of internet users are middle and high school or university students aged 10-24 (18.40%) years and 25-34 (24.40%) years [2], respectively, whereas in the context of health sciences, the ages of 10-18 years are a period of preparation before individuals enter higher education, where, in this age group, the majority of internet users are at the high school education level. One of the unique features of web-based learning is the availability of an independent, effective, and efficient learning environment where users can repeatedly access information and skills to practice without space-time constraints [3], which could benefit the learning in both campuses and clinics [4].

Students are interested in using web-based learning through mobile apps as they offer many interesting features [5-8]: mobile apps can be installed in every Android smartphone [9] and are flexible to use. These are the factors that attract users [10]. Learning media using m-learning, which can be applied in lectures using demonstration learning methods to become more interactive, are popular and commonly used in the health sector [1]. On the other hand, 1 of the limitations of traditional lecture methods is that they can be boring as lecturers deliver materials only via texts, making the lectures passive. Thus, it is necessary to address this issue by using effective learning media, one of which is the use of web-based learning media in the form of mobile apps with a simple concept of a *learning management system* that could stimulate interactions during lectures and provide feedback to students; therefore, it is necessary to design learning strategies well [1].

This is in line with some previous studies, which showed that app media that integrate web-based lectures using electronic learning (e-learning) media can increase student knowledge about the given courses [11-13]. On the basis of a preliminary study by interviewing one of the lecturers and students at the Study Program of Nursing Science, the Faculty of Health Sciences, Muhammadiyah University of Surakarta, it can be concluded that some of the learning media used by lecturers are in the form of PowerPoint slides, handouts, and videos from YouTube, as well as the use of one of the principles of Gagne's instructional design, that is, pretest. Thus, it is necessary to innovate web-based learning media to be used during lectures to assist students in studying.

The interactive learning strategies in this lecture were designed using the 9-step Gagne's model of instructional design with a teaching method using blended learning. Gagne's model of instructional design includes instructions that allow learning processes to be effective [14,15].

On the basis of the abovementioned points, the problems of this study were formulated as follows: "Do the development and utilization of the NEPWA media on education and health promotion course influence the improvement of nursing students' knowledge?"

The objective of the study was to develop and utilize the Nursing Education Progressive Web Application (NEPWA) media in an education and health promotion course among nursing students.

Methods

This was a research and development study [16]. The development of the NEPWA media used the Analyze, Design, Develop, Implement, and Evaluate approach [17]. The first needs analysis was conducted according to the needs of the researchers to develop apps and websites in the form of both software and hardware as well as materials in the NEPWA media. Afterward, the NEPWA media were designed in accordance with the needs of lectures by adjusting to Gagne's model of instructional design, including the features of learning material rooms, discussion rooms, assignment rooms, and test rooms. The design for NEPWA media was then developed and made by a team expert app and web programmer based on the researchers' designs. The web-based learning media created was then named NEPWA. The NEPWA media was developed into 3 sections with their own features, which were correlated with one another, available in the form of both websites and apps. The first result of the NEPWA media was student page, which consists classrooms, discussion rooms, assignment rooms, and test rooms and user profile features, as shown in Figure 1.

Next, students can use the classroom feature that contains instructions on how to use the NEPWA media, modules, course units, and learning materials in the forms of PowerPoint slides, infographics, and the resume of learning materials, as shown in Figure 2.

In addition, students' test room features are also available, as shown in Figure 3.

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Figure 1. Display of the student profile page on the Nursing Education Progressive Web Application media.

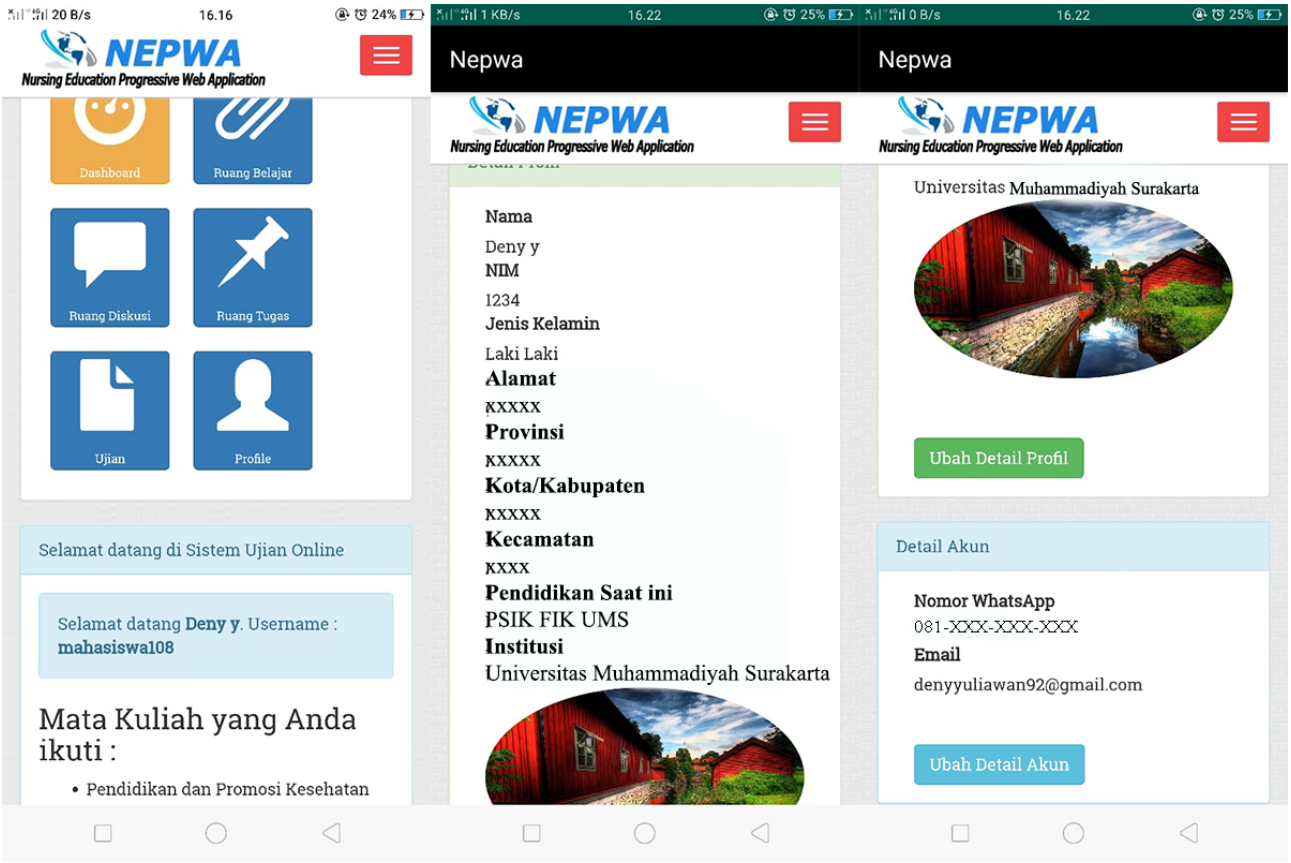

Figure 2. Display of the student classroom page on the Nursing Education Progressive Web Application media.

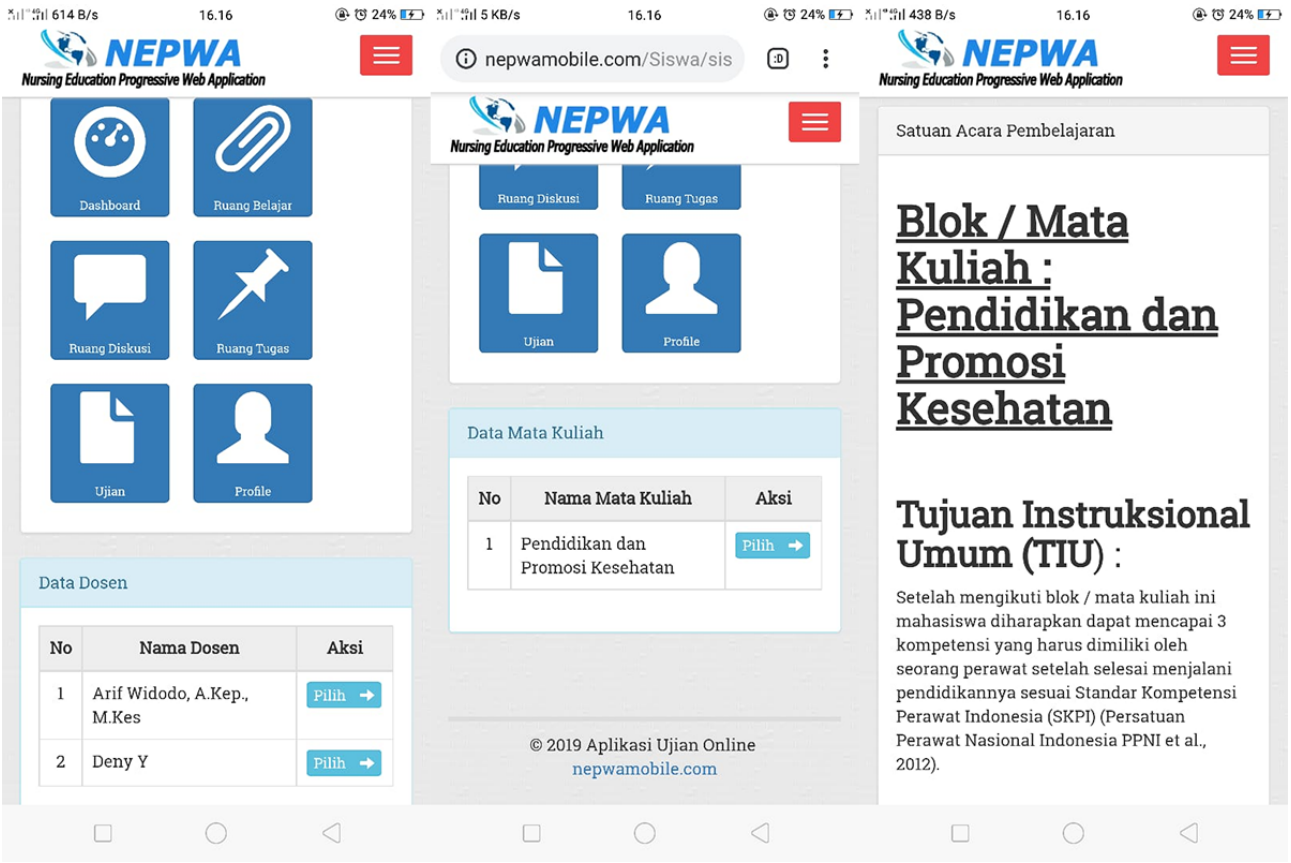

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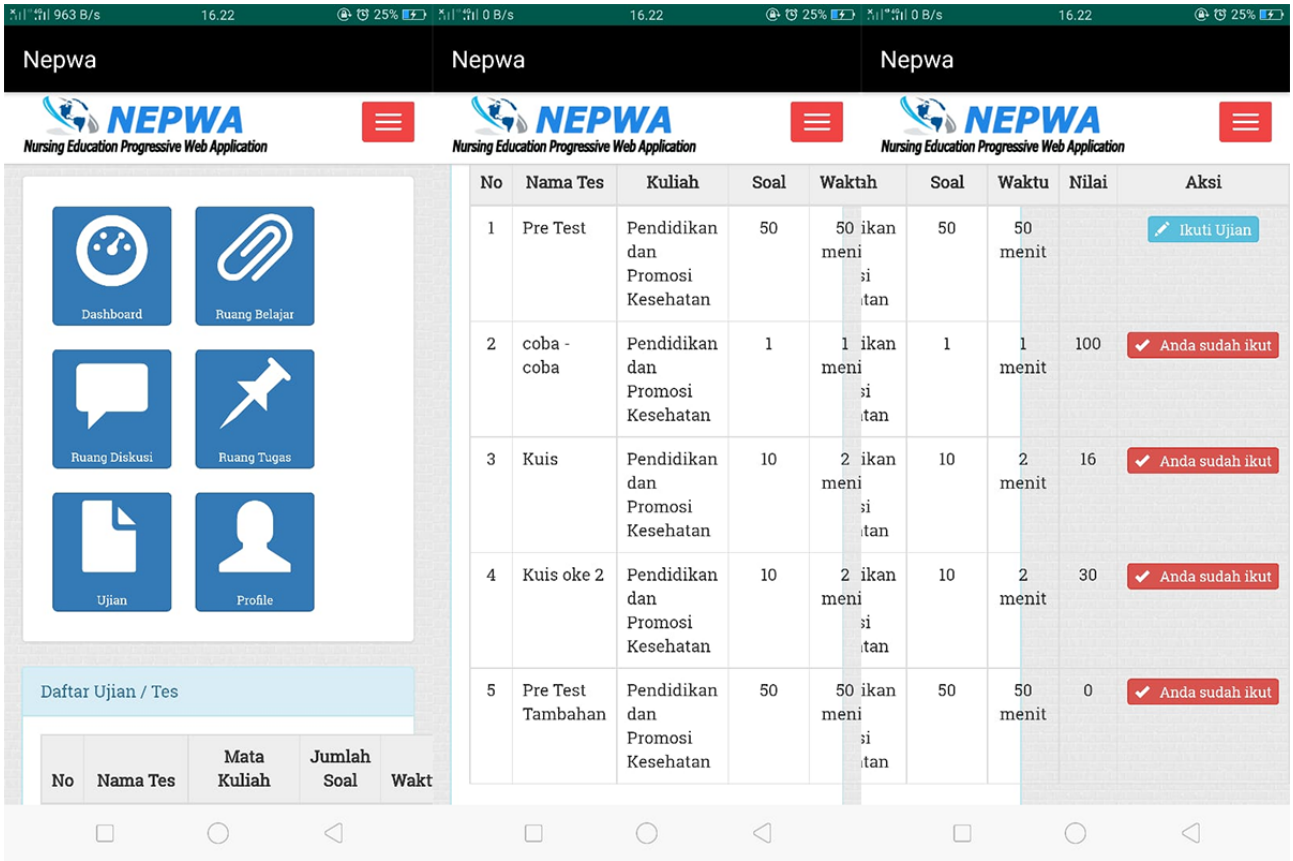
Figure 3. Display of the test room page on the Nursing Education Progressive Web Application media.



The strengths of the test room in the NEPWA media are, first, the questions that simultaneously show up on the account of 1 student are not the same as those showing up on the accounts of other students; thus, students could focus on the questions showing up on their own page. Second, the duration and number of questions set by lecturers are also displayed. Third, the scores for each of the tests taken by students will show up at the end of the test session as taken by each student.

For the second results, the development of the lecturer page display on the NEPWA media contains the features of the question room, test room, test score, learning material room, assignment room, and discussion room, as shown in Figure 4.

Figure 4. Display of the lecturer page containing the question bank and list of tests on the Nursing Education Progressive Web Application media.

The benefits are question rooms for each course and examination registration room for students that can be managed directly by the lecturers are available, such as setting the name of the examination, the number of questions tested, and the

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examination duration. In addition, there are also learning outcome rooms that display the scores of all students who take each examination.

For the third result, the development of the admin page on the NEPWA media consisted of the features of student data, lecturer data, course description data, questions, and the test results, as shown in Figure 5.

The admin page displays student data that can only be managed directly by 1 administrator. The data include student name and number, study program, and *automatic username-password* to be used by students to log in to their accounts on the NEPWA media. In addition, there are also features of lecturer data and course description data, as seen in Figure 6.

Figure 5. Display of the administrator page containing student data on the Nursing Education Progressive Web Application media.

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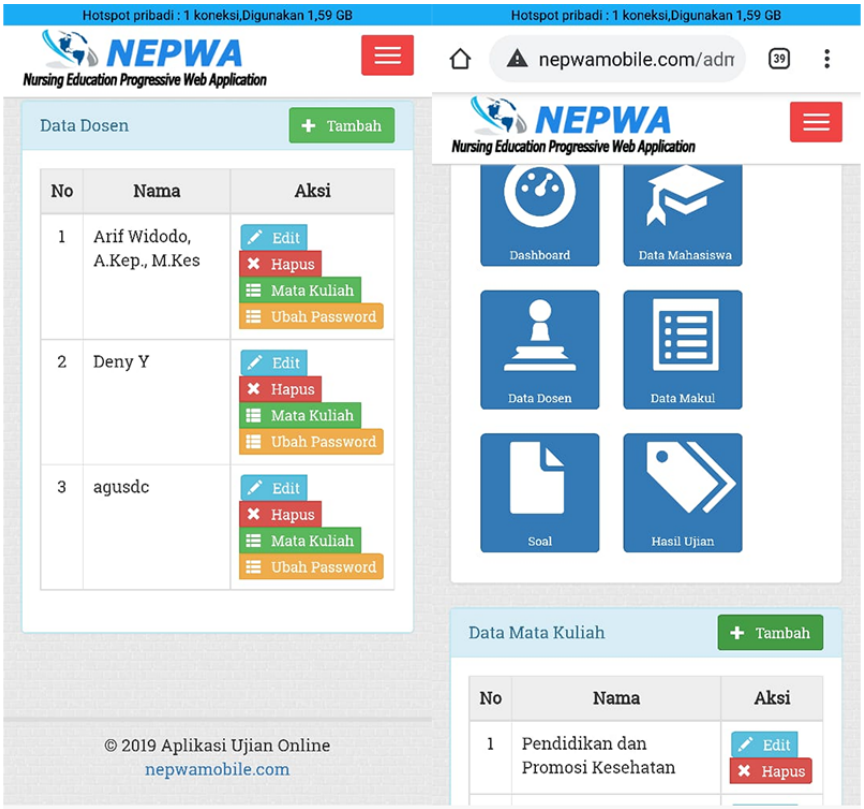
Figure 6. Display of the admin page containing data on lecturers and courses on the Nursing Education Progressive Web Application media.



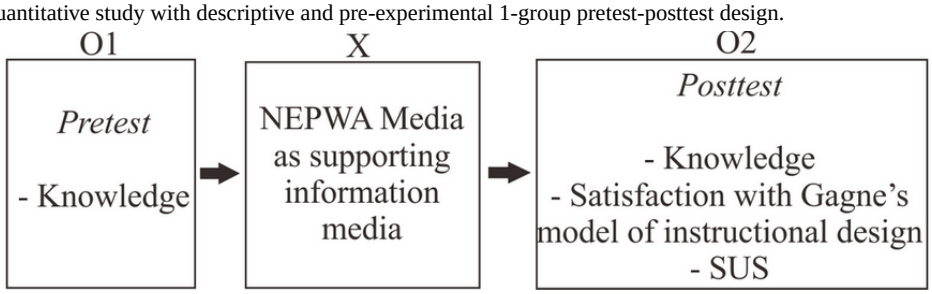
The features of lecturer data and course description data that can only be managed directly by 1 administrator are available. The data include the *lecturer name and automatic username-password* to be used by lecturers to log in to their account on the NEPWA media; these are linked to the features of course description. Moreover, the feature of course description data can be inputted by the admin by entering the name of the course that has been approved by the study program.

The next step is the implementation of the NEPWA media that had been created. The NEPWA media was tested and rated by the students. Once the respondents tried using the NEPWA media, they were then asked to provide feedback by filling out a questionnaire to measure the System Usability Scale (SUS) of the NEPWA media, which was conducted after the posttest was completed.

The next step was when the NEPWA media was already tested and ready to use. Subsequently, research using the NEPWA media was conducted. This was a quantitative study with descriptive and pre-experimental one-group pretest-posttest designs [16,18,19], presented in Figure 7. The group descriptions in Figure 7 are as follows:

- O1: Pretest in the sample group
- X: Treatment (NEPWA media)
- O2: Posttest in the sample group

Figure 7. Scheme 1 Quantitative study with descriptive and pre-experimental 1-group pretest-posttest design.



The following 3 aspects were measured:

1. Student learning outcomes in the factual knowledge (cognitive) domain were measured using multiple-choice questions before and after the face-to-face session as the pretest and posttest in the sample group.
2. Satisfaction with Gagne's model of instructional design was measured after students completed the face-to-face and posttest sessions. The satisfaction questionnaire was adopted from the study by Buzzetto More [20] and used in a previous study by Fandianta [13] in face-to-face and web-based sessions (Multimedia Appendix 1).
3. SUS was measured after students completed the face-to-face and posttest sessions using a reliable and validated questionnaire by Sharfina and Santoso [21] and Mohamad Marzuki et al [22] (Multimedia Appendix 2).

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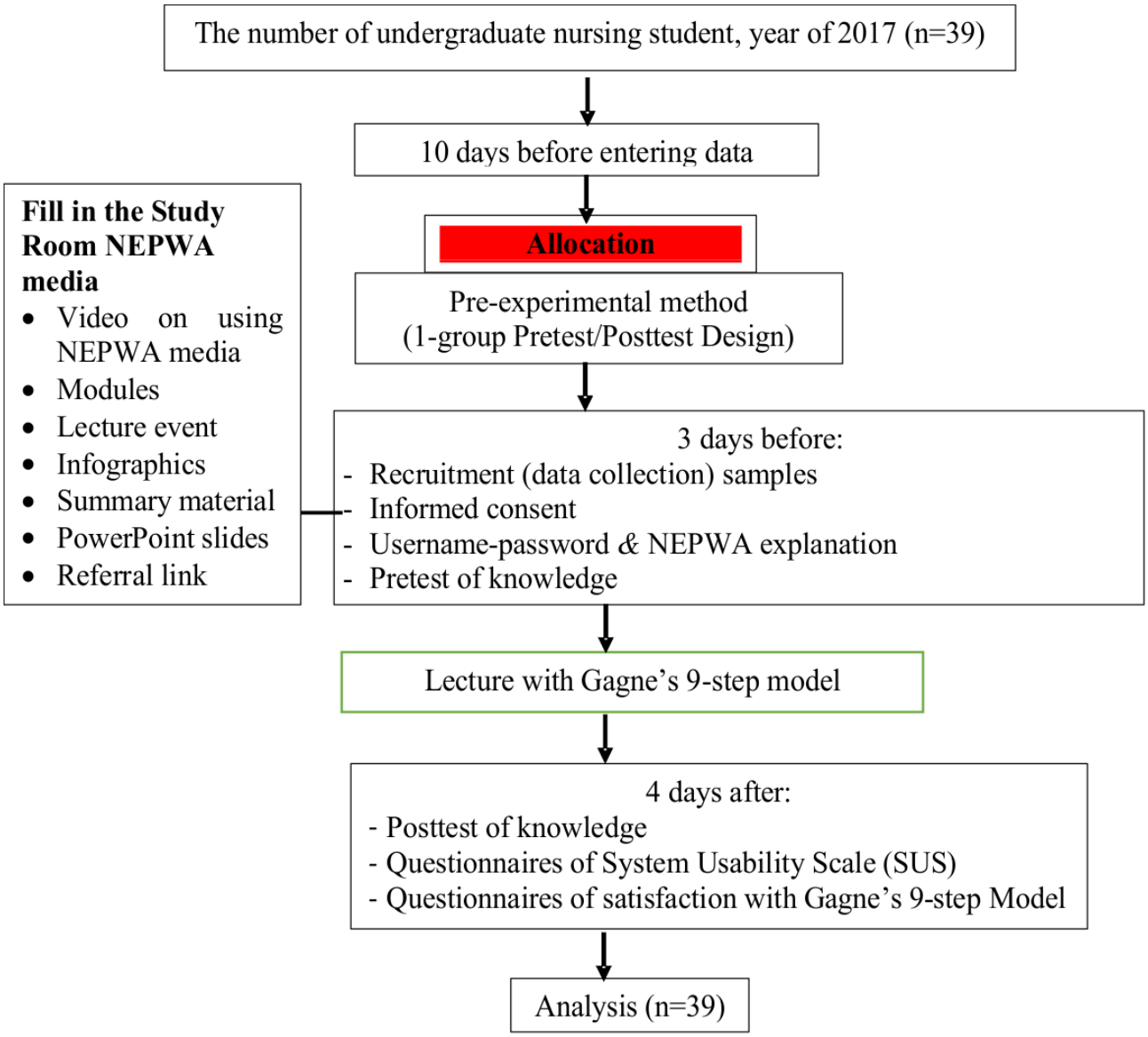
In this study, researchers used a sample of undergraduate nursing students (N=39) calculated using the Harry King's nomogram with saturation [16,23] in the fourth semester of the second year at the Muhammadiyah University of Surakarta between June 2019 and July 2019. These students were asked to participate in this study, and no one refused. No student was excluded, as all of them met the important inclusion criteria of the study, that is, being registered as active students in the education and health promotion course and having a smart phone or tablet to access the NEPWA media. The study had 1 variable, namely, the independent variable that measured satisfaction with Gagne's model of instructional design through the NEPWA media using a satisfaction questionnaire [20] in the Indonesian version [13] adjusted to Gagne's model of instructional design [14,15], and the usability of the NEPWA media was measured using the SUS score [24] in the Indonesian version [21] and the Malay language version [22]. The dependent variable then measured student knowledge using 50 multiple-choice questions with cognitive skill level C2 according to Bloom's taxonomy. Meanwhile, the data collection technique used printed paper for the SUS questionnaire; the NEPWA media was used for the results of the pretest-posttest. This study consisted of 3 stages.

The preparation stage lasted 4.5 months, where the researchers had coordinated with lecturers during the process of designing the module as well as pretest-posttest questions to test student knowledge. In addition to these activities, the researchers also coordinated with the programming team during the process of designing the NEPWA media. Once completed, the researchers pilot tested the NEPWA media, which contained a module to the supervisors, some students of Master of Medical and Health Profession Education and students of Magister of Nursing programs who were in their final semester. Finally, the implementation stage lasted 2 weeks, as shown in Figure 8.

Figure 8. Scheme 2 Research Implementation.



Once all the data were collected and entered into Microsoft Excel, analysis of the characteristics of the research subjects and interpretation of the NEPWA media system usability using SUS score [25,26] were conducted. Mean SUS score ≥68 is categorized as having good usability [21,22,25]. The next step was to conduct an analysis of satisfaction with Gagne's model

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of instructional design. The difference between the pretest-posttest scores in terms of the students' factual knowledge was then determined by analyzing the data of score difference that had normal distribution. Thus, differences could be tested using a parametric statistical test, that is, the paired sample *t* test.

In conducting this study, the researchers obtained research ethics approval from the Committee of Research, Medical and Health Ethics, Faculty of Medicine, Public Health and Nursing at Gadjah Mada University in Yogyakarta with Ref: KE/FK/0290/EC/2018, dated March 18, 2019.

Results

NEPWA Media

The learning media developed by the researchers and a team of programmers ran well. The web-based learning media, called NEPWA, is accessible through the website [27]. It can also be installed as an Android app.

Characteristics of the Subjects

The research could be implemented according to the research design. The students participated in this study voluntarily after they were given an explanation about the research objectives and processes. The selection of the students as the research participants took place right before the pretest was completed after a lecture session on education and health promotion ended, starting on June 17, 2019, in 1 class. There were 39 students in 1 classroom, and 100% (39/39) of them agreed to be the research subjects, and they all met the inclusion criteria. Consequently, these 39 students fully participated in the research activities, and the results were further analyzed.

The characteristics of the research subjects were in the form of demographic data, including age, sex, and grade point average. The distribution normality of the participants' characteristic data was analyzed using the Shapiro-Wilk criteria: data are said to be normally distributed if the $P>.05$. The detailed characteristics of the respondents are shown in Table 1.

Table 1. Characteristics of the respondents (N=39).

Characteristics[a]	Respondents
Age (years), median (min-max)	20 (19-21)
Grade point average, mean (SD)	3.54 (0.17)
Sex, n (%)	
Male	6 (15)
Female	33 (85)
Frequency of using web-based learning media during lectures, n (%)	
Not using at all	1 (3)
<30 min	8 (21)
30-60 min	21 (54)
1-2 hours	8 (21)
3-4 hours	1 (3)

[a]Data collection process was carried out in 2019 using the first or primary source.

Student Satisfaction With the Use of NEPWA Media

The survey of satisfaction with the NEPWA media filled out by student participants included media used to access the internet (mobile phones, laptops, tablets, and personal computers), internet access (Wi-Fi and cellular data), and the frequency of using instructional media. The descriptive analysis results indicated a good level of satisfaction with the use of the NEPWA media. In fact, most of the students used mobile phones as hardware and cellular data to access information provided on the NEPWA media. Besides, the majority of them (>40%) accessed the NEPWA media 1-2 times per day for <30 min before, during, and after the education and health promotion course took place. In addition, the most commonly used and the most useful features were the learning material room and the test room, with a frequency >64%. Meanwhile, the brief answers on the satisfaction questionnaire regarding the use of the NEPWA media resulted in some written statements from the participants, with 3 questions that covered several subthemes of the resume, as follows:

Good aspects of NEPWA media

- Learning has become more effective, efficient, time-saving, and simpler because it can be done anytime and anywhere.
- The learning materials can be read repeatedly, making it easier for students to study.
- It is easier to use all available features.

Some aspects of NEPWA media that need to be improved

- It is necessary to perform system monitoring, preventing it from being disrupted easily.
- The display should be made more attractive, especially the display of user profile, learning material room, and discussion room.

Satisfaction with the use of NEPWA media

- Availability of many test practice questions.

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- Availability of comprehensive learning materials.

SUS of NEPWA Media

On the basis of the results of the distribution analysis, the NEPWA media had good usability and could be accepted by the users in this study, that is, the measurement uses the system usability variable of the NEPWA media of all students (N=39). The mean SUS score per statement can be seen in Table 2.

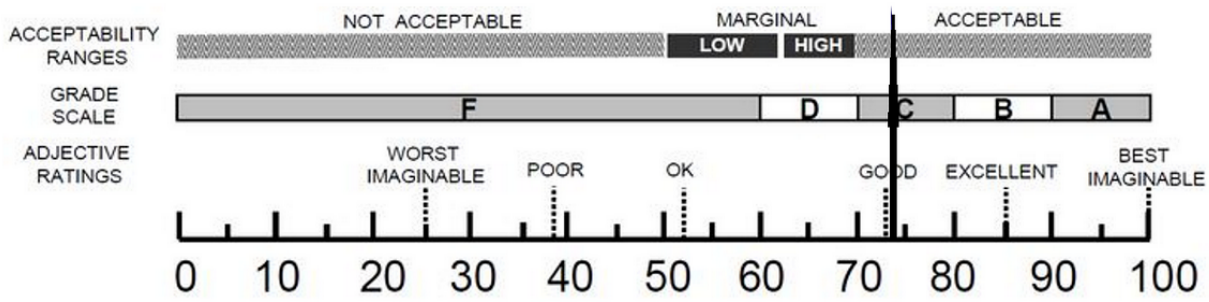
Table 2. Mean System Usability Scale score for each statement.

Number	Statement items[a]	Values, mean (SD)
1	I think that I would like to use this system	3.03 (0.28)
2	I found the system unnecessarily complex	2.95 (0.51)
3	I thought the system was easy to use	3.05 (0.39)
4	I think that I would need the support of a technical person to be able to use this system	2.56 (0.91)
5	I found that the various functions of the system were well integrated	3.15 (0.43)
6	I thought there was too much inconsistency in this system	2.87 (0.52)
7	I would imagine that most people would learn to use this system quickly	3.05 (0.61)
8	I found the system very cumbersome to use	3.03 (0.49)
9	I felt very confident using the system	3.03 (0.67)
10	I needed to learn a lot of things before I could get going with this system	2.18 (1.02)

[a]Data collection process was carried out in 2019 using the first or primary source.

Table 2 presents the mean score for each of the statements of all the subjects, and it can be seen that the positive statements 5, 3, 7, 1, and 9 had a mean score of 3 (ranging from 0 “strongly disagree” to 4 “strongly agree”), which tended to be higher than the negative statements. Next, the total score of each respondent was multiplied by 2.5, resulting in the SUS score of each respondent. The total SUS score was obtained by summing the SUS scores of all the respondents, resulting in a total score of 2817. Afterward, the mean SUS score was obtained by dividing the total SUS score by the number of respondents, resulting in a score of 72.24 (SD 8.54), which indicated that the NEPWA media has good usability, meaning that it is below the acceptable range for the user, as shown in Figure 9.

Figure 9. Results of System Usability Scale score on the Nursing Education Progressive Web Application media. SUS: System Usability Scale.



Satisfaction Scale With Gagne’s Model of Instructional Design

On the basis of the results of the satisfaction analysis, the majority of the respondents in this study were satisfied with the use of Gagne’s model of instructional design in the course using the NEPWA media from all the students (N=39). The mean score of satisfaction with Gagne's model of instructional design using the NEPWA media per statement item is presented in Table 3.

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Table 3. Mean score of satisfaction with Gagne's model of instructional design using the Nursing Education Progressive Web Application media for each statement.

Number	Statement item[a]	Values, mean (SD)
1	Overall, I am satisfied with learning that uses this teaching media	2.92 (0.58)
2	I am satisfied with learning that uses this teaching media as a source of information	2.97 (0.54)
3	I am satisfied with the contents available in this learning media	2.95 (0.51)
4	I always use this learning media to answer questions	2.62 (0.71)
5	I am satisfied with the contents or materials available in this learning media to assist me in learning	3.15 (0.63)
6	I believe that this learning media could enhance my understanding	3.00 (0.51)
7	I am satisfied with the brief summary available in the PowerPoint slides in this learning media	3.15 (0.49)
8	I feel that this learning media provides instructions/keywords available	2.79 (0.73)
9	I am satisfied that I can have discussions using this learning media	3.00 (0.51)
10	I feel that the web-based discussion room available in this learning media could help me gain understanding of learning materials	2.97 (0.43)
11	I am satisfied that I can interact with lecturers and other students through the web-based discussion rooms available in this learning media	2.92 (0.62)
12	I am satisfied that I could take tests using this learning media	3.08 (0.42)
13	I feel that the web-based tests available in this learning media are easier to use	3.03 (0.54)
14	I am satisfied when I receive scores immediately after taking tests using this learning media	3.03 (0.43)
15	I am satisfied that I can send assignments on the web using this learning media	3.00 (0.46)

[a]Data collection process was carried out in 2019 using the first or primary source.

On the basis of the results from Table 3, it can be seen that the mean score of the statement items was ≥3, indicating that the students were satisfied with several statement items or features available in the NEPWA media using Gagne's model of instructional design, including:

1. Satisfaction with the modules or materials available in the learning media.
2. Satisfaction with the brief summary on the PowerPoint slides available in the learning media.
3. Satisfaction because they could take tests using the learning media.
4. Satisfaction because they could easily take web-based tests using the learning media.
5. Satisfaction because they received a score immediately after they completed a test using the learning media.
6. Satisfaction because they could send assignments on the web through the learning media.
7. Satisfaction because they could have discussions using the learning media.

Knowledge-Level Distribution Analysis on the NEPWA Media

The results from the analysis showed that the data were normally distributed. There was an increase in the variable of knowledge level using the NEPWA media among all the students (N=39). The increase in the mean score before and after using the NEPWA media is presented in Table 4.

Table 4. Results of analysis of knowledge levels on the Nursing Education Progressive Web Application media.

Results[a]	Pretest, mean (SD)	95% CI	Posttest, mean (SD)	95% CI
Knowledge levels	44.41 (12.36)	40.40-48.42	72.92 (14.62)	68.18-77.66

[a]Data collection process was carried out in 2019 using the first or primary source.

On the basis of the results in Table 4, it can be seen that the pretest mean score was 44.41 (SD 12.36), which increased to 72.92 (SD 14.62) in the posttest after using the NEPWA media. This indicates that there was an increase in the mean score where the posttest score was higher than the pretest score.

Analysis of Differences in Student Knowledge Improvement Using the NEPWA Media

The level of student knowledge before and after using the NEPWA media and the difference between these two were found to have a normal data distribution; thus, the analysis used a paired sample *t* test to determine the significance of the changes in the level of student knowledge before and after using the NEPWA media. From the test results, the mean score of student knowledge before using the NEPWA media was 44.41 (SD 12.36), which significantly increased ($P<.001$) by 23.51 (SD 14.29) to 72.92 (SD 14.62) after using the NEPWA media. The detailed results of the paired sample *t* test on the level of student knowledge are presented in Table 5.

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Table 5. Differences in the levels of student knowledge before and after using the Nursing Education Progressive Web Application media analyzed through paired *t* test.

Levels of student knowledge[a]	N	Mean (SD)	Difference in mean (SD)	95% CI	*P* value
Before using the NEPWA[b] media	39	44.41 (12.36)	28.51 (14.29)	23.88-33.14	<.001
After using the NEPWA media	39	72.92 (14.62)	N/A[c]	N/A	N/A

[a]Data collection process was carried out in 2019 using the first or primary source.

[b]NEPWA: Nursing Education Progressive Web Application.

[c]N/A: not applicable.

Table 5 shows that the *P* value(<.001) is less than the α value (.05); thus, it can be concluded that there were significant changes in the score of knowledge of education and health promotion before and after using the NEPWA media. These results were also supported by the pretest mean score of knowledge of 44.41, which increased to 72.92 in the posttest after using the NEPWA media, and there was a significant increase in the score after using NEPWA media (0.449). In conclusion, there is a significant change in the score of knowledge before and after using the NEPWA media. This indicates that the use of the NEPWA media affects students' knowledge. In other words, the NEPWA media can increase knowledge.

Discussion

Summary

The variables of knowledge, satisfaction with the learning processes, and system usability in the NEPWA media showed an increase in differences and acceptance by users. The NEPWA media among student users can be said to have good system usability with a range of acceptance to be acceptable by the users. Next, in terms of the variable of satisfaction with Gagne's model of instructional design, the majority of students were satisfied. The variable of student knowledge then increased significantly compared with the conditions before using the NEPWA media.

Students' prior knowledge is an adequate key so that students' interest in the learning process can be achieved properly. This should be supported by adequate learning media, for example, the use of web-based learning media in the form of NEPWA media as supporting information media to improve cognitive learning outcomes. Learning media in the form of e-learning is an innovative app to support the teaching and learning activities of both lecturers and students [28], of which the interactive functions shall be improved to accommodate the needs of students [29] as well as the development of the NEPWA media using Gagne's model of instructional design to support active learning and provide flexibility in improving the quality of student classroom learning by creating creative media content [30].

To allow for the materials to be well delivered to students, a blended learning method between web-based learning methods using app or web media combined with appropriate teaching methods (face-to-face) was used, where blended learning can be used to facilitate communication and improve student learning outcomes [29]. In this case, web-based media use NEPWA media as supporting information media. In line with an earlier study [31], students can feel the benefits of implementing web-based interventions in learning, but they are not yet fully prepared to leave the traditional learning methods, including face-to-face lectures. Consistent with some previous studies [32,33], electronic-based learning provides flexible teaching methods, but both electronic-based learning and traditional teaching methods should be used simultaneously to create a superior learning style, especially for nursing courses. The explanation of the variables in this study is as follows:

Increase in Student Knowledge

Many previous studies have shown that web-based learning media using the blended learning approach in health profession education, in general, could significantly improve learning outcomes in terms of students' cognitive level compared with traditional learning methods. This is based on the fact that web-based learning can optimize learning media by combining images, texts, and video, among others. The media displayed on the NEPWA media are in the form of PowerPoint slides, learning material resumes, interactive quizzes, and additional infographics, which cannot be displayed on print media. Infographics are visualization tools that can be used to improve understanding and attractiveness [34].

This is consistent with the Cognitive Theory of Multimedia Learning [35-38], where multimedia displays can be in the form of text, images, and sound. In line with this theory, there were similar findings in another study [34] where students felt that the summary infographics provided by lecturers are very interesting and useful in understanding the topics being taught. This is in accordance with the Cognitive Load Theory [39-41], which states that humans have limited memory capacity; thus, the materials being learned should be summarized according to the topic of learning. The results of a previous study [42] showed that there are no statistical differences between the groups of students learning via a web-based app or learning in face-to-face sessions in terms of knowledge, although the web-based app media is superior to face to face; because web-based app media is able to optimize learning media with a combination of pictures, writing, and videos, [43] and the effects of learning methods on learning outcomes are very situational [44].

Satisfaction With Gagne's Model of Instructional Design in Learning Media

The use of Gagne's model of instructional design in the learning process using the NEPWA media was well implemented and obtained satisfactory scores on several statement items. This is based on the fact that the first highest mean score was achieved

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by statement 5, “I am satisfied with the contents of the modules or materials available in this teaching media to help me study”; the second highest mean score was achieved by statement 7, “I am satisfied with brief summaries on PowerPoint slides in this instructional media”; and the third highest mean score was achieved by statement 12, “I am satisfied that I can take examination using this instructional media.” Therefore, it is expected that the high level of satisfaction with Gagne’s model of instructional design in the NEPWA media can support student learning activities and help them achieve maximum competencies.

Many previous studies have also shown that users of web-based learning media using a blended learning approach in health professions education, in general, are satisfied with the teaching methods. In line with another study [32], when students have inadequate skills to use web-based learning media, it influences how they communicate effectively. However, the groups of students who used web-based learning media were satisfied with the program as a teaching method. The findings of another study [45] showed that positive results from web-based teaching and learning practices can increase student satisfaction and retention (the ability to store and memorize learning materials). Nonetheless, there are many challenges in performing the abovementioned activities, namely, the need to improve infrastructure and institutional support (training for educators to enhance their information technology competencies and support for multidisciplinary teams to improve web-based learning design) [45].

SUS

The NEPWA media has been well implemented. The results of the SUS were based on the highest mean score in statement 5, “I feel that the features of this system are working properly,” and the next highest mean score was in statement 3, “I feel that this system is easy to use.” In this way, it is expected that this innovative NEPWA media can support the teaching and learning activities of both lecturers and students and have a significant positive effect to continue and enjoy its uses because its features are working properly. However, the sustainable use of the NEPWA media is strongly influenced by the positive and subjective experiences of students, such as being confident and happy when learning by using the NEPWA media to increase learning productivity [28].

The result of the SUS score developed in the NEPWA media was 72.24, indicating that the NEPWA media has good usability with scale C, with a range of acceptance that is acceptable to users [22,25]. This is in line with some previous studies [21,22,25], where systems or products with SUS scores >68 are considered to have a good usability category; thus, the NEPWA media has good usability. As mentioned in another study [46], the SUS score of the Moodle-based m-learning management system named Student Centered e-Learning Environment was 71.25; hence, this app can be categorized as having good usability. The fact that the NEPWA media obtained a good SUS score proved that this media is very easy to use and acceptable by student users. In fact, some of the factors that influence the SUS score are user experience, in which user groups who have repeatedly used it previously tend to give a higher SUS score compared with the group of new users [47]. Next, easy installation is crucial as users are more satisfied when an app is easily installed on a smart phone without having to download first [48].

The study had several limitations. For example, there were no features for the statistical calculation of scores based on answers to questions, the learning materials, and questions on the NEPWA media had not been validated, and there was no repeated measurement of knowledge to determine its impact on learning outcomes.

Conclusions

Web-based learning media called the NEPWA media is designed to increase student knowledge. This research showed that the NEPWA media is acceptable to users, useful, has good usability, and offers flexible learning for students.

With the potential to increase knowledge and have a good usability score, the NEPWA media can be used as supporting information media when implementing blended learning combined with Gagne’s model of instructional design with a good level of satisfaction with the learning processes. In other words, the NEPWA media can be used as alternative learning media, in addition to print media, which can help learning processes.

Recommendations

Future researchers are expected to conduct a validity test and add qualitative research data to support quantitative findings, which can be used to examine repetition of learning outcomes and knowledge retention. In the future, the development of the NEPWA media should focus on adding statistical calculation features to determine the number of answers per multiple-choice question examination results from users and enhancing the interactive skills of the features to be used in various fields, particularly nursing.

Acknowledgments

The authors wish to thank Yoyo Suhoyo, who reviewed and provided feedback related to the development of research methods and techniques for conducting the research and development; Lutfan Lazuardi, who provided feedback related to the selection of web-based learning media; Uki Noviana, who reviewed and provided feedback related to research implementation reports and writing techniques; Arif Widodo, who helped facilitate lectures and provided feedback related to the education and health promotion module; Faizah Betty Rahayuningsih, who helped facilitate the selection of courses following the curriculum of the Study Program of Nursing Science; Arum Pratiwi, the head of the Study Program of Nursing Science, who gave a research permit; Hardiansah, Director of PT Lauwba, who helped make the program website and Android app learning NEPWA media; I'ana Aulia Andari,

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who helped review the road of research in the field; and Muhamad Reza Utama, who helped review the way research was conducted in the field and test the NEPWA media. The researchers used independent funds in this study.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Questionnaires on satisfaction with Gagne's Model.
[DOCX File , 18 KB - nursing_v3i1e19780_app1.docx]

Multimedia Appendix 2
Questionnaires related to the System Usability Scale.
[DOCX File , 14 KB - nursing_v3i1e19780_app2.docx]

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Abbreviations

e-learning: electronic learning
m-learning: mobile learning
NEPWA: Nursing Progressive Web Application
SUS: System Usability Scale

Edited by E Borycki; submitted 01.05.20; peer-reviewed by A McLean, H Akram; comments to author 20.05.20; revised version received 02.07.20; accepted 28.07.20; published 13.11.20.

Please cite as:
Yuliawan D, Widyandana D, Nur Hidayah R
Utilization of Nursing Education Progressive Web Application (NEPWA) Media in an Education and Health Promotion Course Using Gagne's Model of Instructional Design on Nursing Students: Quantitative Research and Development Study
JMIR Nursing 2020;3(1):e19780
URL: https://nursing.jmir.org/2020/1/e19780/
doi:10.2196/19780
PMID:

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Original Paper

Learning With Virtual Reality in Nursing Education: Qualitative Interview Study Among Nursing Students Using the Unified Theory of Acceptance and Use of Technology Model

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Abstract

Background: Digital games–based learning is a method of using digital games to impart knowledge. Virtual reality (VR) programs are a practical application of this method. Due to demographic changes, the nursing profession will become increasingly important. These VR applications can be of use in training nurses for future professional challenges they may encounter. The continuous development of VR applications enables trainees to encounter simulated real life effectively and to experience increasingly concrete situations. This can be of great importance in nursing education, since 3-dimensionality enables a better visualization of many fields of activity and can prevent potential future errors. In addition to this learning effect, VR applications also bring an element of fun to learning.

Objective: The aim of this qualitative research effort is to observe the degree of acceptance of VR applications by nursing students in Germany. Various factors, including social influences, performance expectations, and effort expectations, are taken into consideration.

Methods: With a qualitative cohort study, the acceptance of nursing students towards VR applications in anatomy teaching was determined. The 12 participants were first asked to fill out a quantitative questionnaire on their sociodemographic characteristics and the extent to which they valued and liked using technology. The participants were then allowed to test the VR application themselves and were finally asked about their experience in a qualitative interview. For the collection of data and the analysis of results, the unified theory of acceptance and use of technology was used in this study.

Results: Overall, the study shows that the interviewed persons rated the VR application quite positively. The greatest influence in this was the personal attitude towards technology; the higher this affinity is, the more useful the VR application appears. Social influences can also increase the participant's own acceptance if peers have a positive attitude towards such applications. The study shows that the trainees' motivation to learn was increased by using VR. We believe this is because each trainee could learn individually and the VR application was perceived as an enjoyable activity. Nevertheless, the cost factor of implementing VR applications in nursing training is currently still an obstacle, as not every institution has such financial capacities.

Conclusions: The extent to which the use of VR applications in the training of nursing staff is justified depends on the degree of personal acceptance. The collected results give good practice-oriented insight into the attitude of trainees towards VR. Many of the interviewed persons saw benefits in the use of VR technologies. As VR applications are constantly developing, it is necessary to conduct further studies on VR applications in nursing education and to include other possible disciplines in which these applications can be helpful.

(JMIR Nursing 2020;3(1):e20249) doi:10.2196/20249

KEYWORDS

virtual reality; edutainment; serious games; education; health care; gamification; anatomy; digital game–based learning; nursing; nursing informatics

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Introduction

Nursing or health care support staff work mainly in hospitals, outpatient facilities, and (partially) inpatient facilities [1]. The conditions of the profession and training are regulated by law, as well as the terms “nurses” and “health care professionals” themselves, who are responsible for general care. The vocational training usually takes about 3 years and consists of theoretical as well as practical content, concluding with a state exam [2]. However, the training places have some leeway in regard to the implementation of the external conditions [3]. The 2017 Nursing Professions Act (*Pflegeberufe Reformgesetz*) called for a merger of the nursing care law (*Krankenpflegegesetz*) with the geriatric care law (*Altenpflegegesetz*) from 2020 onwards [4]. Geriatric care, nursing care, and pediatric care are to be part of a generalized apprenticeship and nurses are to be asserted as care experts [4]. Nowadays, the work density, growing bureaucracy, working time regulations, and many other factors increase the burden on nurses [5]. It is difficult to recruit nursing trainees [6]. In addition, the demographic change intensifies this situation. Due to a change in the age structure in society, the amount of elderly people in proportion to young people is increasing. Because illnesses are associated with age, an increase of chronic and multimorbid illnesses is to be expected, while at the same time a decline of the working population takes place [7]. There is also a higher need for qualified nurses, which is partially being covered by untrained staff [1]. In order to prepare future nurses for oncoming challenges, it is important to have a qualitative apprenticeship. Content should be as optimized as possible and be passed on to a wide range of students. It is also important to offer attractive terms and conditions in order to win new trainees.

One possibility to do so is by integrating games into the learning process. As Zupanic et al [8] discovered, almost every trainee in the health care sector uses electronic learning. Therefore, there are different concepts regarding the transfer of information through playful elements. This way, the motivation to learn increases and the player is stimulated [9,10]. The primary function of gaming is not information transfer but influencing thought and action [11]. When taking into consideration which of the current teaching and learning methods are attractive, it is important to note the progress in society as well as in technology. A suitable principle is digital game-based learning, wherein the learning content is transmitted based on a game or simulation under the usage of digital media. For example, this is realized through serious games (SG) [9]. In this, the educational goal comes before the entertainment goal [10]. Additionally, it should be mentioned that the combination of entertainment and learning was present even before and without the use of technology [12].

Serious games have drawn the interest of the health sciences because of their interactive as well as entertaining properties [13]. Breuer and Schmitt [12] formulated 3 fields of application to discuss the effectiveness and significance of SG: preventive health promotion, support of healing processes, and the education of qualified personnel. The results seem positive at first, but there is some caution to be taken due to the wide range of SG and the varying degrees of quality, as well as the missing research on long-term effects. Furthermore, the effectiveness is dependent on the set goal [12]. Nonetheless, SG appear to bring along some advantages when it comes to learning [13]. Graafland et al [14] and Wang et al [15] have made some reviews in this regard.

Some SG make use of virtual reality (VR). This is to be understood as interactive models of reality that are simulated by computer technology. An interactive 3-dimensional (3D) gaming environment is created and becomes perceptible with the appropriate technological equipment (VR glasses, computer, smartphone) [15]. Hellriegel and Čubela [16] see the potential learning success of VR in the field of education. However, it is important to note that the usage of these technologies should be incorporated meaningfully into the lessons [16]. Barré et al [17] investigated the effects that learning a new technique with VR had on novice surgeons. They observed an improvement in the workload of the test persons. Schlegel and Weber [18] tested a nursing education class in VR and particularly emphasized the enjoyment of the students.

It is crucial to analyze the processes of technology acceptance to understand the factors of usability and acceptance. Bracq et al [19] investigated the acceptance and usability of a VR simulation for training purposes of scrub nurses. Results showed that it was accepted and suitable for vocational training.

The objective of this study is to investigate the acceptance behavior of the nursing students towards VR applications. Our research questions are: (1) To what extent does VR support learning in nursing education? (2) What factors influence acceptance and use of VR applications in nursing education? (3) How does the individual’s technical affinity influence the acceptance of VR applications? (4) In what way is the motivation to learn influenced?

Methods

Overview

The aim of the study was to examine the acceptability of VR applications among nursing students in the context of teaching and practicing human anatomy.

Qualitative, semistructured, and open interviews based on the unified theory of acceptance and use of technology (UTAUT2) were conducted. The theory helps to understand and depict the driving factors for usability and acceptance of technology [20]. After extension, the unified theory established 7 key constructs that influence technology use [21]. It defined performance expectancy as the degree to which using a technology will provide benefits to users in performing certain activities. Effort expectancy was defined as the degree of ease associated with consumers’ use of technology [21]. The extent to which consumers perceive that family members believe they should use a particular technology was defined as social influence. Facilitating conditions relate to the consumers' perceptions of the resources and support available to implement a behavior [21]. The extended UTAUT2 model includes 3 more determinants: (1) hedonic motivation, which is defined as the fun or pleasure derived from using a technology, (2) the price value, which is defined as the consumers’ cognitive trade-off

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between the perceived benefits of the technology use and the monetary cost, and (3) the habit, which is defined as the extent to which people tend to perform behaviors automatically because of learning [21].

The price value and habit determinants were not included in the qualitative interviews because monetary costs for the application as well as the habit were not relevant for this study, as there were no interviews with decision makers relating to costs. The main focus was evaluating the circumstances of acceptability of the application.

The VR application that was worked with is a realistic 3D simulation of the human body and its anatomy. It is intended to visualize organs and their natural functions in both a healthy and sick condition (Figure 1). Physiology and state of disease can be simulated. Due to data protection reasons, the name of the application will not be mentioned.

Participants had free access to the testing of the application for the circumstances of the trial.

Figure 2 shows the UTAUT categories in detail. In a semistructured interview (Table 1), open questions regarding performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, and recommended actions and circumstances of reutilization of the VR application were asked. The questions were formulated openly so that participants could share their experiences and opinions in a storytelling way.

Figure 1. Self-created picture inside a lung.

Figure 2. Modified unified theory of acceptance and use of technology.

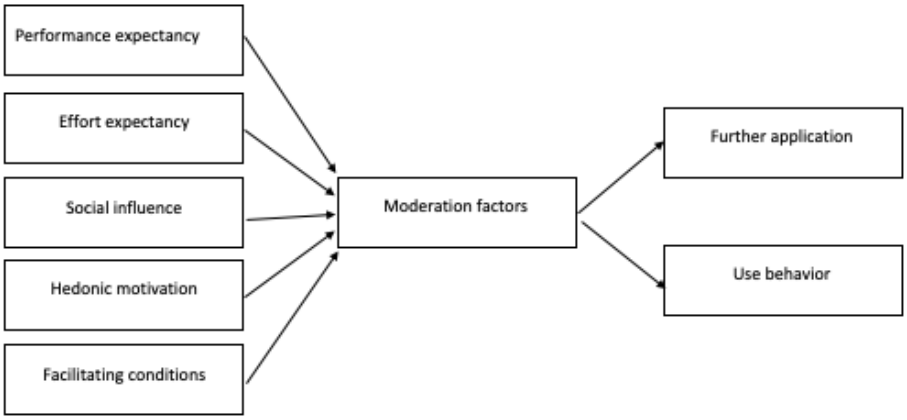

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Table 1. Categories classified.

Classification Category	Definition
Performance expectancy	The extent to which the use of a technology benefits consumers in carrying out certain activities (educational or professional)
Effort expectancy	The extent of ease associated with the use of an information system
Social influence	The extent to which an individual perceives that key stakeholders believe they should use the new technology
Hedonic motivation	The extent to which the use of a technology provides fun or enjoyment
Facilitating conditions	The extent to which consumers are aware of the resources and support available to implement a scheme
Sociodemographic facts	The extent to which gender, age, and culture influence the use of the technology

Quantitative variables were assessed through a questionnaire, which included sociodemographic information (Table 2) and the *Technikaffinität erfassen–der Fragebogen* (TA-EG) questionnaire in German to evaluate technological affinity of the participants. The questionnaire contains 19 items on a 5-point Likert scale (eg, statements such as "I love to own new electronic devices" or "Electronic devices lead to mental impoverishment" [22]). Participants had to state for each of the statements how well it applied to them personally by ticking off the correct number.

Table 2 shows the sociodemographic data (age, gender, education, educational institute, experiences with VR) assessed through the questionnaire.

Table 2. Sociodemographic data.

Characteristics	Participants, n (%)
Gender	
Male	4 (33)
Female	8 (67)
Age	
20-21	7 (58)
22-23	4 (33)
23+	1 (8)
Education	
General A-levels	8 (67)
Advanced technical college entrance qualification	1 (8)
Intermediate maturity level	3 (13)
Educational institute	
Nursing school	11 (92)
University of applied science	1 (8)
Experience with VR [a]	
Yes	7 (58)
No	5 (42)

[a]VR: virtual reality.

Procedure

Before starting the recruitment of participants, a request was submitted to an ethics committee, which was approved soon after. The recruitment of participants took place from November 2019 to January 2020. Leaflets and flyers were placed in health care facilities (2 hospitals, 3 nursing schools). Additionally, teachers in medical nursing schools in North Rhine-Westphalia were contacted to recruit nursing students for participation. After first contact via email, potential participants who met the eligibility criteria of being in nursing education got an appointment confirmation. Nursing education was defined as training in general health care, therefore including curative care, geriatric care, and pediatric care. Because students need knowledge of anatomy in all of these health care fields, there were no specific demarcations. Students of all genders and ages were included.

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Before the VR simulator training of the participants, they were asked to complete the questionnaire with sociodemographic data as well as the TA-EG questionnaire, which both were anonymized.

Afterwards, the participants got instructions on how to handle the VR simulator and went through an introduction and a short training to get familiar with the application. Participants had approximately 20 minutes to use the VR simulator.

The short training included the participants in the exploration of the functions and visualization of the lungs and the heart. They had the opportunity to customize physiology of both organs and adjust severity of specific diseases (eg, chronic obstructive pulmonary disease or arteriosclerosis).

The qualitative interview followed. During the interviews, only the participant and 2 interviewers were present, one interviewer giving the short training through the VR simulator and the other one conducting the interview.

The interviews and trainings were carried out in rotation by all of the authors, who are university students. Interviews were only conducted after the participants signed a declaration of consent for audiorecording of the interview. Duration of the interview itself was mostly about 20 minutes.

In total, 12 nursing students went through the VR training and the interview, with no one dropping out or refusing to participate. Sociodemographic data of the participants are presented in Table 2. The majority of participants were female and graduated with general A-levels. Participants overall were young, including only 1 person older than 23 years. Nearly half of the participants already had experiences with VR, mostly through conventions or exhibitions.

Analysis

Qualitative analysis was completed using the concept maps method of Mayring, a narrative research design [23]. The method is used to summarize the essential content by first paraphrasing the raw input, then selecting, bundling, and lastly, constructing and integrating the content [23]. Audiorecordings of the interviews were transcribed and analyzed within the scope of the 5 categories included in the interviews using the Mayring method. Therefore, a structured overview of the participants' statements is given in the "Results" regarding every category. Transcripts were not returned to participants.

Results

Performance Expectancy

Nursing students considered the use of VR in nursing education to be clearly beneficial. The aspect of perceived quality improvement of the learning process in anatomy was of particular importance. The perceived benefits that resulted from the contrast of digital visual learning with VR and analog learning with graphics from books were first, the time saved in the learning process, and second, the visualization of the content:

> *I would still learn the content with the book. Then I would go into VR and deepen what I had learned. Explore connections, for example.*

The use of VR was particularly relevant in the context of the deepening of learning content. The realistic representation of anatomy content was especially emphasized, which was perceived to be a close match to real organ anatomy:

> *I could imagine the anatomy much better through the VR application. I really didn't think so before. It all looked so freaking real. Like I was really inside the organ.*

However, it is true that VR applications tend to deepen the content already learned rather than teach completely new content. The exchange among student nurses in self-study with the help of the VR application was evaluated as homogenously positive. Consequently, self-study before exams is of great importance. Thus, students who were not able to fully learn the content in class have simplified access to independent learning with VR.

Effort Expectancy

The use of VR applications tends to be perceived as manageable. The acquisition of VR technologies for the respective institution in which the students were located was perceived as cost intensive. Occasionally, fears of excessive demands and incorrect operation have corresponding consequences for health, manifesting themselves in side effects such as nausea, which can limit the use of VR applications. There was a shared attitude among the interviewees that, after a short introduction and testing of the VR application, the handling was no obstacle:

> *Before first use it sounds very complicated, but after a few minutes of use it looks easier than expected.…I immediately found my way around.*

As a further aspect of the expected effort, the integration of VR into the learning process of the students makes one thing clear: An unrestricted access to the tested VR application increases the motivation to deal with necessary anatomy content. Although it also makes a change in the learning routines necessary, this was perceived as a manageable effort.

Social Influence

The family is one of the central points of reference regarding the use and recognition of VR applications in anatomy. The opinions within the circle of friends seem to be equally relevant. However, students also expressed concerns about the experience of their teachers. The participants assumed VR applications are not yet sufficiently accepted among teachers. All in all, positive attitudes towards VR applications in the social environment increased the acceptance to use these applications oneself because social contacts often have an influence on one's own opinion making:

> *If you often hear about such things from friends, you are more aware of these kinds of new technologies. For me it is important to know what kind of experience they have. Especially when something is completely new to me.*

Facilitating Conditions

Facilitating conditions for the use of VR applications were perceived on different levels. These included, besides the

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assessment of general knowledge about VR technology, aspects of technical support, technical introduction, and cost absorption:

> *In my opinion, you need rooms that are already suitable for VR applications. I'm not sure if we have rooms like this in our university. And the teachers need to have time to deal with that first.*

An introduction to the technology is a basic requirement for the interviewees for the assessment and subsequent use in the individual learning process. Help systems and empowerment are also explicitly called for to break down barriers of use. For the use and introduction of the VR application, trained personnel are required. The costs incurred in the acquisition would have to be fully clarified. The potential of VR applications can only be fully exploited by the students through implementation into the training curriculum of the institution:

> *The full benefit potential can only be exploited if learning with VR is embedded in the curriculum.*

Hedonic Motivation

The VR application promoted the motivation to learn through its playful nature, even though it was not perceived as a game application but as a support for the learning process in anatomy. The time required for learning plays an important role for the students in terms of anatomy. Through self-directed learning of new content with the VR application, learning appears to be less time-consuming, further promoting the motivation to learn in general:

> *Studying is stressful. It's good to have a fun alternative to normal learning. This supports me in learning, drives me forward.…Time flies in the VR.*

Moderation Factors

Overall, there were differences between the perception of the value of technology orientation and the associated knowledge about technology and the effort expectancy. The lower the average technology orientation, the more likely attitudes and opinions about the operating effort were discussed as critical. This is where the reference to social influences can be made. The more technology aware the user is, the more independent they are from social influences:

> *Of course I am interested in technology, it is part of my everyday life. So, I form my own opinion. About what makes sense. Especially when it comes to individual things like learning.*

Furthermore, when assessing the effort required to use the VR application, it seems that it is not only the individual assessment of personal handling that plays a decisive role. The interview partners also considered the perspective of the teachers involved in the learning process. The introduction and use of the VR application should not mean any additional burden for teachers and should be easily integrated into the teaching process. This opinion of the interviewees referred mainly to the older generations of teachers:

> *If I were a teacher, I would at first be skeptical about the additional work. It is crucial that VR is integrated into their own training. Technical support may also be needed.*

Further Application Possibilities

In addition to anatomy, the VR application offers potential for further applications. For example, the interviewees mentioned the area of patient education, as well as behavior in an emergency. Both are central teaching topics in the training as a nurse and can be tested more intensively through real experience with a VR application. Nevertheless, a VR application is only a supporting measure to the previous learning processes and cannot completely replace them:

> *VR can by no means replace normal learning situations, but it can complement learning. The link between the two worlds is important. In one moment, I hear what the teacher is saying and in the other moment I can watch it live in VR. The connection between theory and practice can be solved very well.*

An overview of participants' perceptions is found in Table 3.

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Table 3. Results summary.

Classification Category	Hypothesis
Performance expectancy	Learning is more understandable than with analog literature.
	Due to the better visualization, the user can memorize the content more profoundly.
	VR[a] applications are able to consolidate content learned, and content can be memorized better.
	Due to the realistic representation of content, it can be learned better.
Effort expectancy	Side effects such as nausea can limit use.
	The use of the VR applications is intuitive and therefore easy to learn.
Social influence	Positive opinions towards VR applications in the social environment increase the acceptance to use them.
Facilitating conditions	If VR applications are an integral part of the training curriculum, their potential can be fully exploited.
	The use requires trained staff.
Hedonic motivation	The VR application promotes the motivation to learn through its playful nature.
	Through self-directed learning of new content, learning seems less time-consuming.
	Self-directed learning promotes motivation.
Moderation factors	The more technical experience the user has, the more independent they are from social influences.
	Previous experience is essential for optimal use.
	In order to integrate VR applications into nursing education, older generations must be familiarized with the applications.
Further application possibilities	Patient education and behavior in an emergency

[a]VR: virtual reality.

Discussion

Principal Results

The collected results presented in this paper provide new insights on the influence that VR applications have on training and further education of nursing staff. In general, the conducted study shows that the overall perception of the interviewees was quite positive towards the new technologies. VR programs can be an important, supporting part of the training to deepen learning content like anatomy. These results were consistent with previous studies on this topic [24-28].

The data show how different influencing factors, such as performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, and moderating factors, can influence potential users' acceptance of VR in anatomy education.

In this case, personal attitude towards technology in general plays an important role as well. Persons with an affinity for technology therefore consider VR programs to be more useful than persons with less affinity for technology. As a result, in the training of nursing staff, the use of VR depends on the individual characteristics of each person. In practice, this means that for optimal use of such technologies, they would have to be used in a long-term and practical way. This would ensure that every trainee could benefit from the VR application regardless of their technical affinity. Furthermore, the technology has to be easy to use and understandable for the trainees. For this reason, the interviewees stated that VR applications should be included in the curriculum. This could increase the interest of the trainees and create more technical affinity, and it would also lead to greater acceptance of VR. These statements correspond with those from previous studies, according to which a national curriculum would have a positive effect on the development of VR applications and serious games [24,29].

As already found in a study by Patterson et al [25], the results of this study show that learning with such technologies can increase the motivation of the trainees. In addition, individual and free learning is evaluated as very positive because every trainee can learn individually. However, the success of learning also depends on the personal attitude towards learning [25].

It is also mentioned in this study that social influence has an impact on the acceptance of VR technologies. It was reported that there are reservations caused by the rejection of VR technology by the family environment. However, the respondents also stated that VR might be rejected by teachers. Teachers would need to become enthusiastic about this technology in order to use VR optimally in their lessons. As Keskitalo and Ruokamo [30] described in their study, a pedagogical model must be introduced that "ensures that a more holistic and meaningful approach to teaching and learning is adopted." This model could be used to meet the needs of the trainees and teachers to integrate simulation-based learning into

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the classroom. Furthermore, Keskitalo [31] stated that the beneficial parts of VR used in education depend on "the effort of the teachers to familiarize with the environment and a strong expertise in the subject, planning and flexibility."

Due to the practicability, the interviewees mentioned that the cost factor plays a major role in the introduction of such technologies. The interviewees assume from their own findings that educational institutions often lack financial resources, which leads to the use of traditional media (eg, textbooks, presentations, videos). In addition, on the pedagogical level, the interviewed persons criticized the fact that whole classes have to learn with VR in one teaching unit. In this case, each student cannot be addressed individually, nor would the time frame be sufficient. In contrast to other studies, these statements show that further models for embedding VR applications in everyday learning have to be developed [30-32]. Furthermore, both the functionality and limitations of the VR program used in the study were demonstrated by the study participants. The visualization of the anatomical content and the mass of information were considered to be limited, and the study participants were unable to adapt all learning content to the VR application. Manufacturers of VR applications must therefore adapt their programs to the wishes of the customers and further develop the functions. Shorey et al [27] also concluded that content developers should create the VR applications in close consultation with users. In this way, subject-related content and user expertise can be integrated into the programming [27].

Overall, the interviewed persons saw great advantages in teaching anatomy with VR technologies compared with the purely analog method of learning. In addition, if optimized to its full potential, the VR technology could become a useful tool to create valuable learning environments for less motivated trainees or trainees with learning disabilities.

Limitations

The study has various limitations, which result from the number of study participants and the qualitative research method.

Although no confounding variables were apparent during the study, the qualitative data collected are only sufficient for an insight into the topic. In order to draw further conclusions, further studies on this topic have to be conducted with a larger number of participants.

Despite the interview guidelines, we cannot exclude the possibility that questions were interpreted differently by the interview partners. Thus, statements can have different meanings. Furthermore, it is also possible that participants with a high affinity for technology were contacted in the first place. This group of people would have entered the study with different expectations than people with low affinity for technology. As a result, there might be a social bias in the study.

The study was carried out with German nursing students, so their statements refer to the German health educational system. However, the results can be applied to other health educational systems.

Conclusion

VR is one opportunity to support learning in nursing schools. Anatomy learning content in particular can be better explored through visualization. During the study, the acceptance of the VR application was high. This shows that from the students' point of view, the new technologies have a good chance to be introduced into nursing schools. As in other studies, the practicability and the interest of trainees was also recognized in this study [26,31,33-35]. The results reflect previously gained insights into the connection between learning and fun and the creation of new knowledge through VR, as was stated before [34]. The recommendation of the interview partners is a firm integration into the curriculum. Through integration, VR could be offered as a supporting aid that contributes to a better visualization of learning material. Thus, the pedagogically meaningful use of VR applications would be made possible.

From this pedagogical point of view, the use of VR also offers great advantages. As Bruce and Gerber [35] have mentioned, trainees perceive learning differently. The focus is on the transfer of knowledge by a teacher and practical experiences that the trainees make themselves. These skills and knowledge are then specialized by each individual for later professional challenges [36,37]. Through the practical integration of anatomical learning content, a better knowledge transfer can take place. The trainees have the chance to react to gaps in their knowledge and to repeat learning material. Furthermore, the visualization leads to a better idea of upcoming scenarios in the profession and a practice-oriented training.

However, not only nursing schools can benefit from this technology. The interview partners also saw great potential in other application areas of VR technology. Among these are the learning of practical content with virtual patients, presurgical education, or practice with patient communication. This potential has already been recognized by various studies that give information about how VR can support the learning of communication [26,32,37-39].

In view of this, the possibilities of practical training for nursing students are enormous. Due to the wide range of possible applications, nursing schools can respond to the growing challenges in the health care sector. Nursing students can thus be better sensitized to challenges and receive a further benefit in their training.

The study and the existing literature give a good outlook on what could be achieved in the health care sector through new technologies [9,12,14,15,19]. It is of great importance that actors in the health care system are familiarized with the new technologies. On the part of students and trainees, there would likely be great acceptance of VR learning content, so it is up to them to support the introduction of VR. The recommendations for action would be a discussion of the benefits of the new technologies and the embedding of the technologies in a fixed curriculum in learning institutions. Furthermore, further studies on the topic would have to be carried out to improve the evidence regarding the acceptance of VR applications and the benefit of these programs.

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Even if VR technologies are still viewed skeptically from some sides, they can lead to an increase in the quality of education. The results of this study show that all participants, even those with initial skepticism, rated the VR program as positive. These statements give reason to believe that modern learning content and teaching methods are desired and demanded by the trainees.

Acknowledgments

We would like to thank Cornelius Engelbrecht, Jan Felix Trettow, and Marvin Seppmann of the IT Service Center of Bielefeld University for their kind support in providing and testing the VR application. Furthermore, we would like to thank Robin Koschel and Dirk Schauerte for careful reading of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
CONSORT-EHEALTH (V 1.6.1) checklist.
[PDF File (Adobe PDF File), 354 KB - nursing_v3i1e20249_app1.pdf]

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Abbreviations

3D: 3-dimensional
SG: serious games
TA-EG: Technikaffinität erfassen–der Fragebogen
UTAUT2: unified theory of acceptance and use of technology
VR: virtual reality

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Edited by G Strudwick; submitted 14.05.20; peer-reviewed by A McLean, H Akram; comments to author 28.05.20; revised version received 16.07.20; accepted 12.08.20; published 01.09.20.

Please cite as:
Lange AK, Koch J, Beck A, Neugebauer T, Watzema F, Wrona KJ, Dockweiler C
Learning With Virtual Reality in Nursing Education: Qualitative Interview Study Among Nursing Students Using the Unified Theory of Acceptance and Use of Technology Model
JMIR Nursing 2020;3(1):e20249
URL: https://nursing.jmir.org/2020/1/e20249/
doi:10.2196/20249
PMID:

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Original Paper

Augmented Reality Technology as a Teaching Strategy for Learning Pediatric Asthma Management: Mixed Methods Study

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Abstract

Background: Asthma is a major chronic disease affecting 8.6% of children in the United States.

Objective: The purpose of this research was to assess the use of clinical simulation scenarios using augmented reality technology to evaluate learning outcomes for nurse practitioner students studying pediatric asthma management.

Methods: A mixed-methods pilot study was conducted with 2 cohorts of graduate pediatric nurse practitioner students (N=21), with each cohort participating for 2 semesters.

Results: Significant improvements in pediatric asthma test scores (P<.001) of student learning were found in both cohorts at posttest in both semesters. Student satisfaction with the augmented reality technology was found to be high. The focus group discussions revealed that the simulation was realistic and helpful for a flipped classroom approach.

Conclusions: The study results suggest augmented reality simulation to be valuable in teaching pediatric asthma management content in graduate nursing education.

(JMIR Nursing 2020;3(1):e23963) doi:10.2196/23963

KEYWORDS

augmented reality; graduate nursing; pediatric asthma management; flipped learning; nursing; asthma; chronic disease; nurse practitioner; nursing students; pediatric asthma

Introduction

Background

Asthma is a major chronic disease affecting 8.6% of children in the United States [1]. Nurse practitioners play a vital role in assessing and effectively managing asthma. Educating nursing practitioner students and empowering them with relevant clinical health information can improve pediatric asthma care delivery. Furthermore, the US Department of Education [2] advocates that educators enable learning through technology.

This study examined the use of augmented reality (AR) technology in teaching clinical simulation content. AR technology is emerging, and the earliest evidence of its use in the classroom and simulation settings or during independent and asynchronous activities suggests that this pedagogical approach is effective in transforming nursing education [3]. AR technology consists of augmenting layers of sounds, images, and videos into real-life environments.

Results from a study by Aebersold et al [4] in nursing and medical education showed enhanced health care learning and critical thinking when providing a more authentic and engaging experience. Integrating simulation through AR for health care education has been implemented with positive results. Data from 69 students who completed a merged learning experience showed that 86% preferred the augmented virtual simulation experience over the traditional simulation experience [4]. We searched the Google Scholar, JMIR, and literature databases with the search terms “augmented reality” AND “clinical simulation” AND “nursing” AND “graduate” for papers written

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since 2016 and found few comparable studies, with only 1 study in graduate education. A study reported that several studies in science, engineering, and health fields used AR with school students, undergraduate students, or others. Still, only 1% of studies used graduate students as their sample group [5]. Studies have shown that handheld devices, such as iPads, tablets, or glasses, are preferable for delivering AR education because of the affordability and portability they offer [6-8]. AR education offered via mobile devices is adequate for conveying auditory and visual information compared with the increased cognitive demands associated with immersive technologies (and experiences) [4,9]. A critical implication of this modality type is the feasibility for distance learning and telehealth situations [10]. Using iPads, quick response (QR) codes, and the Augmented Reality and Interactive Storytelling (ARIS) mobile app [11], the Augmented Reality Integrated Simulation Education (ARISE) project team developed 150 clinical scenarios [12] for health care students [13]. These scenarios merge the concepts of simulation with AR. The developers replicated realistic storylines in the scenarios with features such as videos and pictures of clinic settings, as well as patient introductions, nurse-patient encounters, and live patient simulations. Creating a sense of realism is essential for educators using simulation lab scenarios. These features maximize student learning and provide opportunities for practice learning in a safe environment compared with a live patient interaction, in which risks for mistakes are higher.

The purpose of this study was to evaluate the use of clinical simulation scenarios using AR technology with nurse practitioner students studying pediatric asthma management.

Research Questions

Our research questions were (1) Does the AR simulation improve student learning outcomes related to pediatric asthma management, and are there differences in the 4 factors (attention, relevance, confidence, and satisfaction) that measure student motivation when using AR technology to learn pediatric asthma management content? and (2) What are the perceived benefits and difficulties of using the AR technology to learn the pediatric asthma management content?

Methods

Study Design

A mixed-methods single-condition study was conducted with 2 cohorts of graduate nursing students [14]. Each cohort participated for 2 semesters (fall and spring). ARISE clinical scenarios (Multimedia Appendices 1 and 2) were used in a flipped classroom approach, in which students interacted with the clinical scenario independently and discussion occurred in class. Students used the AR ARIS app on their iPad to prioritize what to do first, as though in a patient care setting. This process allowed for making connections between classroom learning and clinical practice. The institutional review board decided the study was exempt because it was a program evaluation.

Sample

The sample consisted of 21 students enrolled in 2 courses in the pediatric nurse practitioner program at a large Midwestern US university. There were 12 students in the first cohort (2018-2019) and 9 in the second cohort (2019-2020); 19 were women and 2 were men. Hertzog [15] recommends 20 to 25 participants to demonstrate efficacy in single-group studies.

Measurements

A pretest and posttest of knowledge about pediatric asthma was used to assess student learning. At posttest, data were collected using 3 reliable and valid measurements. The Instructional Materials Motivation Survey (IMMS) has 4 subscales that measure motivational factors: attention, relevance, confidence, and satisfaction (ARCS) [16]. Items on the IMMS are on a 5-point scale ranging from 1 (not true) to 5 (very true). The 20-item Simulation Design Scale (SDS) has 5 subscales that rate the importance of objectives and information, support, problem solving, feedback and guided reflection, and fidelity (realism) design elements [17]. Item responses on the SDS range from 1 (not important or strongly disagree) to 5 (very important or strongly agree). The 13-item Student Satisfaction and Self-Confidence in Learning Scale (SSSC) has point scales ranging from 1 (strongly disagree) to 5 (strongly agree) and measured attitudes toward simulation [18]. All rating scale scores have well-established psychometric properties, with all subscale and total scores having Cronbach α reliability coefficients above .80.

Procedure

All students received an iPad (Wi-Fi connectivity compatible) and the accompanying ARIS app from the university for the duration of the study. Each semester, students took the pretest. A 4-week window was given to complete the pediatric asthma simulation on the iPad, which was followed by the 3 measurements and the posttest. A structured focus group interview was then conducted to elicit student perceptions of the benefits and difficulties associated with the learning experience.

Data Analysis

Descriptive statistics were calculated on all variables and 2-tailed dependent samples *t* tests were performed to assess student learning of pediatric asthma by analyzing the change from pretest to posttest each semester. Correlations were used to assess motivational factors associated with student learning. IBM SPSS version 25 (IBM Corp) was used for all analyses, and a .05 α level was used to determine statistical significance.

Results

Student Learning Outcomes

Significant improvement in pediatric asthma test scores of student learning were found in both cohorts at posttest in both the fall semester (t_{20}=8.95; P<.001) and spring semester (t_{16}=4.35; P<.001), as shown in Figure 1. The test scores indicated that the AR allowed for learning related to the assessment and management of asthma. No studies for comparison were located in graduate nursing didactic education.

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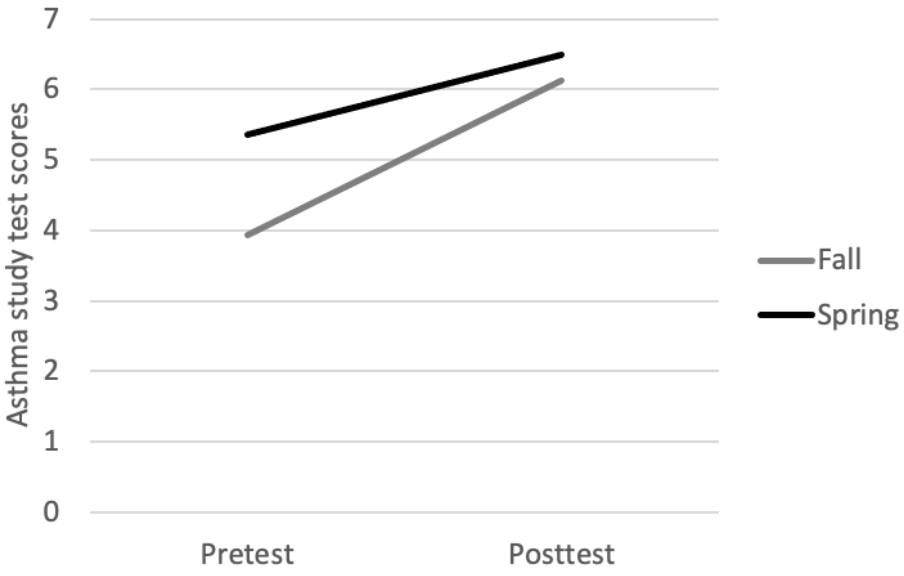
Figure 1. Comparison of asthma study pretest and posttest scores in the fall and spring semesters.



Factors Associated With Student Learning

Overall data from the IMMS and SDS measurements and the subscale scores were reviewed (see Table 1).

Average scores ranged from 3.2 to 4.2, all above the midpoint (3.0) of the subscales, indicating that students were generally motivated, satisfied, and confident with their learning and felt the content was important. Student learning outcomes, represented by increases in pediatric asthma test scores during a semester, were not significantly correlated with any of the factors. There were small to moderate correlations observed, and significant correlations were observed among several factors. There were no significant differences on the ARCS motivation factors in the IMMS scale in either cohort of students between the fall and spring semesters, but pretest motivation was high and did not decline. Average scores were 3.8 for helpfulness and enjoyability of the teaching methods. Student satisfaction with current learning (SSSC) was found to be highly positively correlated with students' motivation and confidence (IMMS) in both semesters (r=0.50 to r=0.67; P<.001 to P=.046).

Table 1. Descriptive statistics (means and standard deviations) of scored measures.

Measurements	Fall, mean (SD)	Spring, mean (SD)
Simulation Design Scale[a]		
Objectives and information	3.73 (0.55)	3.81 (0.83)
Support	3.94 (0.73)	4.06 (0.66)
Problem solving	3.82 (0.65)	4.08 (0.47)
Feedback and guided reflection	3.77 (0.43)	3.89 (0.51)
Fidelity (realism)	4.38 (0.52)	4.35 (0.46)
Student Satisfaction and Self-Confidence in Learning[b]		
Satisfaction with current learning	3.78 (0.59)	3.84 (0.46)
Self-confidence in learning	3.86 (0.46)	3.82 (0.42)
Instructional Materials Motivation Survey[c]		
Attention	3.72 (0.68)	3.7 (0.42)
Relevance	3.71 (0.68)	3.69 (0.51)
Confidence	3.9 (0.54)	4.11 (0.52)
Satisfaction	3.19 (1.03)	3.06 (0.72)

[a]SDS scale ranges from 1 (not important or strongly disagree) to 5 (very important or strongly agree).

[b]SSSC scale ranges from 1 (strongly disagree) to 5 (strongly agree).

[c]IMMS scale ranges from 1 (not true) to 5 (very true).

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Discussion

Summary

The positive correlations among students' motivation, satisfaction, and confidence are a clear indication for faculty that using AR technology in their teaching approach may lead to successful learning outcomes and experiences. These study results are consistent with the finding that students perceived high ease of use and motivation for using AR pedagogy on mobile devices [19]. Future use of QR codes to experience simulated sound recordings could be used in a simulation environment.

Benefits and Difficulties

Focus group leaders asked students questions about the benefits of the AR, such as how the simulation matched the intended pediatric asthma management content, how the simulation fostered confidence in assessment, and what learning pearls they gained from the activity. Leaders asked about difficulties in using the iPad and links to the simulation and what was hard to access. An additional question asked about the future use of iPad learning. Students found the simulation realistic and said that it tied together teaching and learning. However, they struggled with iPad passwords and scanning the simulation codes. They expressed concerns related to using a device that they did not own. Those who already had a personal iPad would have preferred to use their own device. In each cohort, students had fewer questions in the spring than in the fall. Students recommended providing iPads with simulation software already installed. They discussed their difficulty accessing the ARIS app and the appropriate simulation. A suggestion was made to create a series of screenshots to use as guidelines. Once they overcame that problem, students found the simulation realistic and consistent with pediatric asthma management practices. They believed the app could be expanded to include other lung sounds and medical conditions.

Limitations

The study was conducted in a single school location with no control group and a small sample size. Focus groups were conducted by course faculty. Comparable groups using the previous mode of instruction in the courses would have added to the external validity of the results.

Conclusion

Overall, AR technology is promising for simulation in graduate nursing education. AR simulation provided a flexibly timed pediatric situation that improved student learning about pediatric asthma management and aided transfer of knowledge to clinical practice. This study demonstrated the use of technology to provide clinical situations without the concerns related to clinical site placements. Simulation plus AR allowed for realistic pediatric patient assessment. Student comments implied the need for support and guidance using technology devices.

This study advocates that AR technology can be effectively administered in nursing instruction, making it possible for faculty to spend less class time presenting facts and procedures and more time engaging students in quality debriefing. The findings add to our understanding of expanding AR use to other nursing concepts in flipped or emergency remote teaching modalities (see Multimedia Appendix 3).

Conflicts of Interest

None declared.

Multimedia Appendix 1
Asthma Simulation Nursing L1 UNMC version.
[DOCX File , 254 KB - nursing_v3i1e23963_app1.docx]

Multimedia Appendix 2
Asthma Simulation Nursing L2 UNMC version.
[DOCX File , 256 KB - nursing_v3i1e23963_app2.docx]

Multimedia Appendix 3
Example technology implementation considerations prior to using augmented reality technology for instructional activity.
[DOCX File , 20 KB - nursing_v3i1e23963_app3.docx]

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Abbreviations

AR: Augmented Reality
ARCS: Attention, Relevance, Confidence, and Satisfaction
ARIS: Augmented Reality and Interactive Storytelling
ARISE: Augmented Reality Integrated Simulation Education
IMMS: Instructional Materials Motivation Survey
SDS: Simulation Design Scale
SSSC: Student Satisfaction and Self-Confidence in Learning Scale
QR: Quick Response

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Edited by E Borycki; submitted 07.09.20; peer-reviewed by C Foronda, K Carlson, D Tuden; comments to author 22.10.20; revised version received 05.11.20; accepted 08.11.20; published 02.12.20.

Please cite as:
Kotcherlakota S, Pelish P, Hoffman K, Kupzyk K, Rejda P
Augmented Reality Technology as a Teaching Strategy for Learning Pediatric Asthma Management: Mixed Methods Study
JMIR Nursing 2020;3(1):e23963
URL: https://nursing.jmir.org/2001/1/e23963/
doi:10.2196/23963
PMID:

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Original Paper

Comparison of the Results of Manual and Automated Processes of Cross-Mapping Between Nursing Terms: Quantitative Study

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Abstract

Background: Cross-mapping establishes equivalence between terms from different terminology systems, which is useful for interoperability, updated terminological versions, and reuse of terms. Due to the number of terms to be mapped, this work can be extensive, tedious, and thorough, and it is susceptible to errors; this can be minimized by automated processes, which use computational tools.

Objective: The aim of this study was to compare the results of manual and automated term mapping processes.

Methods: In this descriptive, quantitative study, we used the results of two mapping processes as an empirical basis: manual, which used 2638 terms of nurses' records from a university hospital in southern Brazil and the International Classification for Nursing Practice (ICNP); and automated, which used the same university hospital terms and the primitive terms of the ICNP through MappICNP, an algorithm based on rules of natural language processing. The two processes were compared via equality and exclusivity assessments of new terms of the automated process and of candidate terms.

Results: The automated process mapped 569/2638 (21.56%) of the source bank's terms as identical, and the manual process mapped 650/2638 (24.63%) as identical. Regarding new terms, the automated process mapped 1031/2638 (39.08%) of the source bank's terms as new, while the manual process mapped 1251 (47.42%). In particular, manual mapping identified 101/2638 (3.82%) terms as identical and 429 (16.26%) as new, whereas the automated process identified 20 (0.75%) terms as identical and 209 (7.92%) as new. Of the 209 terms mapped as new by the automated process, it was possible to establish an equivalence with ICNP terms in 48 (23.0%) cases. An analysis of the candidate terms offered by the automated process to the 429 new terms mapped exclusively by the manual process resulted in 100 (23.3%) candidates that had a semantic relationship with the source term.

Conclusions: The automated and manual processes map identical and new terms in similar ways and can be considered complementary. Direct identification of identical terms and the offering of candidate terms through the automated process facilitate and enhance the results of the mapping; confirmation of the precision of the automated mapping requires further analysis by researchers.

(JMIR Nursing 2020;3(1):e18501) doi:10.2196/18501

KEYWORDS

health information interoperability; nursing informatics; controlled vocabulary; standardized nursing terminology; ehealth

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Introduction

Cross-mapping is a process by which equivalence is established between terms from different health record structures [1-3]. Some of the purposes of cross-mapping are interoperability [4], updating terminological versions [5], and the reuse of terms [6].

Cross-mapping is a nursing strategy that verifies the relevance of decisions arising from clinical reasoning [7] and is a stage in the construction of terminological subsets of the International Classification for Nursing Practice (ICNP) [8]. The construction of subsets of the ICNP and the cross-mapping of its terms with other terminologies are supported by the electronic health (eHealth) program of the International Council of Nurses [9]. The equivalence established in the mapping is performed by comparing one document that contains source terms to another that contains target terms. The similarity between the source and target is determined using the equivalence degree scale proposed by the International Organization for Standardization/Technical Report (ISO/TR) 12.300:2016 [1].

The ICNP is an object for mapping that is composed of primitive terms (in a 7-axis model) and precoordinated terms (diagnoses, results, and nursing interventions) represented in the Web Ontology Language [10-14]. It should be noted that by recognizing the use of terminologies for the documentation of the practices of the nursing profession [15], nursing terminologies can be mapped to each other [2,10] and among other terminologies that are not restricted to the profession [13,16].

Among the challenges of cross-mapping is the high number of terms [2,11,14], which implies that cross-mapping is a strenuous, extensive, and tedious process [11,17] that requires time and effort to develop [18]. Despite initiatives for automation [19,20], called “self-combining mapping” [1], this process is mostly performed manually [2,14,21], which is called “human mapping” [1].

A study that compared the validity of the two mapping approaches demonstrated weaknesses in the results obtained without computational support [22]. As a support tool, Metamap is an algorithm that identifies and maps terms in free English text for the Unified Medical Language System (UMLS) [20], a system whose use promotes the comparison of terms from different terminologies using a unique identifier, the Concept Unique Identifier [23]. With regard to automating mappings between ICNP terms and other terminologies, precoordinated terms should be considered in the UMLS in English [24]. Further, because the primitive terms of the ICNP are arranged in a 7-axis model, natural language processing (NLP) algorithms and techniques can support its mapping [25].

A study that examined the interoperability between nursing information systems mapped nursing diagnoses of the Clinical Care Classification, the ICNP, and the North American Nursing Diagnosis Association-International for the *Systematized Nomenclature of MedicineClinical Terms (*SNOMED CT) through the UMLS. Problems were evidenced in the concordance of the mapping of ICNP with other terminologies by UMLS, which implies interoperability failure [26]. Another study in which the UMLS framework was used to assess the automation of mapping from ICNP to SNOMED CT generated candidate terms for mapping, which facilitated the work of specialists [13].

In this context, the hypothesis of the study that is reported in this paper is as follows: mapping automation, through computational algorithms, collaborates with the manual mapping process. The goal of this study is to compare results of manual and automated term mapping processes to verify if the automated method is adequate to support the task of mapping, considering the challenges of the manual cross-term mapping process [25], the possible contribution of automated mapping to nursing terminologies [11,13,14], and the incipience of studies that compare manual and automated mappings.

Methods

Mapping Processes

The descriptive, quantitative study that was used as an empirical basis for this paper examines two term mapping processes: manual [14] and automated [27].

The manual mapping process consisted of mapping 2638 terms of nurses’ records from a university hospital in southern Brazil with 2138 primitive terms of the ICNP (2011 version) and 3894 terms of the ICNP (2013 version) [14]. The database used in this paper is called the University Hospital Terms Bank (*Banco de Termos do Hospital Universitário*, BTHU).

The terms of manual mapping (Table 1) were classified as follows: identical, in which the BTHU term was identical to the ICNP term (eg, source term and target term: impaired); similar, in which the BTHU term was similar to the ICNP term (eg, source term: adipose, target term: adipose tissue); present in the definition of another term of the ICNP, in which the source term was found in the definition of another ICNP term (eg, source term: abrasion, target term: wound); and new, for any outcome that did not fit the previous situations.

In the automated process, the 2638 BTHU terms were mapped with the 2401 primitive terms of the ICNP 2017 using a computational tool called MappICNP, which is available for free on the internet [28]. This tool, which was developed in Python version 3.2, uses lexical and semantic methods from NLP 27 [27].

The MappICNP process was structured in two phases. The first phase consisted of normalization of terms from the BTHU and from the ICNP (2401 primitive concepts). This normalization was divided into three steps: accentuation and special character removal, lowercasing, and stopword removal. In the second phase, six NLP rules were created to compare the terms. In all rules except the first one, input and ICNP terms were modified to cover all orthographic variant possibilities. For each rule, the comparison between terms was performed using Levenshtein's distance editing algorithm [27].

In the first rule, each input term was compared to all ICNP terms until a term with 100% similarity was identified. If the similarity was between 90% and 99%, the ICNP term was added to a list of candidate terms that can represent the input term. If this rule

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achieved 100% similarity, the other rules were not executed [27].

Thus, the automated process performed the mapping as follows:

1. Identical term (rule 1): direct mapping between databases by exact coincidence of the term with equal lexical and semantic structures. For example, the source term and the target term are “vein”.
2. Lemmatizer (rule 2): search for the motto, that is, the ideal lexical unit that represents a set of terms. For example, the source term is “abortion,” and the motto of the target term is “to abort”.
3. Stemmer (rule 3): the terms are reduced to their stems, or radicals. For example, the source term is “medicate” and the stemmer of the target term is “medic”.
4. Synonym (rule 4): a synonym for the source term is identified in an online dictionary. For example, the source term is “person” and the target term is “individual”.
5. Restricted term (rule 5): coincidence with a term that has a more restricted meaning than the source term. For example, the source term is “room” and the target term is “operating room”.
6. Comprehensive term (rule 6): a term is identified with a broader meaning than the source term. For example, the source term is “catheterize bladder” and the target term is “catheterize”.

Terms not mapped by any of the rules were considered new. The BTHU terms were mapped by more than one rule, which generated a higher total number of terms than the manual mapping, that is, 2811 terms (Table 2).

The automated mapping generated a rule that provided the mapping of the term, the percentage of similarity between the source and target terms, the numerical code of the term in the ICNP (ICNP code), the term found in the ICNP (ICNP term), the modification of the term carried out by the rule (ICNP mod), the axis of the term mapped within the ICNP 7-axis model (ICNP axis), the version in which the term was first described in the ICNP (ICNP version), and for each BTHU source term, the candidate target terms in the ICNP 2017.

Table 3 lists examples of candidate target terms for the “clinical” source term and respective additional information.

Table 1. Number of terms resulting from manual mapping for each classification of terms in the BTHU (N=2638).

Classification of terms in the BTHU[a]	Terms
Identical	650
Similar	622
Present in the definition of another term of the ICNP[b]	448
New	918

[a]BTHU: Banco de Termos do Hospital Universitário.

[b]INCP: International Classification for Nursing Practice.

Table 2. Number of BTHU terms resulting from automated mapping using each mapping rule (N=2811).

Mapping rule	BTHU[a] terms
Rule 1: Identical term	569
Rule 2: Lemmatizer	122
Rule 3: Stemmer	140
Rule 4: Synonym	525
Rule 5: Restricted term	348
Rule 6: Comprehensive term	76
New terms	1031

[a]BTHU: Banco de Termos do Hospital Universitário.

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Table 3. Information provided by automated mapping for the source term "clinical".

Rule	Similarity (%)	ICNP[a] code[b]	ICNP term[c]	ICNP mod[d]	ICNP axis[e]	ICNP version[f]
2	100	10004459	Clinic	Clinical	Location	1
3	100	10004459	Clinic	Clinic	Location	1
4	100	10014522	Physician	Doctor	Means	1
8	100	10013367	Nursing Clinic	Nursing clinic	Location	1
8	100	10014579	Physiotherapy Clinic	Physiotherapy clinic	Location	1
8	100	10012033	Midwifery Clinic	Obstetrics clinic	Location	1
8	100	10005732	Dental Clinic	Dentist's clinic	Location	1
8	100	10004463	Clinical Pathway	Clinical conduct	Means	1

[a]ICNP: International Classification for Nursing Practice.

[b]ICNP code: term code in the ICNP.

[c]ICNP term: candidate target term.

[d]ICNP mod: modification of the term carried out by the rule.

[e]ICNP axis: axis of the term in the ICNP.

[f]ICNP version: version in which the term was first described in the ICNP.

Comparison of the Two Processes

The identical and new terms of the two mapping processes were compared in three stages, with manual mapping being considered the standard.

In the first stage, *assessment of equality and exclusivity*, equality was considered when the output of the automated mapping was the same as the output of the manual process. Here, exclusivity occurred when the mapping resulted in a set of terms mapped by only one of the processes.

In the second stage, *evaluation of new terms of the automated process*, possible equivalent terms were sought in the ICNP 2017. The authors analyzed the definition of each new term with the aid of technical and Portuguese dictionaries and searched for an equivalent term in the terminology. The equivalence degree scale proposed by ISO/TR 12.300:2016 was used: value 1: lexical and conceptual equivalence, value 2: equivalence of meaning with synonymy, value 3: source term broader than the target term, and value 4: source term more restricted than the target term [1]. Values 1 and 2 represent equivalence of meaning, and values 3 and 4 represent the hierarchical relationship; value 3 indicates that the source term is a class of the target term, while value 4 indicates that the source term is a subclass of the target term. In some cases, although a relationship of equivalence was identified, it was not possible to assign a value due to a change in the grammatical class of the terms.

In the third stage, *evaluation of candidate terms*, the terms offered by automated mapping to the new terms of manual mapping were analyzed. The analysis was carried out collaboratively between the authors and nurses participating in a Brazilian research group that studies the ICNP. This analysis considered clinical experience of cross-term mapping and knowledge of the terminology used; thus, it met the quality requirements for mapping proposed by ISO/TR 12.300:2016. The results were determined by consensus, and the semantic relationships between the source and target terms were confirmed using Portuguese language dictionaries and the ICNP 2017.

The terms mapped by the lemmatizer (rule 2), stemmer (rule 3), synonymous terms (rule 4), restricted terms (rule 5), and comprehensive terms (rule 6) were not compared to the results of the manual mapping, as the latter process did not categorize the terms in the same way as the automated mapping rules. For example, the source term "openness" was categorized as similar by the manual process and as restricted by the automated process; however, not all similar terms were equivalent to this rule. Thus, this research was limited to analyzing the identical terms (rule 1) and new terms.

Results

Equality and Exclusivity Assessments

Regarding equality, the automated process mapped 569/2638 (21.57%) of the BTHU terms as identical to the ICNP terms, and the manual process mapped 650/2638 as identical (24.64%) (Table 4). The agreement between the processes was 84.46%. The automated process erroneously mapped the source terms "hyperkalaemia" and "reference" to the terms "hypercalcaemia" and "preference", in which the similarities between the source and target were 92% and 90%, respectively. In mapping new terms, the automated process mapped 1031/2638 (39.08%) of the BTHU terms as new and the manual process mapped 1251/2638 (47.42%) as new (Table 4). The agreement between the processes was 65.70%.

Regarding exclusivity, manual mapping mapped 101/2638 (3.83%) terms as identical and 429/2638 (16.26%) as new, whereas automated mapping mapped 20/2638 (0.75%) as identical and 209/2638 (7.92%) as new (Table 4).

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Table 4. Absolute and relative frequencies of terms mapped manually and automatically as identical and new according to equality and exclusivity (N=2638), n (%).

Mapping process	Equality		Exclusivity	
	Identical	New	Identical	New
Manual	650 (24.64)	1251 (47.42)	101 (3.83)	429 (16.26)
Automated	569 (21.57)	1031 (39.08)	20 (0.75)	209 (7.92)

Analysis of New Terms of the Automated Process

Of the 209 terms mapped as new by the automated process, it was possible to establish an equivalence with ICNP terms in 48 cases (23.0%). Examples are shown in Table 5; the others are listed in Multimedia Appendix 1.

Analysis of Candidate Terms

An analysis of the candidate terms offered by the automated process to the 429 new terms mapped exclusively by the manual process resulted in 100 (23.31%) candidates that had a semantic relationship with the source term (for examples, see Table 6).

Table 5. Examples of new source terms identified by the automated process, their equivalent terms in the ICNP, and their degrees of equivalence according to ISO/TR 12.300:2016.

New source term	Equivalent term in the ICNP[a] (ICNP code)	Degree of equivalence
Alcoholism	Alcohol Abuse (10002137)	2
Apron	Lead Gown (10011222)	3
Bedridden	Confined To Bed (10050397)	2
Infuse	Administering Medication (10025444)	3
Mask oxygen	Oxygen Therapy (10013921)	4
Palpation	Palpating (10013997)	Not attributed
Post-surgical period	Postoperative Period (10027242)	1
Sorotherapy	Intravenous Therapy (10010808)	4
Tracheostomized	Tracheostomy (10019933)	Not attributed
Woman/man Nurse	Nurse (10013333)	1

[a]ICNP: International Classification for Nursing Practice.

Table 6. Examples of manual mapping results obtained from evaluation by nurses.

Source term	ICNP[a] code[b]	ICNP term[c]	ICNP axis[d]
Padded	10007740	Feather Bed Cover	Means
Escort	10042609	Accompanying	Action
Adapt	10001741	Adaptation	Focus
Itch	10010934	Itching	Focus
Stump	10002251	Amputation stump region	Location
Back	10003106	Back	Location
Escape	10027407	Elopement	Focus
Evolution	10015789	Progress	Judgment

[a]ICNP: International Classification for Nursing Practice.

[b]ICNP code: term code in the ICNP.

[c]ICNP term: candidate target term.

[d]ICNP axis: axis of the term in the ICNP.

Discussion

Principal Findings

Similarities were found between the results of the manual and automated mapping processes in the identification of identical and new terms. A similar result was found in a research study in which it was concluded that mapping through UMLS performed similarly to mapping performed by specialists [17]. This demonstrates that both processes are able to map the presence of equal terms between terminologies and indicate the

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absence of representation of source terms in the target documents.

One advantage of the automated process is the organization of the results in an output table. This includes the location of the term in the ICNP 7-axis model, its code, and the version in which it was included in the terminology. This facilitates decision-making regarding the choice of the most suitable target term for objective mapping and contributes to the reduction of selection inaccuracies.

The numeric code improves the mapping process, increases its accuracy [18], and reduces the possibility of incorrect mapping in noncoded databases due to typing and spelling errors. This organization of the results can be carried out by the manual process; however, more time and careful detailing are required for the individual allocation of each term.

Some exclusivities identified in the list of identical and new terms by manual mapping can be explained by three situations: a hierarchical relationship, such as the terms “oxygen therapy”, which is a means in the ICNP, and “oxygen mask”, which is a device that is used to provide oxygen therapy; an equivalence relationship of meaning, such as the terms “sorotherapy” and “intravenous (or endovenous) therapy”; and a list of orthographic equivalences, such as the terms “woman/man nurse” and “nurse”. In this work, these three situations were also evidenced in the evaluation of new terms in the automated process that was performed manually by the authors. In the automated process, the establishment of these relationships would depend on the inclusion of new rules, given the complexity of the Portuguese language. Currently, with the evolution of NLP methods, new rules may be incorporated into MappICNP.

For the hierarchical relationships, the ICNP aims to represent the nursing practice and its various specialties worldwide. Due to the breadth of practice, it becomes impossible to include more specific terms in the subclasses of ontology unless such specificities are essential to the priorities established in the terminological subsets. Thus, depending on the purpose of the mapping, hierarchical relationships between a broader term and a more restricted term are allowed.

Regarding the equivalence relations of meaning, for mapping execution, the use of the ISO/TR 12.300:2016 equivalence degree scale is indicated. This standard allows researchers to establish equivalence of meaning (lexical and conceptual), synonymy, scope, and restriction of meaning of the terms [1].

Regarding relationships of orthographic equivalence, source terms from nonstandard bases require normalization [8]. This process, which precedes the mapping, is essential to minimize errors and reduce the number of source terms. The normalization of terms requires caution in relation to the use of traditional rules, among them the substitution of the term female for male. In addition, in this case, the researcher’s knowledge about the target terminology is crucial. A similar situation was indicated in a previous study in which normalization was performed only when pertinent. For example, the term “right”, when appropriate to the male, can refer to the “focus” axis (patient’s right) or the “location” axis (right side) [11].

When the source document consists of nursing records in natural language, the results of the mapping can be affected by the writing of the terms. For example, the source term “tracheostomized”, which was categorized as new by the automated process, had an established equivalence to the term “tracheostomy”. The adjective “tracheostomized” was registered by the nurses to refer to a location that is represented in the ICNP by the noun “tracheostomy” [9].

Although automated mapping considers the lexical and semantic structures of the terms, there is a need for evaluation of the nonexplicit relations by a researcher. An example is found in [29], in which the automated mapping of the term “mood stabilizer” was related to the term “mast cell stabilizer”. This result implies that equivalence errors can occur if there is no expert evaluation of automated mapping results.

In turn, manual mapping is more time-consuming and depends on the experts’ knowledge of the terminology used [18]. In addition, the analysis should provide strategies to minimize precision errors in the selection of the target term, including the use of technical and English dictionaries and structured vocabularies such as the Health Sciences Descriptors (*Descritores em Ciências da Saúde*, DeCS) and Medical Subject Headings.

In this study, the exclusive use of the English dictionary to map synonymous terms was identified as a limitation of MappICNP. This could be seen in the term “acromion”, which was defined in the dictionary as “scapula apophysis, in the form of a spatula” and in the DeCS as “lateral extension of the spine of the scapula and the highest point of the shoulder.” The last definition enables the mapping of “shoulder” as a term candidate in the ICNP.

The percentage of similarity of the candidate term assists the specialists in analyzing equivalence errors; this allows the manual analysis to be directed to the terms whose similarity is not 100%. The automatic offer of candidate terms expands the possibility of choosing target terms and increases the time for selecting alternatives. An example of this was demonstrated by automated mapping of ICNP terms to SNOMED CT, in which the source term “tobacco (or smoke) abuse” generated the candidate terms “tobacco abuse” and “tobacco addiction syndrome” for evaluation by the specialists [13].

In this research, the relevance of the candidate terms could be seen in the nurses’ analysis. One-third of the new terms identified by manual mapping had equivalents, demonstrating that the use of an automated process can minimize weaknesses in the manual process.

Although it was not an objective of this study, the time spent by the automated process was shorter than that spent in the manual process. The schedule of the study in which the manual mapping was performed was 3 months for the mapping stage, while automated mapping processed the rules in less than 12 h. The time optimized in this step through the automated process can be directed to the manual analysis of the candidate terms.

Limitation of This Study

As a limitation of this study, the use of different versions of ICNP and the exclusive use of the primitive terms of the ICNP

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in the manual mapping with the 2011 version and in the automated process should be taken into consideration. Due to this limitation, it was impossible to compare potential results in relation to the precoordinated terms. It is expected that the standardization for categorizing mapping results proposed in the ISO/TR 12.300:2016 equivalence grade scale will contribute to overcoming this limitation in future research studies.

Conclusion

Identical and new terms are similarly mapped by automated and manual processes; hence, it has been concluded that these processes can be complementary. Although the automated process requires manual analysis by a researcher to confirm the accuracy of the terms, it facilitates and enhances the results of mapping by identifying identical terms and candidate terms.

The importance of one process complementing the other is the ability to use different methods of mapping terms so that the result is better than the performance of each process separately. Given the complexity of hierarchical, equivalence, and orthographic relationships, analysis by specialists is essential to establish equivalences not identified by the automated process. However, with the aid of automation, the time to perform the analysis is reduced.

The results of this research can contribute to improving the MappICNP tool. As a contribution to nursing, these results support the construction of terminology subsets of the ICNP with regard to the cross-mapping stage and can aid the comparison of nursing practices in different scenarios.

An additional contribution of this study is that interdisciplinarity was established to achieve the proposed objective, providing opportunities for the integration of different knowledge from nursing and informatics.

Acknowledgments

This study was carried out with the support of the Coordination for the Improvement of Higher Education Personnel, Brazil (Financing Code 001).

Authors' Contributions

All authors made significant contributions to the data analysis and the writing of the paper.

Conflicts of Interest

None declared.

Multimedia Appendix 1
New source terms identified by the automated process, their equivalent terms in the ICNP, and their degrees of equivalence by ISO/TR 12.300:2016.
[DOCX File , 14 KB - nursing_v3i1e18501_app1.docx]

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Abbreviations

BTHU: Banco de Termos do Hospital Universitário
DeCS: Descritores em Ciências da Saúde
eHealth: electronic health
ICNP: International Classification for Nursing Practice
ISO/TR: International Organization for Standardization/Technical Report
NLP: natural language processing
SNOMED CT: Systematized Nomenclature of Medicine Clinical Terms
UMLS: Unified Medical Language System

Edited by E Borycki; submitted 01.03.20; peer-reviewed by P Sousa, C Mather, F Lau, A Boyd; comments to author 05.04.20; revised version received 26.04.20; accepted 05.05.20; published 09.06.20.

Please cite as:
Torres FBG, Gomes DC, Hino AAF, Moro C, Cubas MR
Comparison of the Results of Manual and Automated Processes of Cross-Mapping Between Nursing Terms: Quantitative Study
JMIR Nursing 2020;3(1):e18501
URL: https://nursing.jmir.org/2020/1/e18501/
doi:10.2196/18501
PMID:

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Original Paper

Care Staff Perspectives on Using Mobile Technology to Support Communication in Long-Term Care: Mixed Methods Study

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Abstract

Background: Long-term care (LTC) homes provide 24-hour care for people living with complex care needs. LTC staff assist older adults living with chronic conditions such as Alzheimer disease, related dementias, and stroke, which can cause communication disorders. In addition to the complex cognitive challenges that can impact communication, further difficulties can arise from cultural-language differences between care staff and residents. Breakdowns in caregiver-resident communication can negatively impact the delivery of person-centered care. Recent advances in mobile technology, specifically mobile devices (tablets and smartphones) and their software apps, offer innovative solutions for supporting everyday communication between care staff and residents. To date, little is known about the care staff's perspectives on the different ways that mobile technology could be used to support communication with residents.

Objective: This study aims to identify care staff's perspectives on the different ways of using devices and apps to support everyday communication with adults living in LTC homes and the priority care areas for using mobile technology to support communication with residents.

Methods: This descriptive study employed concept mapping methods to explore care staff's perspectives about ways of using mobile technology with residents and to identify the usefulness, practicality, and probable uses of mobile technology to support communication in priority care areas. Concept mapping is an integrated mixed methods approach (qualitative and quantitative) that uses a structured process to identify priority areas for planning and evaluation. In total, 13 care staff from a single LTC home participated in this study. Concept mapping includes 2 main data collection phases: (1) statement generations through brainstorming and (2) statement structuring through sorting and rating. Brainstorming took place in person in a group session, whereas sorting and rating occurred individually after the brainstorming session. Concept mapping data were analyzed using multidimensional scaling and cluster analysis to generate numerous interpretable data maps and displays.

Results: Participants generated 67 unique statements during the brainstorming session. Following the sorting and rating of the statements, a concept map analysis was performed. In total, 5 clusters were identified: (1) *connect*, (2) *care management*, (3) *facilitate*, (4) *caregiving*, and (5) *overcoming barriers*. Although all 5 clusters were rated as useful, with a mean score of 4.1 to 4.5 (Likert: 1-5), the care staff rated cluster 2 (*care management*) as highest on usefulness, practicality, and probable use of mobile technology to support communication in LTC.

Conclusions: This study provided insight into the viewpoints of care staff regarding the different ways mobile technology could be used to support caregiver-resident communication in LTC. Our findings suggest that care management, facilitating communication, and overcoming barriers are 3 priority target areas for implementing mobile health interventions to promote person-centered care and resident-centered care.

(JMIR Nursing 2020;3(1):e21881) doi:10.2196/21881

KEYWORDS

mobile apps; mobile phone; caregivers; dementia; communication; patient care

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Introduction

Background and Rationale

By 2021, it is predicted that the number of adults aged 65 years or older will account for approximately 25% of the Canadian population [1,2]. Moreover, by 2030, the proportion of adults who are aged 85 years or older will account for approximately 20% of all older adults and 3% of the Canadian population. As the population ages, there will be an increase in the number of older adults living with multiple chronic health conditions that contribute to physical, functional, and cognitive decline, resulting in complex care needs that require the services offered in long-term care (LTC). Indeed, most LTC residents are aged older than 85 years, with 80% of residents being functionally dependent on care staff, whereas an estimated 90% of all residents are living with at least some cognitive impairments, including dementia [3].

In LTC homes, care staff are responsible for meeting the complex health care needs of residents. For instance, nursing staff administer medication and coordinate patient care, whereas resident care aides and/or personal support workers engage residents in basic activities of daily living (ADLs; eg, dressing, bathing, eating). The ability of care staff to support the complex needs of residents living with physical and functional limitations is further complicated when a communication disorder (eg, aphasia) or language differences are also present. Communication impairments are associated with various chronic conditions that are prevalent in LTC (eg, dementia, stroke), and breakdowns in communication during interpersonal and task-focused activities [4] can strain the relationship and lead to unmet care needs [5]. Furthermore, care staff–resident communication can be challenged by cultural-language barriers [6-8]. Efforts have been made to support people living with communication barriers in the LTC setting through the development and implementation of evidence-based communication strategies [9-12] and language translation supports [13]. However, these current solutions require training, staffing and time resources, and could be inaccessible when needed, making residents vulnerable to unmet needs and social isolation [14]. With some training, recent advances in mobile technology, which includes mobile devices (tablets/smartphones) and their software applications (apps), have the potential to yield innovative solutions for supporting care staff-resident communication and prevent or overcome communication barriers.

The increased sophistication of mobile technology has permitted the successful merging of multiple features (eg, portability, communication function, on-demand powerful computer technology, and a huge range of app options) into a single device that can be used to provide services that aim to improve health outcomes [15]. The health care industry has been driving the growth of mobile technology due to an increased demand for using technology to support health care practice and delivery, otherwise known as mobile health (mHealth) [16]. This demand has contributed to a large increase in the number of consumer mHealth apps available in the app marketplace [17] for various health categories (eg, diabetes, weight loss). These mHealth apps are designed to run on smartphone or tablet computer operating systems (eg, iOS and/or Android) to support a range of health care practices, including decision support aids, educational information, health monitoring, health promotion, staff-client communication, and care of the elderly [16]. mHealth apps are cost-effective, innovative point-of-care tools that immediately connect health care staff with information, presented in multiple forms (eg, text, images, sound, touch) and can be used to improve communication between health care staff and patients [18]. Although it is important to recognize the limitations of implementing this technology in health care and to ensure that mHealth apps meet a standard for quality and safety [19,20], mHealth apps continue to bring added value to health care practice and delivery, including accessibility, convenience, lower cost of health care delivery, and promotion of healthy choices [20]. Undoubtedly, the continued growth in mHealth will impact the use of this technology by both professionals [18,21,22] and health consumers [23,24].

Importantly, there is a demand for mHealth solutions to support the growing aging population, people living with chronic conditions, and patient-centered care [25-27]. In LTC, immediate access to information and the interactivity of mHealth interventions have the potential to support care staff–resident relationships as well as to improve the quality and quantity of resident care. Although it has been shown that certain health care providers (eg, physicians, nurses) have incorporated mHealth in their professional practice and during health care practice or delivery [18,28,29], there is a gap in our understanding of how LTC staff could adopt mobile technology in their daily care practice. As mobile technology offers many innovative apps for the care of older adults living in LTC homes [30], there is a need to better understand care staff utilization of currently available mainstream communication apps (cApps) to support residents during the completion of daily activities. This includes augmentative and alternative communication (AAC) apps designed for adults living with communication impairments (eg, *Proloquo2Go*) as well as translation apps (eg, *Google Translate*). The first step to better understand mHealth utilization in LTC is to examine the experiences and perspectives of care staff about the ways that mobile technology could be used to support care staff–resident communication as well as the priority care areas for using mobile technology to support communication. Ultimately, this knowledge could be used to facilitate meeting residents' physical care and psychosocial needs.

Research Aims

This study aimed to better understand LTC care staff perspectives on using mobile technology to support everyday communication with residents during activities of daily living. The study's objectives were to identify the different ways that care staff would use mobile technology to support communication with residents living in LTC; the level of importance of the different ways of using mobile technology by examining their usefulness, practicality, and probable use; and priority care contexts for using mobile technology to support communication with residents.

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Methods

Setting and Participants

Participants were recruited from a single LTC home in Vancouver, British Columbia, Canada. A purposive sample of full-time and part-time day and evening care staff who had direct interaction with residents during daily activities (eg, resident care aides, nurses) were included in this study. In addition, administrative staff and casual staff were invited to participate. The research team worked with a staff liaison to coordinate study information sessions for the morning and the evening shift on each care unit (ie, floor). A second information session was scheduled for care staff who were not able to attend the initial information session. A total of 36 care staff attended the information sessions. At the end of each information session, the care staff were asked to review the consent form and ask any questions they may have. All participants provided written consent before participation in this study. This study was approved by the University of British Columbia Research Ethics Board (H15-00270).

Design, Data Collection, and Analysis

To better understand care staff's perspectives on the use of mobile technology to support everyday communication with residents living in LTC homes, this study used concept mapping, also known as group concept mapping, to engage care staff in the research process. Concept mapping is a mixed methods approach that involves a structured process to integrate qualitative and quantitative data. Although historically used for program planning and evaluation [31], concept mapping has also been used for a wide range of studies, including measurement development [32-35], public health priority setting and program development [36,37], examining patient experience for quality improvement projects [38-40], understanding caregiver perspectives around care issues [41], and developing evidence-based public health care practices [42]. Concept mapping permits a diverse participant group of any size, in a wide range of settings, identifies participants' perspectives, and visually represents their viewpoints about a focused topic on a map [43-45]. In addition, the visual display outputs derived from the concept mapping data show how topic ideas are related to each other and can reveal which ideas are more important, appropriate, or relevant [44]. A recent detailed description of this method can be found in a study by Trochim and Mclinden [45].

This study used 5 phases of the concept mapping method to identify the different ways that mobile technology could be used in LTC to support everyday communication and to better understand actionable areas to target the use of mobile technology during daily activities in LTC: (1) preparation—the development of the focused prompt; (2) idea generation—brainstorming and statement analysis or synthesis; (3) structuring—unstructured statement sorting, followed by rating statements; (4) representation—performing concept mapping analyses, including multidimensional scaling, hierarchical cluster analysis, and bivariate plots; and (5) interpretation—research group examines maps and agrees on the number of clusters as well as their names and descriptions. These phases are described below. Following the completion of phase 5, the final phase of concept mapping, phase 6 (ie, utilization), was undertaken and involved the reporting and dissemination of the research findings. Concept mapping was employed in this study for the following key reasons: (1) the approach uses a structured process that encourages a participatory method (ie, care staff engagement) to data collection and analysis; (2) the approach generates output that is more comprehensive than interviews [46](3) the method can be tailored to specific needs of the study by offering a level of flexibility to data collection (eg, both web-bas and face-to-face options). For example, having both web-based and face-to-face data collection options can increase the number of care staff participants (eg, casual staff, night staff) by offering a solution for overcoming scheduling and time constraints inherent to the work setting; and (4) the approach is efficient, requiring less time and research-intensive resources during the data collection and data analysis phases than traditional focus group interviews (eg, no transcription and coding involved).

Phases 1 and 2: Preparation and Statement Generation

To identify the different ways that mobile technology could be used to support caregiver-resident communication, a single focused prompt, "A specific way that mobile technology [eg, smartphones, tablets, and their applications (apps)], could be used to help everyday communication between residents and care staff during daily activities is...," was used to generate statements. The statement generation step took place during 2 in-person group sessions. Participants were asked to independently write down their responses to the focused prompt and then share ideas as a group. Statements generated during the group discussion were recorded on a list visually available to all participants. The brainstorming activity ended after the participants indicated that all possible ideas were listed. Within 1 week of the brainstorming activity, the statements were consolidated by removing duplicates and overlapping or similar ideas. Next, participants were invited, via email, to individually complete the statement structuring phase.

Phase 3: Statement Structuring

To better understand target areas for using mobile technology to support communication in LTC, care staff completed statement sorting and ratings. For unstructured statement sorting, participants were asked to independently group the statements generated in phase 2 into piles based on how similar in meaning the statements were to one another. Care staff were instructed to categorize the statements in a way that *made sense* to them and to provide a name for each pile. The participants were also informed that each statement must be in a pile, that a statement can belong to only one pile, and that the creation of 10 to 20 piles is typical. Next, regardless of whether they had used mobile technology or not, care staff were asked to rate each statement in terms of 3 dimensions: (1) usefulness, or the degree to which using the app, as stated, would help or enhance everyday communication with residents during their care practice; (2) practicality, or how feasible would it be to use the app, as stated, to support everyday communication during their care practice; and (3) probable use, or how likely it would be that they would use the app, as stated, with residents to support everyday

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communication. All statements were rated on a 5-point Likert scale: *1=not at all*; *2=somewhat*; *3=moderately*; *4=very*; and *5=extremely*. Participants had the option to complete the sorting and rating steps on the web using Concept System Global MAX [47] or offline by sorting paper cards and rating sheets. The first author entered the data collected offline into Concept System Global MAX.

Phases 4 and 5: Representation and Interpretation

Once data from phase 3 were sorted and rated by participants, they underwent analysis to produce a series of concept maps. First, a multidimensional scaling analysis was used, whereby a point map and a point rating map were generated. The point map is relational, with separate points on the map corresponding to each statement with other statements. Points that are closer together indicate that sorters generally grouped these statements into piles. The point rating map represents an overlay of the point map and the average rating for each statement across participants [43]. Second, a hierarchical cluster analysis was conducted, which divides statements on the point map into clusters that represent conceptual groupings of the original set of statements [43]. From this analysis, point cluster maps were generated, which represents the overlap between the point map and the cluster analysis. Cluster maps provide an *overall picture* that represents the content of the concept being studied. In this instance, the different ways that mobile apps could be used to support everyday communication with residents living in LTC homes. Of note, cluster shape holds meaning, with wider clusters indicating a broader concept and a compact cluster representing a narrower concept [43]. Clusters that are closer to the middle of the map indicate that some statements within the cluster were also sorted with statements included in another cluster, representing a *bridging item*. During this step, the research team generated and reviewed several point cluster maps to determine the number of clusters that the statements should be grouped into (ie, final cluster solution). Research team consensus was used to decide the final cluster solution as well as to confirm the cluster names and descriptions. All subsequent analyses were based on the final cluster solution. Three cluster rating maps were generated, which represented the average participant ratings for each statement in a cluster, along the dimensions of usefulness, practicality, and probable use in practice. Clusters with higher values contained statements that received higher average ratings from the care staff participants.

Finally, Go-Zone analyses were performed, which visually display the relationship between 2 variables based on pairwise comparisons of cluster ratings: (1) usefulness and practicality, (2) usefulness and probable use, and (3) practicality and probable use. A Go-Zone analysis generates a bivariate graph that displays 4 quadrants that are divided based on the mean rating of each of the 2 variables. The upper right quadrant (quadrant 4) represents statements that are above average on both variables, thus indicating the *go-to care zone*, or priority (actionable) ways of using mobile apps to support everyday communication with residents living in LTC homes. Conversely, the bottom left area of the graph (quadrant 2) represents statements that are deemed lower on both variables, or the *no-go care zone* statements, or low priority ways of using mobile apps with residents. Following the analyses, based on the final cluster solution, the research team convened for phase 5 to interpret the findings. All concept mapping data analyses were conducted on the web using Concept System Global MAX.

Results

Participants

Of the care staff who attended the information sessions (n=36), 16 provided consent and 13 participated in this study. Of those who attended the information sessions but did not participate, 4 indicated that they were not interested during the information session and 16 were lost at follow-up. Although casual staff and administrative staff were invited to participate via a paper information package provided in their staff mailbox, none expressed an interest to participate. All participants completed at least one step (brainstorming: n=11; sorting: n=8; and rating: n=9; Table 1). Five participants completed the sorting and/or rating on the web at their convenience, and 4 participants completed these steps offline during an in-person meeting with the first author (RW). Overall, the majority of participants identified as female (12/13, 92%), ranging in age from 24 to 60 years (mean 45.4 years, SD 13.4), were residential care aides or health care aides (9/13, 69%), indicated English as their primary language (9/13, 69%), and spoke more than one language (9/13, 69%). Participants worked for an average of 12.7 years (SD 10; range 2-35) in the LTC setting.

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Table 1. Participant characteristics for each data collection step.

Characteristics	Overall[a] (n=13)	Concept mapping steps		
		Brainstorming (n=11)	Sorting (n=8)	Rating (n=9)
Age (years)				
Mean (SD)	45.4 (13.4)	43 (13.5)	45.9 (14.5)	45.2 (13.7)
Range[a]	24-60	24-60	24-60	24-60
Gender				
Female, n (%)	12 (92)	10 (91)	7 (88)	8 (89)
English primary language, n (%)	9 (69)	8 (73)	5 (63)	6 (67)
Number of years working in long-term care				
Mean (SD)	12.7 (10)	12.5 (10.9)	11.2 (8.4)	10.7 (8.1)
Range[b]	2-35	2-35	2-28	2-28
Job title, n (%)				
Residential care aide or attendant	7 (54)	7 (64)	3 (38)	4 (44)
Health care aide or assistant[a]	2 (15)	1 (9)	2 (25)	2 (22)
Licensed practical nurse	1 (8)	1 (9)	1 (13)	1 (11)
Activity therapist (eg, art, music)	2 (15)	2 (18)	1 (13)	1 (11)
Dietician[a]	1 (8)	0 (0)	1 (13)	1 (11)

[a]One health care aide or assistant and the dietician did not participate in the in-person brainstorming step but did participate in the sorting and rating steps.

[b]One participant did not provide this information.

Generated Statements and Cluster Map Analysis

A total of 93 statements were generated during the brainstorming activity. The researchers consolidated the statements to 67 unique ways that mobile apps could be used to support communication with residents, which were then used in the sorting and rating steps (Multimedia Appendix 1). Data generated during the sorting and rating informed the concept mapping analysis, and all analyses reported hereafter were based on the final cluster map solution. To determine the final cluster solution, a cluster map analysis was performed, which involved generating a range of possible cluster maps (5-10 possible cluster solutions were examined). The larger cluster maps divided clusters into concepts that were deemed to be similar. The research team selected the five-cluster solution, which included concepts that represented nonoverlapping care categories for using mobile technology to support everyday communication. The five-cluster solution had a stress index value of 0.30, which indicated that the cluster map had a good overall fit with the data points and was within the range of most concept mapping projects [43]. Labels for the five-cluster maps were derived from the categories created by participants, and the descriptions were based on the statements included in each cluster, which pertained to the concept overall. The clusters centered around actionable areas of care that occur within the LTC setting. *Care cluster 1: connect* was characterized by 12 statements that focused on using apps to build interpersonal relationships through personalized, meaningful engagement (eg, “Use pictures on the iPad/tablet that are meaningful to the resident [eg, personal history, culture, generational] to stimulate conversation”) and to foster trust and connection during leisure or recreational activities (“Use photos on the iPad/tablet to build trust with residents during recreation activities”). *Care cluster 2: manage* included 13 statements that were around using apps to assess resident needs (eg, health status, behavior, mood, pain, mobility) to provide individualized care (eg, “Use music apps to help residents with their mood and/or emotion”). *Care cluster 3: facilitate* had the highest number of statements (n=17) that focused on using apps to improve staff-resident communication by using verbal and nonverbal forms of communication to meet residents’ individual communication needs (eg, “Use apps with basic sign/symbol functions to communicate with residents”). *Care cluster 4: provide* was categorized by 14 statements that centered around using apps to support residents during the completion of daily tasks and to encourage residents to participate in their self-care (eg, “Use apps with pictures to show residents what care staff will be doing with them during personal care”). Finally, *care cluster 5: overcome* contained 11 statements that pertained to the use of apps to offer a way to reduce or remove cultural-language and/or hearing barriers to engaging residents (eg, “Use apps with speech-to-speech translation function to ‘talk back’ to residents in their language”; Figure 1).

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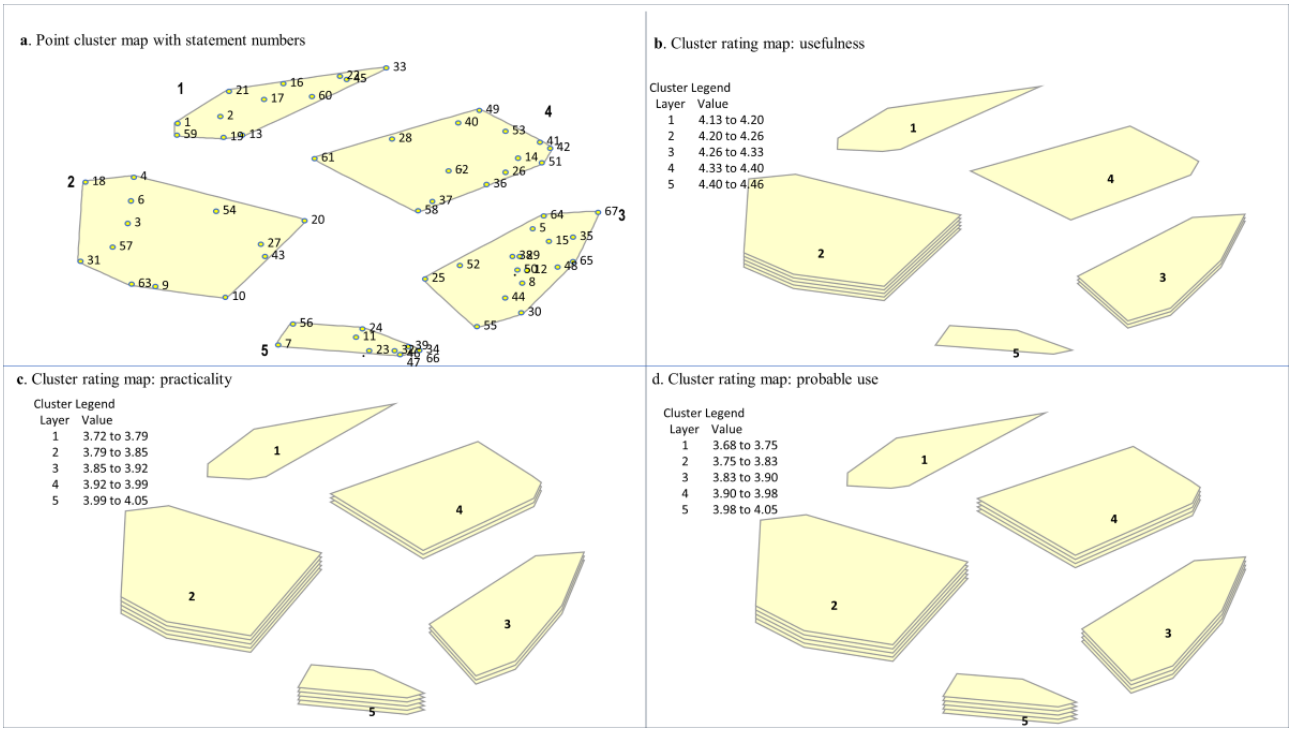
Figure 1. Cluster maps. The five Care Cluster names: (1) Connect (2) Manage (3) Facilitate (4) Provide and (5) Overcome. (a) The point cluster map denotes a 3D nonoverlapping representation of the 5 clusters, determined during the hierarchical cluster analysis process, with their points and statement numbers. Points that are closer together represent statements with a more similar meaning, based on participant sorting. (b) This cluster rating map denotes ratings of the usefulness of each statement, with more layers indicating a cluster with higher average ratings of usefulness for the statements contained within the cluster. Cluster 2 has 5 layers, cluster 3 has 3 layers, and clusters 1, 5, and 4 only have 1 layer. (c) This cluster rating map denotes care staffs' ratings of the practicality of each statement in their care practice. (d) This cluster rating map denotes care staffs' probable use ratings in their care practice for a statement.



Statement and Cluster Ratings

The average statement ratings across the 3 variables ranged from 2.89 ("Use apps to communicate with residents in palliative care") to 4.78 ("Use music apps to help residents with their mood and/or emotion." "Use apps with basic sign/symbol functions to communicate with residents"; Multimedia Appendix 1). No statement was rated, on average, as *somewhat* or *not at all* useful, practical, or likely to use. In terms of perceived usefulness, 2 statements had the highest average rating: "Use music apps to help residents with their mood and/or emotion" and "Use apps with basic sign/symbol functions to communicate with residents" (Multimedia Appendix 1). Care staff rated 3 statements as highest on practicality: "Use pictures on the iPad/tablet that are meaningful to the resident [eg, personal history, culture, generational] to stimulate conversation"; "Use apps that can also translate what care staff say into the language that a resident can understand/speak"; and "Use apps with pictures/text with residents who cannot speak but can point to what they want or need." Finally, 2 statements were rated highest on the care staff's probable use in their care practice: "Use apps that include both visual and written forms of communication during activity sessions" and "Use apps with pictures/text with residents who cannot speak but can point to what they want or need."

Overall, the care staff's average ratings for the 5 care clusters ranged from 4.13 (*care cluster 1: connect*) to 4.46 (*care cluster 2: manage*) on usefulness, from 3.72 (*care cluster 1:connect*) to 4.04 (*care cluster 1: overcome*) on practicality, and from 3.68 (*care cluster 1:connect)* to 4.03 (*care cluster 1: overcome*) on probable use (Multimedia Appendix 1). The results from the cluster map analyses showed that, relative to other care clusters on the maps, the care staff considered *care cluster 2: manage* to contain statements with the highest ratings for using mobile apps to support everyday communication with residents (Figure 1). The average statement ratings in this care cluster ranged from 3.56 to 4.78 (Multimedia Appendix 1). For example, the statements with the highest average ratings for usefulness were as follows: "Use music apps to help residents with their mood and/or emotion." (statement number 6: average rating 4.78), "Use apps to ask information about residents' needs and wants." (statement number 20: average rating 4.67), and "Use apps to keep an up-to-date record of a resident's needs." (statement number 31: average rating 4.67; Multimedia Appendix 1). Care staff ratings indicated that using mobile apps to overcome barriers (*care cluster 5: overcome*) was highly practical and that there was a strong likelihood that they would use mobile apps for this purpose in their care practice. For example, "Using apps that can translate what care staff say into the language that a resident can understand/speak" (statement number 47) was rated, on average, as highly useful (average rating 4.56), practical (average rating 4.56), and likely to use in their care practice (average rating 4.44; Multimedia Appendix 1). Conversely, although *care cluster 1: connect*, on average, was rated as moderate-to-very important in terms of usefulness, practicality, and probable use, it was the care cluster with the lowest average ratings. For example, the statement "Use map apps as a topic of discussion with residents (eg, talk about where they used to live)" was rated lower on both a practical (average

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rating 3.11) and probable (average rating 3.33) way to support everyday communication in LTC.

Go-Zone Analysis

The Go-Zone analysis generated 3 visual displays that were derived by comparing care staff's ratings on the 3 rating variables: (1) usefulness and practicality; (2) usefulness and probable use; and (3) practicality and probable use (Figure 2). Across the 3 comparisons, a total of 20 actionable statements were in quadrant 4, or the *go-to* care zone, meaning that all these statements were rated above average on usefulness, practicality, and probable use (Table 2). The majority (13/20, 65%) of the statements found in the *go-to care zone* were from *care cluster 2: care management* (n=7) and *care cluster 3: facilitate* (n=6). Two care clusters contained only one statement that care staff rated as *very* across all 3 rating comparisons: *connect:* "Use pictures on the iPad/tablet that are meaningful to the resident (personal history, culture, generational) to stimulate conversation." and *caregiving*: "Use apps with pictograms to help with directions given to residents." Conversely, quadrant 2, or the *no-go care zone* included 18 statements that were commonly rated lower across the 3 variable comparisons, with the majority of the statements (11/18, 61%) included in *care cluster 1: connect* (n=7) and *care cluster 4: provide* (n=4; Table 3). Finally, paired-sample *t* tests were conducted to examine any differences between the overall ratings for the clusters on the different rating variables. There were no statistically significant differences between practicality and probable use for any of the care clusters and no differences in any of the rating variables for cluster 5: *overcome* (all $P>.05$). However, the ratings were statistically significantly different for clusters 1 to 4 on the rating categories of usefulness and probable use (*t* statistic, $P<.01$), indicating that the staff may perceive a statement as useful but less likely to use in the mobile app for this purpose in their care practice.

Figure 2. Go-Zone analysis displays comparing statements across the rating criteria. Q4: quadrant 4 (top-right shaded quadrant) of the Go-Zone display represents statements that were rated high on both variables in the comparison (ie, very useful and very likely to use in practice; go-to care zone). Q2: quadrant 2 (bottom-left quadrant) included statements that were deemed lower on both variables (eg, somewhat practical and likely to use). The size and location of the quadrants vary from cluster to cluster because the quadrants are formed by drawing a line at the cluster average of the variable ratings.

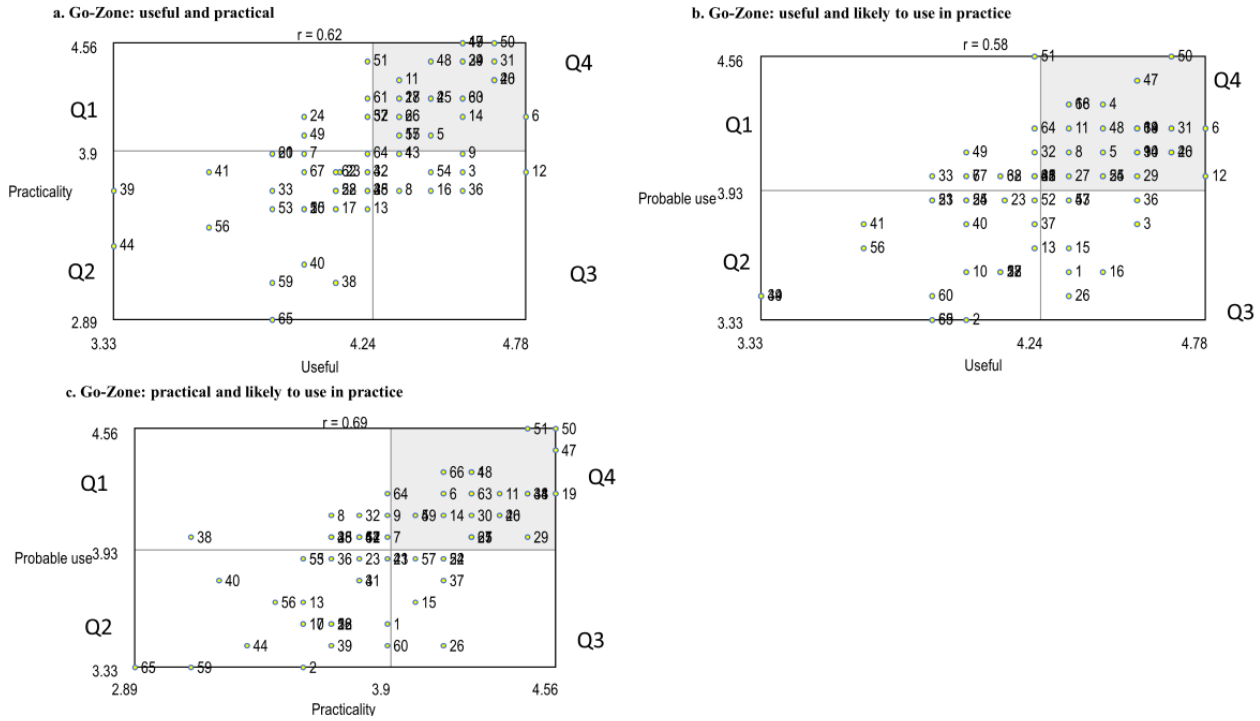

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Table 2. The "Go-to" uses of mobile technology to support everyday communication in long-term care across the fourth quadrant of the 3 Go-Zone graphic displays (n=20).

Care cluster and statement number	High-priority statements
Care cluster 1: connect	
19	Use pictures on the iPad/tablet that are meaningful to the resident (eg, personal history, culture, generational) to stimulate conversation
Care cluster 2: manage	
4	Use apps that include a music option for its therapeutic benefits to residents
6	Use music apps to help residents with their mood and/or emotion
18	Use art therapy apps with residents who have limited mobility
20	Use apps to ask information about residents' needs and wants
27	Use apps to ask the resident how they are feeling
31	Use apps to keep an up-to-date record of a resident's needs
63	Use apps to assess if the resident is in pain
Care cluster 3: facilitate	
5	Use apps with pictures that residents can use to self-express with care staff
25	Use translation apps to provide instructions on how to do a task so that residents can understand
29	Use apps that include pictures, text, and speech to communicate with residents
30	Use photos on the iPad/tablet to support communication with residents living with hearing loss
48	Use apps with pictures to communicate with residents
50	Use apps with pictures/text with residents who cannot speak but can point to what they want or need
Care cluster 4: provide	
14	Use apps with pictograms to help with directions given to residents
Care cluster 5: overcome	
11	Use translation apps with both text-to-text and text-to-speech functions to communicate with residents who do not speak English
34	Use apps to translate what residents say in other languages into English (eg, speech-to-speech)
46	Use apps with speech-to-speech translation function to "talk back" to residents in their language
47	Use apps that can also translate what care staff say into the language that a resident can understand/speak
66	Use translation apps to help residents who speak other languages to indicate their needs

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Table 3. Low priority statements identified across the second quadrant of the 3 Go-Zone graph displays (n=18).

Care cluster and statement number	Lower priority ways of using mobile technology to support everyday communication in long-term care
Care cluster 1: connect	
2	Use apps with custom personal videos (eg, family) to connect with residents
13	Use customizable apps to create communication topics that help staff get to know residents
17	Use painting apps to communicate with residents
21	Use photos on the iPad/tablet to build trust with residents during recreation activities
22	Use apps to engage in fun activities with residents (eg, write stories together)
59	Use map apps as a topic of discussion with residents (eg, talk about where they used to live)
60	Use apps to engage in social conversation to get to know residents
Care cluster 2: manage	
10	Use apps that are preprogrammed with a voice that is familiar to residents to help communication
Care cluster 3: facilitate	
44	Use apps to communicate with residents living with dementia
55	Use translation apps with English-to-English function to help residents understand care staff who have an accent
65	Use apps to communicate with residents in palliative care
Care cluster 4: provide	
40	Use apps to play simple, short instructional videos of an activity to help communicate with residents
41	Use apps to inform residents about programs and activities that are happening in the facility
53	Use apps to invite residents to join programs and activities that are happening in the facility
58	Use apps with pictures to provide instructions to residents on how to do a task (ie, visual cues)
Care cluster 5: overcome	
23	Use tablets/apps to amplify translated speech for people living with a language barrier and a hearing impairment
39	Use translation apps with text-to-speech/speech-to-text features to overcome language barriers that residents with Alzheimer disease or dementia face when they no longer speak English
56	Use tablets/apps to amplify care staff's speech for people living with a hearing impairment

Discussion

Key Ways of Using Mobile Technology to Support Everyday Communication

This study aimed to increase our understanding of the various ways that care staff would use mobile technology to support everyday communication with residents as well as provide insight into which care contexts staff perceive mobile cApps to be most useful, practical, and would likely use with older adults living in LTC homes. The qualitative results of this study identified 67 different ways that mobile apps could be used to support everyday communication between care staff and residents, indicating that care staff recognize a wide range of possible ways of using mobile apps to support communication with residents. Moreover, all the different ways of using mobile apps were rated by staff, on average, as moderately to extremely useful, practical, and would likely use in their care practice. The quantitative results indicated that, generally, the highest-rated ways of using mobile apps with residents were for 3 key purposes: nonpharmacological intervention, AAC, and language translation. Specifically, care staff viewed using music apps to improve residents' mood or emotion and using mobile apps to provide visual representations (pictures or images and text) that support communication with residents as most useful. Furthermore, care staff indicated that using mobile apps to present meaningful pictures to stimulate conversation, using apps with a translation feature, and using apps with pictures or text to help people who no longer speak to be most practical. Finally, care staff indicated that they would most likely use mobile apps during activities that include both visual and written forms of communication to help support people who have limited verbal communication.

The participants' emphasis on using music to manage the care needs of residents aligns with evidence that music can play an important role in communication [48,49]. The enjoyment of music involves sensory, cognitive (attention, memory, and language), and emotional processing, with the pleasure of music offering a therapeutic approach for individuals living with mood disturbances [50]. People living with dementia continue to enjoy the mood benefits of music and respond to music even in later stages of the disease when verbal forms of communication are limited [51]. Indeed, there is now a growing body of evidence

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reporting the benefits of music therapy based on a reduction in disruptive behaviors, anxiety, and depressive moods [52-55]. Given the reported benefits of music in the literature, it is not surprising that care staff identified the therapeutic use of adding music into their care practice toolbox.

Care staff perceived using mobile apps that offer multiple communication modes (pictures or images, text, and speech) to meet residents' needs or preferences as useful, practical, and likely to be used in their care practice. AAC tools and techniques supplement or replace speech for those living with a communication disorder that impacts language production and/or comprehension [56]. AAC tools aim to engage, connect, and improve the quality of life of people living with spoken and/or written communication impairments resulting from dementia and their care partners [57]. There has been a wide range of traditional nontech (eg, gestures, signing, facial expression, body language, vocalizations) and low-tech AAC options (eg, picture communication boards or books, memory books, communication or memory wallet, photos, objects, paper and pen for written messages, written choice cards, printed reminders) available to support the complex communication needs of people living with dementia so that they can express their wants or preferences as well as connect with their care partners [56-63].

With recent advances in mainstream technologies (eg, tablets or smartphones and their apps), there is a growing number of high-tech AAC solutions that have been developed to address a range of communication needs for people living with communication disorders [57,64]. For example, several traditional low-tech AAC tools have been adapted to high-tech formats (eg, digital communication books, digital memory books, mobile reminiscence, multimedia videos, electronic picture boards) [57,65-72]. AAC tools available as mobile apps (eg, *GoTalk NOW*) offer several potential advantages over low-tech AAC solutions in the LTC setting, including ease of access, portability, size and storage, variety of features, low cost, and range of customization. Furthermore, the key advantages of using mobile AAC apps with residents are that they can include multiple communication modes (pictures or images, music, text, and speech) and can be personalized to support residents' individual communication needs and preferences [60,73]. Although mobile AAC apps have the exciting potential to offer LTC staff and residents innovative communication solutions that can be adapted to the users' ability level, there is a need to develop and evaluate evidence-informed mobile apps that aim to address the communication needs of people living with dementia and their caregivers generally [74] and specific to the LTC home setting [75].

Canada is a culturally and linguistically diverse country, with more than 1 in 5 Canadians being foreign-born citizens [76]. Health care settings located in major urban areas (eg, Vancouver, Toronto, Montreal) comprise cultural-linguistically diverse staff and patients, making language barriers a common issue that can impact equitable assessment of care, treatment, health outcomes, quality of care, and patient satisfaction [77,78]. Estabrooks et al [79] surveyed care aides working in LTC homes across western Canada to better understand demographics. Findings from their study highlighted that the majority of care aide respondents were not born in Canada and that English was not their first language [79]. Although the use of professional medical interpretive services (eg, telephone, video, in person) is the standard practice in a health care setting to connect residents and care providers, these resources are limited in terms of cost, access, and time and are not always available on demand to support everyday communication taking place during daily care routines [13,80,81]. Access limitations mean that residents' immediate needs may go unmet, leading to frustrations for both residents and care staff. Although learning some basic words in the resident's language or requesting assistance from a coworker who speaks the resident's language may offer an occasional solution [6], there is a need for care staff to have access to on-demand translation tools available in the mobile app marketplace. It has been recognized that using commercially available mobile translation apps in the health care setting has raised concerns about the risks of inaccurate translations of important health care information, with some studies indicating poor translation accuracy of medical information or phrases in popular apps such as *Google Translate* [82-84]. However, although accuracy is a major concern for communicating sensitive medical information (diagnosis, treatment, and consent), using mobile apps for everyday communication during daily activities (eg, identifying pain, toileting, dressing, and mealtime) may be of less risk. Indeed, a recent study by Panayiotou et al [81] identified 15 free commercially available translation apps in the Apple iTunes Store and evaluated their suitability for everyday communication with older adults in health care settings. The results indicated that 2 translation apps designed for the health care setting, *CALD Assist* and *Talk To Me*, were most suitable for translating everyday communication, as the apps were limited to preset phrases that could be used during noncritical care contexts (eg, communicating care needs) [81]. As is the case with AAC apps, although there are a few apps showing promise for supporting translation during everyday communication in health care settings, caution needs to be taken when using unregulated, commercially available translation apps that have not been examined clinically or empirically for use in LTC [13].

Key Care Contexts for Using Mobile Technology

Care staff categorized the different ways of using mobile apps to support everyday communication into 5 key care contexts, such as building interpersonal relationships through shared activities and encouraging residents' participation in their self-care tasks. Across all identified care contexts, providing individualized care appeared to be the purpose of using mobile apps to support everyday communication with residents living in LTC homes. The cornerstone of person-centered care in health care settings is the provision of individualized care by gathering information about an individual's values, needs, personal history, and preferences to better understand their health care goals as well as encouraging participation in one's own health care decisions [85-90]. Person-centered approaches to care have been developed to address the needs of people living in LTC homes [91-95]. Person-centered dementia care was founded on the principle of personhood and emphasized the importance of relationships in the LTC context [92,96,97]. Person-centered dementia care has evolved into a care model that includes 4

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fundamental elements: (1) value people living with dementia and their caregivers; (2) treat people living with dementia as individuals with unique needs and preferences; (3) consider the perspectives of people living with dementia to help better understand their reality; and (4) create a positive social environment that supports communication, fosters interpersonal relationships, and promotes well-being [98-100]. The care contexts identified in this study overlap with several key principles of person-centered dementia care within the LTC home setting, including effective communication (*care clusters:facilitate and overcome*), individualized care (*care clusters: manage and provide*), and building social relationships and engaging in meaningful activities (*care cluster*: *connect*). Furthermore, this study's findings align with components of the recently published person-centered dementia care practice recommendations: (1) know the person living with dementia (need, preference, history, values, beliefs, interest, and abilities) to inform everyday encounters; (2) recognize and accept the person's reality and know that behavior is communication; (3) identify and support ongoing opportunities for meaningful engagement that support interests and preferences; and (4) build and nurture authentic caring relationships that focus on the relationship and not only the task [101,102].

This study's Go-Zone analysis highlighted the ways of using mobile apps that are high priority (ie, rated *very* to *extremely*) and the care contexts that care staff considered most useful, practical, and likely to use in their care practice to support everyday communication with residents (ie, *go-to care zones*). These findings offer a better understanding of where to target communication interventions that use mobile apps. Specifically, care staff perceived 3 care contexts to be most useful, practical, and likely to use mobile apps with residents to support communication: *care management, facilitating communication, and overcoming barriers*. The context of managing care was characterized by activities that focused on assessing and/or responding to residents' care needs. In addition to including several ways of using music apps for therapeutic purposes, this care context focused on using mobile apps to identify residents' needs and wants, to keep up-to-date records of these needs, and to assess pain. Chronic pain is a common symptom among older adults living in LTC homes [103-105] resulting from comorbid conditions (eg, injury, surgery, and disease) [106]. Given the prevalence of pain in the LTC home setting and that pain assessment and management are further challenged for residents living with dementia, recognizing and treating residents' pain needs improvement. Indeed, it is not surprising that care staff identified pain assessment as a priority in the LTC setting, as using innovative tools to better detect and effectively treat pain among residents living in LTC homes [107] would help to improve the well-being and quality of life of residents living with pain [105,108].

Care staff perceived the majority statements included in the *care cluster:connect* as moderately important for supporting everyday communication with residents during daily activities. *Care cluster: connect* included a dozen statements that focused on using mobile apps to foster positive caregiver-resident interpersonal relationships through shared activities and meaningful engagement. Interestingly, although care staff perceive several ways of using mobile apps to be useful for supporting social participation and nurturing relationships, care staff may have experienced or, possibly foreseen, challenges with implementing mobile technology interventions for this purpose in their care practice. For example, while *centered* approaches to resident care are beneficial [93], building and nurturing resident–care staff relationships takes time, staffing resources, and care staff education or training. Staffing and environment constraints, high workload demands, time pressure, workplace culture, limited experience, and/or training can hinder *centered* approaches to care [109-111]. Indeed, the *care cluster: connect* encompasses the principles of relationship-centered care, which shifts the focus of care beyond the individual (ie, person-centered care) to include the relational and social contexts of care [89,112,113]. In the relationship-centered care approach, more emphasis is placed on relationships, including the resident–care staff relationship. This approach focuses on enhancing the dyad's care experience and cultivating a reciprocal relationship that meets both the residents' and the care staff's needs. Building and nurturing relationships take time and would require changes to the focus of care practice approaches, with greater emphasis placed on relationship-oriented care over task-oriented care.

Strengths and Limitations

To our knowledge, this is the first study to explore care staff's perspectives about using mobile technology to support everyday communication with older adults living in LTC homes during daily activities. This study demonstrated the feasibility of using the mixed methods concept mapping approach with care staff in the LTC setting to identify the various ways that mobile apps could be used with residents to support communication and highlight priority care contexts to target future mHealth interventions. Employing the concept mapping approach offered a way to promote care staff engagement in the research process as well as capitalize on group discussion to quickly generate various ideas that may not be captured during in-depth interviews. In addition, this efficient and timely method offered flexibility in the research process. However, the concept mapping method is limited in its ability to explore care staff's perspectives in greater detail. Therefore, to enhance concept mapping results, future research should consider including traditional interviews concurrent with the concept mapping method or following up on key findings with interviews to capture both the breadth and the depth around care staff perspectives on using mHealth in LTC. Indeed, the combination of concept mapping methods and focus group interviews has been shown to produce complementary results, capturing the complexities of a topic under inquiry [34].

Although methods used in concept mapping are suitable for any sample size above 10 [43], the small sample size in this study means that the findings cannot be generalized to other care staff in the LTC setting. Furthermore, this study included only one male; thus, this study may overlook the unique perspectives of male care staff. Participating care staff did not engage in the interpretation phase of this study (cluster map name and description consensus). Therefore, participant engagement was limited to 2 phases of the study, and interpretations were based on the research team consensus. In addition, although the

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information gathered from care staff is the first step to better understand the ways mobile technology could be used with residents, this study acknowledges that resident perspectives were not included. Future research should consider including residents in the research process to better assist in identifying key areas that they would want to use technology with care staff.

Conclusions

Effective communication is fundamental to the provision of person-centered care. According to care staff, there are a variety of ways to use mobile apps to support communication with residents living in LTC homes. Care staff categorized the various ways of using mobile apps with residents into 5 care contexts. The findings expand our understanding of priority areas for using mobile apps with residents in LTC homes, which included using mobile apps to support communication during care management activities, to facilitate verbal and nonverbal communication to meet residents' individual needs, and to overcome cultural-language barriers. This study demonstrated that concept mapping is a useful tool for engaging caregivers in the research process to illuminate caregivers' perspectives around using mobile apps to support communication with older adults living in LTC homes. Using mobile apps to deliver interventions (eg, AAC and nonpharmacological) is a key area for future research and clinical practice. For example, using a mobile app to measure health status could be employed as part of a resident's care plan to support person-centered care or using a mobile app to assess pain offers residents a way to communicate their care needs. This study provides an initial understanding of the ways in which mobile apps could be used to support caregiver-resident communication. Identifying priority care areas for using mobile apps is essential for targeting innovative mHealth interventions designed to support and enhance resident-caregiver communication in the LTC setting, ultimately improving person-centered care and residents' quality of life.

Acknowledgments

This work was supported by a postdoctoral training fellowship to RW from the University of Washington Advanced Training on Outcomes in Rehabilitation Research supported by a grant from the National Institute on Disability and Rehabilitation Research (grant number H133P120002). Additionally, a portion of this work was supported by the Canadian Frailty Network (formerly known as Technology Evaluation in the Elderly Network), which is supported by the Government of Canada through the Networks of Centres of Excellence Health Technology Innovation Grant (HTIG2014-20). The content of this paper is solely the responsibility of the authors and does not necessarily represent the policy of the Canadian Frailty Network. The authors wish to thank all the participating care staff at the long-term residential care home for generously sharing their experiences, perspectives, and time for this research. The authors are also grateful to the administrative staff for scheduling staff for the brainstorming activity and for assisting with participant recruitment. The authors wish to thank the research support provided by Diana Cochrane during the participant recruitment phase of this study and map interpretation. Finally, the authors would like to acknowledge the Concept System Global MAXTM software team for their support.

Conflicts of Interest

None declared.

Authors' Contributions

RW and JS contributed to the study's conception and design. RW made significant contributions to all aspects of the study (data collection, data analysis, and reporting) and prepared the draft manuscript. JS critically revised and commented on the draft manuscript and approved the final version of the manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

Multimedia Appendix 1
Conceptual clusters: generated statements and average ratings on usefulness, practicality, and probability of use.
[DOCX File , 26 KB - nursing_v3i1e21881_app1.docx]

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Abbreviations

AAC: augmentative and alternative communication
ADL: activity of daily living
cApps: communication applications
LTC: long-term care
mHealth: mobile health

Edited by E Borycki; submitted 27.06.20; peer-reviewed by G Towsley, J Walsh; comments to author 28.07.20; revised version received 10.08.20; accepted 12.08.20; published 29.09.20.

Please cite as:
Wilson R, Small J
Care Staff Perspectives on Using Mobile Technology to Support Communication in Long-Term Care: Mixed Methods Study
JMIR Nursing 2020;3(1):e21881
URL: https://nursing.jmir.org/2020/1/e21881/
doi:10.2196/21881
PMID:

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Original Paper

Vaccipack, A Mobile App to Promote Human Papillomavirus Vaccine Uptake Among Adolescents Aged 11 to 14 Years: Development and Usability Study

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Abstract

Background: More than 90% of human papillomavirus (HPV)-related cancers could be prevented by widespread uptake of the HPV vaccine, yet vaccine use in the United States falls short of public health goals.

Objective: The purpose of this study was to describe the development, acceptability, and intention to use the mobile app Vaccipack, which was designed to promote uptake and completion of the adolescent HPV vaccine series.

Methods: Development of the mobile health (mHealth) content was based on the integrated behavioral model (IBM). The technology acceptance model (TAM) was used to guide the app usability evaluation. App design utilized an iterative process involving providers and potential users who were parents and adolescents. App features include a vaccine-tracking function, a discussion forum, and stories with embedded messages to promote intention to vaccinate. Parents and adolescents completed surveys before and after introducing the app in a pediatric primary care setting with low HPV vaccination rates.

Results: Surveys were completed by 54 participants (20 adolescents aged 11 to 14 years and 34 parents). Notably, 75% (15/20) of adolescents and 88% (30/34) of parents intended to use the app in the next 2 weeks. Acceptability of the app was high among both groups: 88% (30/34) of parents and 75% (15/20) of adolescents indicated that Vaccipack was easy to use, and 82% (28/34) of parents and 85% (17/20) of adolescents perceived the app to be beneficial. Higher levels of app acceptability were found among parents with strong intentions to use the app (P=.09; 95% CI –2.15 to 0.15).

Conclusions: mHealth technology, such as Vaccipack, may be an acceptable and nimble platform for providing information to parents and adolescents and advancing the uptake of important vaccines.

(JMIR Nursing 2020;3(1):e19503) doi:10.2196/19503

KEYWORDS

cervical cancer; prevention; mobile health; parents; adolescent health; vaccine; human papillomavirus

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Introduction

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States and a cause of cervical and other anogenital cancers [1]. HPV types 16 and 18 lead to 70% of cervical cancers, and HPV infection has been linked to anal, oral, and throat cancers in women and men [2]. HPV vaccines, available in the United States since 2006, are safe and highly effective [3]. The currently utilized 9-valent vaccine covers the HPV types associated with the majority of cervical, anal, and throat cancers and can prevent an estimated 92% of all HPV-related cancer cases [4]. Recent data demonstrate that HPV vaccines are associated with a significant reduction in precancerous lesions [5]. HPV vaccines are most beneficial when given to younger adolescents and before the onset of sexual activity. As such, the Advisory Committee on Immunization Practices recommends the HPV vaccine as a two-dose series for routine administration to both boys and girls between ages 11 and 12 years [6]. However, the vaccine may be given as early as age 9 and should be offered as catch-up to any adolescent through age 26.

Despite the profound individual and community-level benefits of HPV vaccination, rates in the United States consistently lag behind the other routinely recommended adolescent vaccines [7]. Recent data from the 2019 National Immunization Survey–Teen (NIS–Teen) [8] indicate that 72% of adolescents aged 13 to 17 years have received the first HPV dose and 54% have completed the age-appropriate HPV vaccine series compared with 90% for tetanus, diphtheria, and acellular pertussis vaccines and 89% for meningococcal vaccines. These data also show that there have been persistent differences in vaccine uptake across sociodemographic groups, including gender, insurance status, and community type. Higher series initiation rates have been observed in girls (68%) compared with boys (65%), adolescents covered by Medicaid (75%) and insurance (71%) compared with those uninsured (60%), and among adolescents who reside in urban (74%) and periurban (71%) areas compared with those from other/rural communities (64%) [8]. Periurban refers to areas outside of but near large metropolitan areas (populations greater than 50,000). In addition, White non-Hispanic adolescents have the lowest series initiation rate (68%) compared with peers from other racial and ethnic groups (71% to 77%) [8]. Lastly, NIS–Teen 2018 results demonstrated that among adolescents who had initiated the HPV vaccine series, completion rates were higher when parents received a provider recommendation (74.7%) than when there was no provider recommendation (46.7%) [9].

Challenges to HPV Vaccine Uptake

Barriers to HPV vaccine uptake are well-described in the literature [10,11]. Understanding and addressing parental views about HPV vaccines may be critically important since parents/caregivers are the primary health care decision makers for their adolescents [12]. Many of these parental beliefs can inform behaviors around pursuing vaccines, consistent with the integrated behavioral model (IBM). IBM constructs have been widely used in identifying modifiable determinants of HPV vaccine behavior that are useful for informing interventions [13,14]. The IBM posits that intentions exert the most influence on behavior and, in turn, are influenced by attitudes, norms, and perceived behavioral control (also referred to as control or self-efficacy). Each of these three general constructs (attitudes, norms, and control) are influenced by a set of corresponding underlying beliefs. In relation to the HPV vaccine, behavioral beliefs refer to the favorable and unfavorable consequences, normative beliefs refer to those who would support or not support, and control beliefs refers to barriers and facilitators. Awareness and knowledge are considered relevant background factors that are necessary but often not sufficient for behavior change. Beliefs are potentially modifiable, and addressing these IBM social-cognitive constructs has led to many successful health behavior interventions [15]. Some known modifiable parental beliefs associated with HPV vaccine initiation or completion include (1) behavioral beliefs, such as vaccine safety and concern about sexual activity among adolescents [16-21], (2) normative beliefs, such as opinions of family, friends, and providers [17,19-28], (3) control beliefs, such as cost and access [16,28-30], (4) general views on vaccines, such as safety and effectiveness [20,31,32], and (5) knowledge and awareness of HPV and HPV vaccines [17,20,22,23,26,29,30,32-34] (see Multimedia Appendix 1 for a summary of these findings from the literature).

Sources of Health Information

Parents rely heavily on their child's health care providers to provide reminders for and schedule vaccines [35]. In recent years, there has been increased use of mobile phones to acquire health information, receive reminders, and track progress in attaining health goals. Patient-facing mobile health (mHealth) technology is useful to augment clinical care, as it can efficiently deliver information remotely before and after in-person clinic visits [36]. Additionally, smartphones are now accessible to a broad spectrum of the population [37]. Therefore, mHealth apps have great potential to deliver health behavior interventions to a broad spectrum of the US population.

As the use of mHealth technology expands, so too has the number of vaccine-focused health promotion initiatives, such as text messaging for reminders and recall appointments [38]. Studies examining the effectiveness of automated reminders and text messages to promote completion of the HPV vaccine series have yielded positive results [39-41]. There are a couple of mobile apps focused on helping parents understand adolescent development and health needs that include information on vaccines, although they have not yet been evaluated for impact [42,43]. There are also several apps available to help parents learn about and track recommended vaccines for infants and young children, but few include adolescent vaccines [44]. However, to our knowledge, no studies have evaluated the use of a mobile app to improve vaccine uptake through the dissemination of targeted educational messages that focus on the needs of young adolescents and support their emerging health care agency.

Thus, our objective was to develop an app (Vaccipack) as a tool to increase HPV vaccine acceptance by leveraging health behavior theory and mHealth to target key parental beliefs related to HPV vaccines. Vaccipack is exclusively focused on

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adolescent vaccines and designed for parents (to use and share with their adolescents) to promote the initiation and completion of the HPV vaccine series in their adolescent children.

Theory-based content design, although standard practice in behavioral intervention research, has not been a typical approach adopted by app developers [45]. Evaluation of acceptability and likely use, as we present here, is an important preliminary step for developing apps and in designing behavioral interventions that are most likely to achieve the desired health outcome [15,46]. Therefore, the purpose of this paper is (1) to describe the theory-based, community-informed development and features of the Vaccipack mobile app, and (2) to evaluate the acceptability of, and intention to use, the Vaccipack app among a sample of parents and parent-adolescent dyads presenting for a visit at a primary care clinic in which the HPV series' initiation rate was lower than the national average.

Methods

In this section, we first describe the development of the mobile app Vaccipack (phase 1a) and the features of the app that was created as a result of this process (phase 1b). Next, we describe the study that was conducted to evaluate the usability of Vaccipack (phase 2).

Phase 1a: Mobile App Development

In developing Vaccipack content, we used the IBM-categorized parental beliefs about HPV vaccine uptake (see Multimedia Appendix 1) to increase motivation for uptake of the HPV vaccine [15]. We also incorporated basic information about HPV and the HPV vaccine. The app development process itself was also informed by applying user-centered design principles, which focused on designing an application from the perspective of the user [47]. Additionally, our preliminary evaluation of the app was guided by the technology acceptance model (TAM), which focuses on two aspects of acceptance—usability and usefulness—and the IBM, which indicates that intention is the most proximal predictor of behavior [48,49].

We elicited input from community advisory board (CAB) members. Adolescents and parents of adolescents were included as CAB members (as potential users), and pediatric clinicians were included in CAB meetings (as potential recommenders of the app). Five meetings with representatives from these CAB groups were held. Study team members facilitated each meeting using a discussion guide that focused on better understanding potential users' current strategies for vaccine decision making, functions users might value in a vaccine-related app, and user preferences for potential app content. Wireframes (drawings of various functions as they would appear on screens) of the proposed app were also used to facilitate discussion in some of the meetings.

During each CAB meeting, we presented proposed app features and elicited recommendations for additional features. The name for the app, Vaccipack, was generated from the first adolescent CAB meeting and endorsed in a subsequent parent meeting. The adolescents indicated the name represented the ability to conveniently carry around the vaccine information, akin to a backpack. CAB members were not included in the participant dyads for the survey portion of this study.

Two of the central features of the Vaccipack app were to provide information about and tracking for all three recommended adolescent vaccines—HPV vaccine, Tdap (tetanus, diphtheria, and acellular pertussis) vaccine, and meningococcal conjugate vaccine—as well as the yearly influenza vaccine. While the focus of Vaccipack was to improve uptake of the HPV vaccine, it is important to strongly endorse all adolescent vaccines equally as a bundle [50]. Another central feature of Vaccipack was the use of brief stories to provide vaccine information and target modifiable parental beliefs associated with adolescents' HPV vaccine uptake (Multimedia Appendix 1). To accomplish this, we created 26 stories addressing IBM constructs related to HPV vaccine behavior drawn from the literature as a way to promote HPV vaccine initiation and completion. Stories were written from the perspective of parents/primary caregivers, adolescents, and clinicians. Each story incorporated HPV and HPV vaccine knowledge and two to three HPV-related beliefs that might promote vaccine acceptance. Stories ranged from two to four paragraphs and were written at a middle school reading level. Topics were drawn from events that may occur in the daily lives of families with adolescents, including visits to see a health care provider. The 26 unique stories were developed so that a new weekly story could be highlighted with a push notification (indicated by a message on one's mobile device noting, "you have a new story in Vaccipack") for 26 weeks, or approximately 6 months, which is the amount of time needed to complete the two-dose HPV series for youth aged 11 to 14 years. If participants did not complete their HPV vaccine series in the 6-month time allotment, the series of 26 stories would repeat over the subsequent 6 months. Table 1 outlines the description of the five theory-derived concepts (based on the IBM) used as the framework for the content developed in each of the 26 stories: (1) behavioral beliefs, (2) normative beliefs, (3) control beliefs, (4) general norms, and (5) knowledge. The 26 stories were developed as two sets of 13 stories (set A and set B), with each set addressing all IBM theory-based modifiable factors at least once. Each theoretical concept addressed specific themes generated from the existing literature, and the relevant contextual content was drawn from CAB meetings. The frequency of each theme presented in the app story content is shown in Table 1.

Additionally, input obtained from our initial CAB meetings favored having an interactive component of the app; thus, a discussion forum was included as one of the app's features. The app was collaboratively built by Big Yellow Star, Inc, with iterative feedback regarding content and functionality from members of the study team. The color scheme, illustrations for each story, and customized font were all designed to appeal to the target audience. In addition to the mHealth app, the developer also created a web-based staff console that allowed research staff to review forum posts and respond as needed.

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Table 1. Frequency of human papillomavirus (HPV)-related themes addressed in 26 stories.

Theoretical concept	Theme	Set A (n=13)	Set B (n=13)	Total, n (%)
Behavioral belief	Vaccine safety and vaccine side effects	2	1	3 (12)
	Vaccine will not lead to increased sexual activity	2	3	5 (19)
	Cancer prevention	5	3	8 (31)
	Being a responsible parent	5	5	10 (38)
	Anticipated regret for not getting the vaccine	2	2	4 (15)
	Herd immunity (community benefit)	1	1	2 (8)
Normative belief	Provider recommendation	10	3	13 (50)
	Opinions of friends (positive and/or negative)	3	3	6 (23)
	Opinions of family (positive and/or negative)	2	1	3 (12)
Control belief	Cost	2	2	4 (15)
	Insurance coverage	2	2	4 (15)
	Access to provider	2	0	2 (8)
	Where to get vaccinated	2	0	2 (8)
General norm	General preventative care and immunizations	3	4	7 (27)
	Parent health history of HPV	2	1	3 (12)
	Family cultural background	2	1	3 (12)
	Media influence	0	1	1 (4)
Knowledge	Two doses versus three doses	3	2	5 (19)
	Do boys need the vaccine?	1	1	2 (8)
	What are the effects of HPV?	3	2	5 (19)
	How common is HPV?	3	3	6 (23)

Phase 1b: Description of the Vaccipack Mobile App

Vaccipack is a free, downloadable mobile app for both iPhone operating system (iOS) and android formats that can be used on mobile phones and tablets. It is currently only available in English and is written for a middle school or higher reading level. A webpage for the app with some basic information is also available [15]. Vaccipack was designed to provide parents of adolescents aged 11 to 14 years with convenient access to vaccine health information. The application was designed to work in concert with provider recommendations and serves as a practical tool for parents (see Multimedia Appendix 2).

More specifically, the main features of the app include an introductory video, a vaccine checklist that serves a tracking function, stories about parents and their adolescents navigating adolescent vaccinations, and a discussion forum with additional resources on adolescent vaccines. A 2.5-minute video, displayed in a narrated animation format, provides basic information about meningococcal conjugate vaccine, Tdap vaccine, and HPV vaccine, as well as a reminder to get the yearly influenza vaccine. Ideally, a brief description of the app with instructions on how to download and view it would be available in the clinic waiting room, before seeing a provider. After the visit with a health care provider, the parent could enter information regarding vaccination histories for multiple children into the vaccine checklist for each adolescent child aged 11 to 14 years. Brief introductory information about each vaccine is also provided in the checklist. After the first HPV vaccine is entered, a set of push notification reminders are sent to the user (6, 9, and 12 months after the first dose) about the second dose (intended to be completed 6 to 12 months after the first dose). As described above, each story in the app addresses a few of the most common parental beliefs related to HPV vaccine uptake, such as provider recommendations, cost of the vaccine, and whether a vaccine should be delayed if the adolescent is not sexually active [9,10,13]. The stories describe families in realistic situations and address barriers to vaccine uptake and strategies to overcome them. Each story is followed by a list of several forum posts that are related to the topic of the story. On the forum, users can post new discussion items or respond to other posts. For each new forum post, the user can select one or more of the 14 “tags” to identify the topic, such as “vaccine schedule,” or “effects of HPV.” Users can filter the forum posts by these tags to read about topics they are most interested in. Several exemplar posts have been entered into the forum by members of the research team, consisting of several frequently asked questions with responses that include a mention of resources, such as the Vaccines for Children program, which provides financial assistance for vaccines to families in need [43].

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Phase 2: Acceptability and Intention-to-Use Evaluation of the Vaccipack App

To assess the acceptability of and intention to use the Vaccipack app, baseline and post-app surveys were designed to garner feedback from potential users. The baseline survey included items adapted from the Parent Attitudes About Childhood Vaccines survey instrument [51], technology acceptance model (TAM) [48,49], and the Pew Research Center's health information survey [37]. Vaccine beliefs and behaviors included history of vaccine delay or refusal, trust in vaccine information, and belief that following the recommended immunization schedule is good for one's child. Health information items included the source of health information parents and adolescents used, devices used to search for health information, comfort using mobile phones for health information, and current health app use. Responses were captured as discrete categories, measured yes/no/don't know, agree/disagree, or using a Likert scale. A post-app introduction survey was also adapted from previously published work [52] and included items based on both the TAM [48,49] and the IBM. Survey items related to app acceptability included perceived usefulness and perceived ease of use. Items were rated on a 5-point Likert scale of agree/disagree. The three acceptability questions were combined into an acceptance measure, with a possible response range of 3 to 15. Items derived from the IBM [15] related to an intention to use the app in the next 2 weeks (5-point Likert scale of agree/disagree). In addition, there were four open-ended questions eliciting behavioral beliefs (eg, "What would be good/bad about using the app in the next 2 weeks?") and self-efficacy beliefs (eg, "What would be easy/hard about using the app in the next 2 weeks?"). A final post-app survey item, scored on a 5-point Likert scale, asked, "How likely are you to share Vaccipack with your adolescent (parent survey) or parent (adolescent survey)?" Finally, app usage data were gathered in aggregate for participants and other users from Google Analytics.

Eligibility and Recruitment

The app evaluation study protocol was reviewed and approved by the Institutional Review Board at Children's Hospital of Philadelphia. Following approval, the study team enrolled parents and parent-adolescent dyads from a periurban primary care pediatric clinic. This primary care clinic was selected because its aggregate HPV vaccination rates among adolescents were below the national average. Dyad inclusion criteria were as follows: (1) the adolescent was between the ages of 11 and 14 years, (2) the adolescent had received primary care services at the study site, (3) the adolescent's respective parent or guardian had a smartphone or tablet with Vaccipack app download capability, and (4) the adolescent and parent or guardian had the ability to read and understand English. Although the study aimed to recruit parent-adolescent dyads, parents could participate even if their adolescent was not interested in participating in the study. Parents or adolescents who participated in the app-development CAB group were not eligible to enroll in the survey study.

All eligible parents and parent-adolescent dyads were approached in the study site's waiting room and, if interested in participation in the study, were consented and evaluated for eligibility. Recruitment occurred on specific study recruitment days over a 3-month period. Staff at the respective recruiting clinic ensured that we captured all eligible families. Consenting parents and adolescents individually completed a paper-and-pencil–based baseline survey that included sociodemographic characteristics (eg, age, race/ethnicity, education), immunization-related beliefs and behaviors, internet and app usage habits, and health information preferences. Following completion of the baseline survey, research staff introduced the Vaccipack app, which parents then downloaded. After an opportunity to review the app at the visit, parents and adolescents individually completed the second brief post-app-use paper-and-pencil–based survey.

Data Analysis

Demographic data and closed-ended question responses from the pre- and post-app surveys were analyzed using descriptive statistics. Likert scale results were dichotomized due to skewed responses. An independent *t* test was used to assess the difference in mean values for the acceptability measure among parents, comparing those who strongly agreed (n=17) with those who did not strongly agree (n=17) that they intended to use the app in the next 2 weeks. Responses to the open-ended survey questions were coded by two research team members to identify dominant themes using the content analysis method described by Fishbein and Ajzen [15], which uses IBM concepts as the thematic framework. App usage data were summarized using descriptive statistics.

Results

Pre-App-Introduction Baseline Survey: Parents and Adolescents

Of the 34 parents who completed the parent baseline survey, 28 (83%) were aged 40 or older, 27 (79%) were White, 21 (62%) had completed a bachelor's degree or higher, and 22 (65%) had a yearly household income of US $80,000 or more (Table 2). Eighteen of 34 (53%) parents kept track of their child's vaccines using home records, while 9 of 34 (26%) parents relied on reminders from their child's health care provider and 7 of 34 (21%) parents did not keep track of immunization records at all. Thirty-two of 34 (97%) parents thought that following the recommended vaccine schedule was a good idea for their child, and 29 of 34 (88%) parents indicated that they trusted the information they received about vaccines. However, of the 34 parents, 7 (21%) parents had delayed and 5 (15%) parents had declined having their child get a vaccine for reasons other than illness or allergy, with 9 (26%) parents endorsing one or both of these indicators of vaccine hesitancy.

In terms of health information–seeking practices for their own health, 30 of 34 (88%) parents relied on the internet and 27 of 34 (79%) parents relied on health care providers, while only 8 of 34 (24%) parents utilized health apps. Of the 34 parents, 24 (77%) had used a smartphone most frequently (compared with a computer or tablet) for seeking health-related information and 30 (88%) were comfortable doing so. Although only 1 of 34 (3%) parents had used an adolescent health app previously, 33

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of 33 (100%) parents who responded believed that they could be a reliable source of information. Seventeen of 34 (50%) parents indicated that they would be very likely to use a health app if their health care provider recommended it, and 7 of 34 (21%) parents had privacy concerns. The most common anticipated barriers to using a teen health app that parents identified included cost of the app (14/34, 41%) and not having time to try it out (11/34, 32%) (see Multimedia Appendix 3).

Twenty adolescents, whose parents also participated in the study, completed the baseline adolescent survey. Adolescents were in grades 6 through 9. Eleven of 20 (55%) adolescents identified as girls and 9 of 20 (45%) identified as boys (Table 2). Most (13/20, 65%) of the adolescents relied on their parent or guardian for health information, with 50% (10/20) of adolescents indicating that the internet was their most common resource for seeking health information on their own.

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Table 2. Parent and adolescent participants' characteristics.

Characteristic	Adolescents (n=20), n (%)	Parents (n=34), n (%)
Parent age (years)		
32-39		6 (18)
40-49		20 (59)
50+		8 (24)
Adolescent age (years)		
11-12	11 (55)	
13-14	9 (45)	
Race		
Black/African American	2 (10)	3 (9)
White	13 (65)	27 (79)
Other	5 (25)	4 (12)
Hispanic/latino/latina ethnicity		
Yes	4 (20)	6 (18)
Adolescent gender		
Female	11 (55)	
Male	9 (45)	
Parent education level		
Some high school/high school graduate/high school equivalency certificate		6 (18)
Some college/technical training		7 (21)
Bachelor's degree		15 (44)
Higher education degree		6 (18)
Adolescent grade level		
Grade 6	4 (20)	
Grade 7	10 (50)	
Grade 8	4 (20)	
Grade 9	2 (10)	
Total household income in previous year (US $)		
$12,000-$24,000		2 (6)
$25,000-$79,000		10 (29)
$80,000 or higher		22 (65)
Total household size		
3 people		8 (24)
4 people		7 (21)
5 people		12 (35)
6 people		7 (21)

Seventeen of 20 (85%) adolescents reported that their parents made decisions about vaccines for them, while 3 of 20 (15%) adolescents made decisions together with their parents. Thirteen of 20 (65%) adolescents trusted the information they received about "shots," while 6 of 20 (30%) adolescents were unsure that the information was accurate. Eleven of 20 (55%) adolescents were comfortable discussing health information with their parents, and 15 of 20 (75%) adolescents reported that they would receive a vaccine if recommended as being important by a parent or guardian (see Multimedia Appendix 4).

Although none of the 20 adolescents had previously used an adolescent health app, 19 (95%) indicated that they would be interested in using one if they learned about it from a doctor or

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nurse (whose endorsement they valued most) rather than from their parents (13/20, 65%), friends (9/20, 45%), or teachers (5/20, 25%). Adolescents stated that their trust in the information on an app would be higher if the app was recommended by doctors or nurses (15/20, 75%) than if recommended by parents (12/20, 60%) or friends (1/20, 5%). More than one-half (12/20, 60%) of adolescents indicated that an app would be a good way to learn about health information, and only 2 of 20 (10%) adolescents had privacy concerns. Potential barriers to using a health app included cost and not knowing how to use it (see Multimedia Appendix 5).

Post-App-Introduction Survey: Parents and Adolescents

In total, 34 parents and 20 adolescents completed short surveys that were administered after participants had been introduced to the Vaccipack app and had had time to explore the features. Perceived ease of use was generally favorable for both groups, with more parents believing that Vaccipack was easy to learn about (31/34, 91%) and to use (30/34, 88%) compared with adolescents (14/20, 70% and 15/20, 75%, respectively). Regarding perceived usefulness, 28 of 34 (82%) parents and 17 of 20 (85%) adolescents agreed that Vaccipack would be beneficial. Of note, 15 of 20 (75%) adolescents and 30 of 34 (88%) parents intended to use the app in the next 2 weeks (Table 3). The measure of app acceptability among parents had a Cronbach alpha of .76 and an overall mean of 12.91 (range 9-15). The mean acceptability among parents who strongly agreed that they intended to use the app in the next 2 weeks (17/34, 50%) was 13.41 compared with 12.41 among parents who did not strongly agree (17/34, 50%), a difference that was marginally significant at P=.09 (95% CI 2.15 to 0.15).

Open-ended responses regarding anticipated app use benefits, drawbacks, barriers, and facilitators were similar for parents and adolescents. The most common reported benefits of the app were (1) being able to keep track of their (or their child's) vaccine schedule, (2) being able to receive information about vaccines, and (3) being able to receive information about adolescents' health. Most participants noted no drawbacks of the app. However, 2 of 20 (10%) adolescents mentioned that it would not be good if the app had "scary information." Both adolescents and parents noted "time" as the most common anticipated barrier. Additionally, forgetting to check the app was a common potential barrier noted by parents, while not being sure of how to use the app was a common possible barrier for adolescents. Two of 20 (10%) adolescents also mentioned "lots of reading/a lot to get through" as an additional potential barrier. A common facilitator for app use among both parents and adolescents was the potential ease of use. In addition, parents cited having reminders and the convenience of having information readily available anywhere on their mobile device as potential facilitators of using the app. Finally, adolescents noted having been shown how to use the app as a significant facilitator.

Table 3. Post-app-introduction responses.

	Agree/strongly agree	
Concept/statement	Parents (n=34), n (%)	Adolescents (n=20), n (%)
Acceptability—perceived ease of use		
Easy to learn how to use	31 (91)	14 (70)
Easy to use	30 (88)	15 (75)
Acceptability—perceived usefulness		
Will be beneficial	28 (82)	17 (85)
Intention		
Likely to share with your teen	25 (74)	
Likely to share with your parent/guardian		14 (70)
Plan to use in next 2 weeks	30 (88)	15 (75)

App Usage Indicators

App usage data specific to our study participants was available on the staff console for the three main features: tracking, stories, and forum. In the 2 weeks following enrollment, users accessed between one and three of the app's features (mean two features): they read between one and 15 stories (mean three stories) and between one and 10 questions (mean three questions) in the forum. Although we did not advertise the app, it was free and publicly available on the app stores. According to Google Analytics, which provides overall app usage data, for the period from July 2018 to July 2019, there were 85 users (15 were research staff and developers), most of who lived in the greater Philadelphia area. It was also accessed in several US cities (eg, Washington, New York, Houston, and Cupertino), and it was viewed in China and Sweden. Most of the individuals who accessed the app used the iOS (Apple) version (70/85, 82%), with the remaining 18% (15/85) using the android version.

Discussion

Principal Results

The Vaccipack app was designed to be used primarily by parents, but it was also meant to be shared with adolescents as an avenue for promoting adolescent involvement in their own health care. Intention to use Vaccipack was high among both parents and adolescents after they had been introduced to the app and had some time to explore it, although it was higher

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among parents (30/34, 88%) than among teens (15/20, 75%). Perhaps fewer adolescents viewed the app as relevant to them given that 85% (17/20) indicated their parents made the decisions about their vaccines. In addition, most parents and adolescents found Vaccipack easy to use. However, a higher percentage of parents (31/34, 91%) found the Vaccipack app easy to learn how to use compared with adolescents (14/20, 70%). This could be due to adolescents not having used a similar app before, a reason indicated by 35% (7/20) of adolescents as an impediment to learning how to use a teen health app, which by comparison was only endorsed as a potential barrier by 18% (6/34) of parents. Perhaps adolescents needed more time to explore the app to become comfortable using it. Notably, higher levels of app acceptability were found among parents with strong intentions to use the app compared with others, an association that trended toward significance. These findings are encouraging given that previous studies using the TAM to examine various forms of technology use have found a strong relationship between both components of acceptability (perceived usefulness and perceived ease of use), intention to use, and actual use [48]. In developing technology-based interventions, it is important to first assess their acceptance among the target population, as we have done in this study.

Given as open-ended responses, the most common anticipated benefits of Vaccipack noted by parents and adolescents were to help keep track of required vaccinations and to access information on adolescent vaccines and health more generally. These findings support the relevance of the main features of the app—the vaccine tracker, video, stories, and forum. Open-ended responses from parents and adolescents suggest that an app that is easy to use, not complicated to learn, does not require too much reading, and provides easy-to-find information would facilitate its use. To further refine Vaccipack, future iterations could turn the written stories into audio or short video versions to make them more engaging and accessible [53]. Actual Vaccipack app use in the 2 weeks following the study visit varied widely, with a mean usage of two features—accessing three stories and three forum posts—which was very favorable given that the app was designed to highlight one story per week.

Our sample consisted of 34 parents (79% White) and 20 adolescents aged 11 to 14 years in a periurban setting, with two-thirds (22/34, 65%) of participating families having yearly household incomes of US $80,000 or higher (likely with private insurance). While almost all parents thought it was a good idea to adhere to the recommended vaccine schedule, more than one-quarter (9/34, 26%) of parents endorsed one or two indicators of vaccine hesitancy. Given that our study's participants were from a clinic with HPV vaccination rates below the national average, these findings echo national statistics that indicate children aged 11 to 14 years whose families have private insurance have lower HPV vaccination rates compared with those covered by Medicaid [8]. Across race/ethnicity groups, the rates of HPV vaccination initiation and completion are lowest among White non-Hispanic families compared with all other groups [8].

Approximately one-half of the parents in this study did not keep track of their adolescent's vaccines, and most relied on their provider or clinic to provide reminders for upcoming vaccines. This may help explain why parents may not be fully aware of or overestimate their adolescent's vaccination status [35], and it suggests that an app, such as Vaccipack, with vaccine tracking and reminder features may be beneficial. As adolescents take on more responsibility for monitoring and maintaining their vaccine records, Vaccipack could be a helpful adjunct to support that process. It is notable that adolescents indicated they would be more likely to use an app and trust its content if they heard about it from a health care provider rather than from their parents or friends. This suggests providers may have a window of opportunity to talk about health technology use directly with young adolescent patients.

HPV vaccines are highly effective at preventing cancer, yet even with successful biologic interventions, the advantages will be limited if they are not adopted by those who can benefit. Thus, vaccine uptake behavior is an important area of study, especially now with promising COVID-19 vaccines on the horizon along with substantial skepticism of these new biologics [54,55]. mHealth is a promising area with the ability to promote advantageous health behaviors, such as vaccine uptake, especially because information can reach families remotely, but it will be vital to build apps on a strong foundation of behavioral science in order to be effective. For that reason, it will be important to guide content using well-validated health behavior theories, such as the IBM [15], which was used to create Vaccipack. Additionally, theory-guided interventions enable the measurement and evaluation of relevant mediators, such as beliefs, represented in component messages, which are the levers of behavior change [15]. Identifying relevant mediators can also assist in streamlining app content to include the most essential elements.

Patient-facing apps and mobile technologies provide a nimble platform to modify messages to parents and adolescents as scientific understanding of diseases, vaccines, and factors influencing vaccination evolves. In addition, the future potential for compatibility of such apps with patient portals and electronic health records will facilitate bidirectional access to relevant data, such as vaccine records, which will make apps like Vaccipack both easier to use (eg, automated data entry) and more useful (eg, able to download verified vaccine records into the app to share with schools, etc).

In order to advance patient-focused interventions to promote uptake of the HPV vaccine during the adolescent years, the Vaccipack app was designed for parents and their adolescents aged 11 to 14 years to provide information, assist with vaccine tracking, and enhance motivation for all adolescent vaccines, with more detailed content specifically on the initiation and completion of the HPV vaccine series. The longer-term goal of Vaccipack as an intervention is to increase knowledge and favorable outcome expectancies, promote norms of vaccine acceptance, and support self-efficacy by building skills and providing resources for HPV vaccine initiation and completion among parents for their vaccine-eligible adolescents because parents are the primary decision makers for younger adolescents. However, as adolescents are beginning to develop more agency related to their own health care [56], the app was secondarily developed to directly engage adolescents who may be involved in learning about their own health. Although this

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app is focused on the parent and their adolescent, and is not a provider-focused app, another goal of Vaccipack was to provide additional support to providers before and after the primary care visit. Undoubtedly, a strong provider recommendation for the HPV vaccine is among the strongest influencing factors for vaccine uptake [9]. For example, the introductory video in Vaccipack, which contains basic vaccine information, was intended to be viewed before seeing the health care provider, who could then focus on providing patient-centered decision-making support regarding vaccine uptake.

Limitations

This research has a few limitations that can be addressed in future studies. The sample was drawn from one periurban clinic in the northeastern United States, which may not represent the variety of settings with lower vaccine uptake. This limits generalizability, and further research is needed that encompasses a variety of settings in various geographical regions, notably in rural areas where HPV vaccination rates are also low [8]. This is especially needed because national statistics indicate that some differences in smartphone ownership persist by location as well—83% ownership in urban and suburban residents, and 71% in rural residents [37]. Because we recruited in a health care facility, this study did not examine access to care among those who are uninsured, which is also an important barrier to HPV vaccine uptake given that those without insurance have among the lowest rates of HPV vaccine initiation [8]. The age range targeted for vaccine promotion was limited to adolescents aged 11 to 14 years. This was because behavioral interventions with a focused target behavior and group can be assessed more effectively [15]. However, older adolescents could also benefit from an app, such as Vaccipack, but would likely need a different type of app given the greater autonomy they have over their health care. Future app development and evaluation research could include participants with greater income, race and ethnic diversity, geographic diversity, and a wider age range of adolescents. While our current findings are promising, future research is needed to assess the actual use of the Vaccipack app in a larger sample and over time and its impact on HPV vaccine uptake behavior.

Conclusions

Incorporating user-centered design principles led to the development of an app to promote the HPV vaccine that was acceptable in a sample of parents and adolescents in a clinic with lower HPV vaccination rates than the national average. Our theory-based approach to content development will facilitate future evaluation. It is remarkable that HPV vaccines can prevent many HPV-related cancers, yet tragic that this valuable vaccine has suboptimal uptake in the US. mHealth technology, such as Vaccipack, may provide an acceptable and nimble platform to provide information to parents and adolescents and advance uptake of life-saving vaccines.

Acknowledgments

Funding was provided by the Abramson Cancer Center through an internal grant (Principal Investigators: Teitelman and Feemster) from the University of Pennsylvania (Parent Grant: NCI Cancer Center Support Grant—NCI P30 CA016520).

Authors' Contributions

All coauthors made substantial contributions to either conception and design, acquisition of data, or analysis and interpretation of data. All coauthors were involved in drafting the article or revising it critically for important intellectual content and provided final approval of the version to be published.

Conflicts of Interest

Coauthor KAF is currently an employee of Merck & Co, Inc, Global Medical Affairs, Pneumococcal Vaccines. Please note that this study was conducted and the manuscript was submitted prior to KAF's employment at Merck. KAF's participation in this study is entirely independent of and in no way represents Merck & Co, Inc.

Multimedia Appendix 1
Parental social-cognitive factors associated with adolescent's HPV vaccine uptake identified in the literature.
[DOCX File , 15 KB - nursing_v3i1e19503_app1.docx]

Multimedia Appendix 2
Vaccipack app screenshots.
[PDF File (Adobe PDF File), 127 KB - nursing_v3i1e19503_app2.pdf]

Multimedia Appendix 3
Parent health technology use and perspectives on adolescent health applications (n=34).
[DOCX File , 15 KB - nursing_v3i1e19503_app3.docx]

Multimedia Appendix 4
Adolescent vaccine practices (n=20).

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[DOCX File , 14 KB - nursing_v3i1e19503_app4.docx]

Multimedia Appendix 5
Adolescent health-related technology use (n=20).
[DOCX File , 14 KB - nursing_v3i1e19503_app5.docx]

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Abbreviations

CAB: community advisory board
HPV: human papillomavirus
IBM: integrated behavioral model
mHealth: mobile health
NIS–Teen: National Immunization Survey–Teen
TAM: technology acceptance model
Tdap: tetanus, diphtheria, and acellular pertussis

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Edited by T Risling; submitted 20.04.20; peer-reviewed by R Mpofu, A Budenz, P Kreniske; comments to author 24.05.20; revised version received 31.08.20; accepted 28.09.20; published 29.10.20.

Please cite as:
Teitelman AM, Gregory EF, Jayasinghe J, Wermers Z, Koo JH, Morone JF, Leri DC, Davis A, Feemster KA
Vaccipack, A Mobile App to Promote Human Papillomavirus Vaccine Uptake Among Adolescents Aged 11 to 14 Years: Development and Usability Study
JMIR Nursing 2020;3(1):e19503
URL: https://nursing.jmir.org/2020/1/e19503/
doi:10.2196/19503
PMID:

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Original Paper

Experiences With Developing and Using Vital Sign Telemonitoring to Support Mobile Nursing in Rural Regions: Feasibility and Usability Study

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Abstract

Background: Modern information and communication technology has the potential to support mobile care in rural regions such as the Alpine region, which is characterized by long distances or even physically unreachable areas.

Objective: This study investigated the potential of supporting mobile nursing organizations in rural regions with the use of mobile telemonitoring systems in a case study setting.

Methods: As a subproject of the European Union–funded project INTESI, the VITAl parameter MOnitoring (VITAMO) project gathered stakeholders' requirements for telemonitoring support of mobile care in rural regions and then developed and implemented a prototype system that was used for a 3-month test period with a local nursing organization in Austria. Log analysis, surveys, and interviews were used to evaluate the system according to the Technology Acceptance Model. The focus was technology assessment and user satisfaction of both patients and nurses.

Results: Participants were provided Bluetooth devices to measure blood pressure, body weight, and blood glucose and to track activity. They also received a tablet with a mobile internet connection to see the results. The nurses were able to access the results remotely. Regularly executed speed tests and log analysis demonstrated the availability of high-speed mobile internet in the rural test region. Log analysis, surveys, and interviews revealed the suitability of the technology environment and showed that the system was easy to use and potentially useful. The perceived usefulness for supporting mobile care was rated meaningfully low, and the frequency of nurses using the tool declined continuously over the field test period. Further group discussions investigated this issue.

Conclusions: While the technology environment with mobile internet, Bluetooth devices, and smart vital sign monitoring devices was adequate and suitable to support mobile nursing in rural regions, the potential benefit for the nursing organization could not be confirmed. Further analysis revealed that operational care processes did not follow a well-defined care strategy. Technology has the potential to leverage the available environment for developing meaningful solutions. These experiences could contribute to further investigations that need to identify and analyze existing mobile care processes at an organizational level.

(JMIR Nursing 2020;3(1):e17113) doi:10.2196/17113

KEYWORDS

mobile health; telemedicine; vital signs; health monitoring; mobile nursing

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Introduction

Due to demographic changes, the amount of people receiving home care has recently increased, while the overall working population has declined. These social changes have had a significant impact on the economy and especially the health care domain. In 2016, 455,000 people in Austria received a care allowance [1]. Of these people, 147,000 (~1.7% of Austria's total population) received mobile care [2]. These general developments in health care expenditure are also reflected in the cost of mobile care in Austria, which increased from €489.3 million in 2011 to €615.5 million in 2016 [2].

Nonetheless, as part of high-quality health care delivery, mobile care and social care are providing the necessary support for the elderly to live at home with maximum autonomy and health. The Alpine region represents a challenging environment for the provision of mobile nursing services [3]. It is characterized by rural regions with long distances or even physically unreachable regions due to weather conditions like snow in the winter. These circumstances are affecting mobile care organizations, impeding seamless home health care delivery for patients. The aim of mobile nursing or mobile care is to provide health care services for patients at their homes. These services are comprised of monitoring health conditions and status as well as conducting care activities, supporting medication and personal hygiene needs, advising the patient and family members, and documenting the conducted activities. Patients who receive home care usually have age-related chronic conditions and are visited regularly by a nurse (ie, about every 2-7 days depending on the health condition and situation).

Modern information and communication technology (ICT) could help overcome certain issues with the provision of mobile care. With the proliferation of smartphones and mobile internet, the age of the Internet of Things has started, where everyday things are connected and exchange data seamlessly and continuously [4]. Fitness trackers, smart watches, smart weight scales, and blood glucose monitors are just examples of potential hardware to enable telemonitoring applications.

Although geographical barriers for mobile care in the Alpine region are common, the overall technology infrastructure in rural regions in Austria often conforms to a high standard. According to a report by OpenSignal, Inc [5], people in Austria had access to mobile internet with 3G and 4G connections at an average download speed of 19.39 Mbps as of February 2017, ranking Austria within the top 15 countries in the world [6]. The 4G mobile connection had an availability of 75.60% with an average download speed of 26.91 Mbps as of February 2018.

The European Union–funded Alpine Space project Integrated territorial strategies for Services of General Interest (INTESI), conducted from 2014-2020, is assuring the delivery of long-term service of general interest (SGI) via integrated, territorial strategies and policies [7]. A subproject of INTESI was dedicated to investigating the potential to support mobile care for rural regions in the Alpine region, especially regarding the monitoring of vital signs. This was based on recent studies that demonstrated the importance of continuous vital sign monitoring in older age, especially of persons with chronic conditions [8].

The project was started in 2017 as a joint effort by different stakeholders, including clients, nurses, nursing scientists, health information scientists, and administration, and ended in the second quarter of 2018.

The following objectives were defined in the project:

1. Identification of technical and user-related requirements and use case scenarios for mobile and social care with a high level of client involvement
2. Conceptualization and implementation of a prototype application for vital parameter self-measurement that is integrated into nursing processes
3. Implementation of a suitable prototype application and test in the field
4. Evaluation of ICT support for mobile care related to its acceptance and impact on nursing process support

The Reutte region in Tyrol, Austria consists of 37 municipalities and was selected as the test region for this project. Tyrol is an Austrian province with a population of 750,000 people and 45 health care organizations providing home nursing and mobile care [9].

The nursing organization SGS Reutte in Tyrol was selected for the present study. The organization frequently supported 381 patients in 2018. In the same year, the mean effort for the care-related activities of a patient was 80.8 hours per year. From these, 16.9 hours per patient were spent driving to the patients' homes.

In the VITAl parameter MOnitoring (VITAMO) project, a system for telemonitoring vital signs was conceptualized and implemented as a prototype. The aim of the current study was focused on the field test of the prototype, final technical and user acceptance evaluation, and system's impact as a supportive system for mobile care in the Alpine region. Thus, the paper is structured as follows: We describe the methodology by describing the overall idea of the prototype, the setting of the field test, and the methods for quantitative and qualitative evaluation, and we provide the qualitative and quantitative results on system usage, environment analysis, and user satisfaction.

Methods

To reach the proposed goal, the prototype system for VITAMO was developed as a case study, incorporating smart devices to self-monitor the vital parameters of blood pressure, blood glucose, body weight (scale), and activity and sleep (movement tracker) as well as a tablet with mobile internet to synchronize measurements with the server. The tablet also provided a communication interface for telephone calls between the patient and nurse as well as a patient reminder function set by the nurses.

The initial step of the project involved gathering technical and user-related requirements, which included state-of-the-art transmission technology, avoiding complex patient involvement for the measurements, and adherence to existing nursing processes. Suitable use cases were derived from the gathered requirements. More details on the requirements engineering

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[10] and prototype development [11] have been reported previously. The prototype development followed an agile approach [12], which continuously delivered updates during the test period.

The project was approved and granted by the university ethics committee RCSEQ at the University for Health Sciences, Medical Informatics, and Technology in Austria.

Field Test

A 3-month field test was planned and conducted with the local mobile nursing organization responsible for the selected test region Reutte. The organization determined nurses to participate in the project and use the system within their working routine. Suitable patients were recruited as study participants by the nurses, based on the criteria of physical and cognitive ability to use the system to conduct self-measurements with the devices (eg, blood pressure device) and use a tablet device. The participant sample was limited to patients of SGS Reutte. The nurses filtered suitable patients to those they thought were able to use the telemonitoring system. All eligible patients were personally asked to participate using information material about the project and were included if they provided written consent. The participating nurses were responsible for delivering the devices to the patients and for patient training on how to use the system for the field test. The nurses were educated by the system developers on how to use the prototype for both roles: the nurse role and the patient role. They also delivered the devices, educated the patients, and provided primary support for the patients during the test period.

The VITAMO test environment, including the server and connected mobile devices, was set up, and the ability to log on to the server was ensured according to the previously published implementation [11].

A basic initial working prototype was provided to start the field test. The test was integrated into the development process of the prototype (ie, a formative evaluation provided feedback for loopback changes). The feedback of participating nurses was given through email and telephone directly to the developers. All support requests were validated and ranked (ie, critical errors, standard errors, ideas for improvement), where the most critical and crucial issues got solved first. A support hotline was offered by the developers who were available on workdays between 8:00 am and 6:00 pm for technical, functional, and organizational questions and problems.

Quantitative Evaluation

The summative evaluation included quantitative and qualitative components. For the quantitative evaluation, the server log files were analyzed according to the system's utilization (eg, frequency of measurements, activities patients conducted with the devices), which analyzed the technical environment for stability, performance, and user interaction. Further, system logs were analyzed for the state of the mobile connection (between tablet and server) and Bluetooth connection (between tablet and Bluetooth Low Energy [BLE] devices).

To consider the related effects on the system's uptime, further investigations were conducted to examine the available internet speed via the mobile data network and the data volume required for system operation.

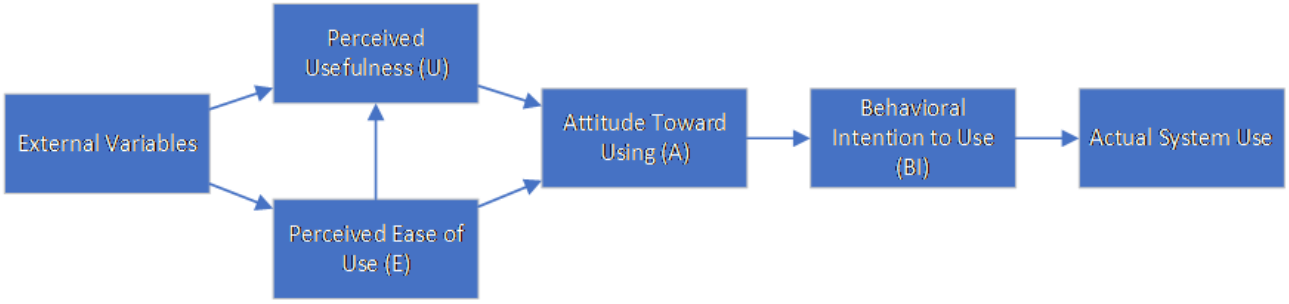
The technological environment was basically analyzed through speed tests of internet data transmission and server logs. The speed tests were conducted using the online test from the Austrian Regulatory Authority for Broadcasting and Telecommunications [13] once a week for all active tablets during the test phase.

The raw logs of the server, as well as the other quantitative investigations (eg, internet speed tests), were processed and analyzed by developed R scripts (R Core Team, Vienna, Austria).

Qualitative Evaluation

The qualitative evaluation was based on the Technology Acceptance Model (TAM) [14] and focused on user satisfaction for patients and nurses (Figure 1). To date, the original TAM has been modified several times, and although the evaluation concept was created already more than 2 decades ago, it has been used for many technology evaluations [15].

Figure 1. Technology Acceptance Model (TAM) [14].



Stakeholders, nurses, and patients were evaluated according to the TAM, which tries to determine the attitude towards using a certain system based on how easy the system was to use and how users perceived the usefulness of the system. Based on the perceived usefulness and the attitude towards using, a behavioral intention might be inferred. For the VITAMO evaluation, the participating nurses received a 34-question survey using a 5-point Likert scale. It included the topics as proposed by TAM: ease of use, perceived usefulness, attitude toward using, and behavioral intention to use. We added one topic for general attitudes toward information technology (IT). A specific field for "no answer" was added for each question. All TAM questions were randomly displayed to hide any topic affiliation. One additional question about the frequency of the use of

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VITAMO was added, with the following possible answers: several times a day, once a day, once every 2-3 days, and less than once every 3 days. Further, 2 open questions were included: ideas for VITAMO to support mobile care and general comments. The evaluation followed a triangulation approach where the survey analysis was extended with a semistructured group interview to get further information about the experiences and user acceptance during the field test. The interview guideline had 3 topic groups:

1. Technical: experience before the pilot started, experience during the pilot (eg, problems with devices, interfaces, phone calls, reminders, updates), usability (ie, pros and cons), and effects on the care workflow
2. Social: effects of the VITAMO system on the patient-nurse relationship
3. Economic: impact on work assistance, optimization of visits

The interview was qualitatively analyzed by comparing the results with the quantitative analysis as well as the surveys. Due to the participating patients' old age and health status, a shorter survey with 7 questions focusing on ease of use and patient satisfaction and a 5-point Likert scale was conducted with the remaining 6 patients at the end of the pilot phase. This survey also included 2 open questions about the perceived pros and cons of VITAMO. The survey was distributed immediately to all participating nurses and patients after the field test ended. The raw results of all paper-based surveys were transcribed to Excel (Microsoft Corp, Redmond, WA), exported as CSV files, and analyzed using scripts implemented with R. The focus was set on a descriptive analysis. The use of boxplots for ordinal data even for the small set of participants was intended, as it provides insights into the distribution of the selected answers, which reflects the anonymous attitude of all participants. However, it should be noted, that no intercorrelation between questions is possible. All interviews and surveys were held in German, and all results were translated to English for this paper.

Results

Field Test

The pilot field test was held in the district Reutte, Tyrol, Austria. Reutte had ~31,000 inhabitants in 2015, and 18.6% of the residents were older than 65 years. Care allowance was received by 32.7% of persons older than 75 years. The regional mobile nursing organization in Reutte had 381 patients in 2015, with an average weekly 1.5 hours spent per patient. In that year, the nurses drove 324,774 km in total [16].

The pilot test was conducted from November 2017 until February 2018 (a total of 103 days). The system was being used by 8 nurses in their daily working routines. Patient recruitment was based on the nurses' experience of whether a patient would be able to self-monitor their vital signs. The nurses listed the eligible patients (28/381), and each patient was asked to participate in the project. Finally, 7 patients (4 female, 3 male; mean age 70.83 years, SD 14.13 years) were recruited to participate in the 3-month test. One patient quit after one week without giving a reason. Within the first week of the test phase, each participant received a tablet with Long-Term Evolution (LTE) mobile connection and BLE devices for blood pressure and heart rate measurements, body weight and body composition measurements, and activity and sleep tracking. A screenshot of the mobile app is depicted in Figure 2. Two people also received devices to regularly measure blood glucose. The responsible nurses introduced and educated the patients about how to use the devices and tablets at the patients' homes. The combination of a tablet and the related devices are called a "set" for the remainder of this paper.

Figure 2. Dashboard view of the VITAl parameter MOnitoring (VITAMO) tablet app.

In total, 8 nurses participated during the test phase of VITAMO. All participating nurses and patients are part of the local mobile care organization in Reutte. In addition to the sets for the 7 participating patients, 2 additional sets were integrated into the field test (1 used by the nurses of the mobile care organization simulating a patient and 1 by the developers). The nurses' test set was used within the production environment while the developer set was only used in the staging environment without

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a remote internet connection. As the study was intended to evaluate technical feasibility but not health care–related content, the nurses' test set was also included in the summative evaluation, while the developer set was not.

Quantitative Results

Usage

After the field test, a log analysis was used primarily to extract relevant values concerning direct use by patients (ie, total executed measurements and mean tablet unlocks per day) and technological aspects (ie, mean data volume and internet connection speed). The results from the log analysis, interviews, and survey were collectively analyzed.

The log analysis was conducted for measurements collected over the entire test period. The results were extracted from the server log database. Table 1 shows the total number of different measurements for each set during the test phase. The patient with set 4 ceased participating during the project and was not included within the survey but was included in the log analysis. The fitness tracker was excluded from this analysis as this device did not have an active user-triggered measurement process; the tracker was automatically synced periodically (ie, the fitness tracker device tried to connect to the tablet every 15 minutes to synchronize the data from the previous 24 hours). The tablet then managed the transfer of new data to the server for storage. Each participant was encouraged to complete at least one measurement of each type per day.

Table 1. The number of measurements executed for each combination of a tablet and the related devices (ie, set) over the complete 3-month pilot phase.

Set	Blood pressure	Blood glucose	Body weight	Heart rate
Set 1	189	0	113	189
Set 2	77	0	36	77
Set 3	121	86	99	121
Set 4[a]	13	6	5	13
Set 5	132	0	111	132
Set 6	120	0	120	120
Set 7	196	88	103	196
Mean of all sets	121.14	25.71	83.86	121.14

[a]The patient with Set 4 discontinued participation at the beginning of the test phase.

Information about tablet use was derived from the number of tablet unlocks. An unlock was defined as the first touch interaction with the tablet after a minimum 10-minute duration with no interaction. The VITAMO app was continuously pinned on the tablet's screen, and no other app (nor the home screen) could be accessed on the tablet. On average, each tablet was unlocked 1.47 times a day. When interacting with the tablet, patients usually accessed the dashboard, followed by viewing blood pressure and body weight (see Table 2). Patients changed the views of the app more often than the nurses.

Table 2. Frequency at which different views were accessed in the VITAMO app, categorized by patients and nurses.

View	Patients (n=7)	Nurses (n=8)
Activity	116	28
Dashboard	172	135
Reminder	22	8
Blood pressure	158	47
Body weight	124	25
Total views	592	243

The frequency at which nurses opened patients' details decreased continuously throughout the test period, starting at 180 opens in week 1 and decreasing to 6 opens in week 14.

Technical Environment

The mobile internet connection was used to establish a connection between the server and tablet. The average upload volume per set during the test period was 517.3 MB (about 172 MB per month), and the download volume was 244.9 MB (about 82 MB per month), including the pilot phase. Set 4 was excluded from this analysis due to discontinued participation. A detailed view of the volume of each set is depicted in Table 3.

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Table 3. Overall upload and download data volumes needed for each tablet and the related devices (ie, set) during the complete test period.

Set	Upload data volume (KB)	Download data volume (KB)
Set 1	221,079.44	624,484.68
Set 2	365,358.84	591,325.24
Set 3	242,408.92	670,272.28
Set 4[a]	45,576.20	64,863.52
Set 5	266,006.36	625,790.48
Set 6	233,961.16	375,895.64
Set 7	238,564.44	421,482.80
Set 8	188,388.72	398,916.04
Total data volume	1,801,344.08	3,773,030.68

[a]The patient with Set 4 discontinued participation at the beginning of the test phase.

The total data transfer volume for the test phase was 6097 MB. However, 2.5 million log entries were transmitted, which is related to a volume of 1100 MB. The mean volume for one measurement was 0.5 KB.

The test for internet speed was conducted weekly for each set, resulting in an average upload speed of 6.14 Mbps and download speed of 32.40 Mbps. The speeds for each set are shown in Table 4. Except for one set, the LTE connection of all tablets could be guaranteed continuously. Due to poor reception, one set could only partly be reached via 2G (EDGE) mobile technology, and sometimes complete loss of connection occurred.

Table 4. The mean upload and download speeds and pings for the internet connection of each each tablet and the related devices (ie, set).

Set	Mean download speed (Mbps)	Mean upload speed (Mbps)	Mean ping duration (ms)
Set 1	13.0	0.98	30.0
Set 2	46.0	9.18	25.2
Set 3	36.4	9.42	24.4
Set 5	45.6	5.34	25.6
Set 6	14.8	2.202	32.2
Set 7	37.0	9.24	25.6
Set 8	34.0	6.64	29.0
Mean for all sets	32.4	6.14	27.4

Qualitative Results

Survey

The nurses provided the evaluation questionnaire to the patients after the pilot test ended. All remaining 6 participating patients returned the questionnaire.

The qualitative evaluation of the questionnaire regarding the patient's use of VITAMO showed that both the tablet and measuring devices were perceived as easy to use (see Figure 3). The smart devices performed slightly better than the tablet (see Figure 3, items 1 and 2).

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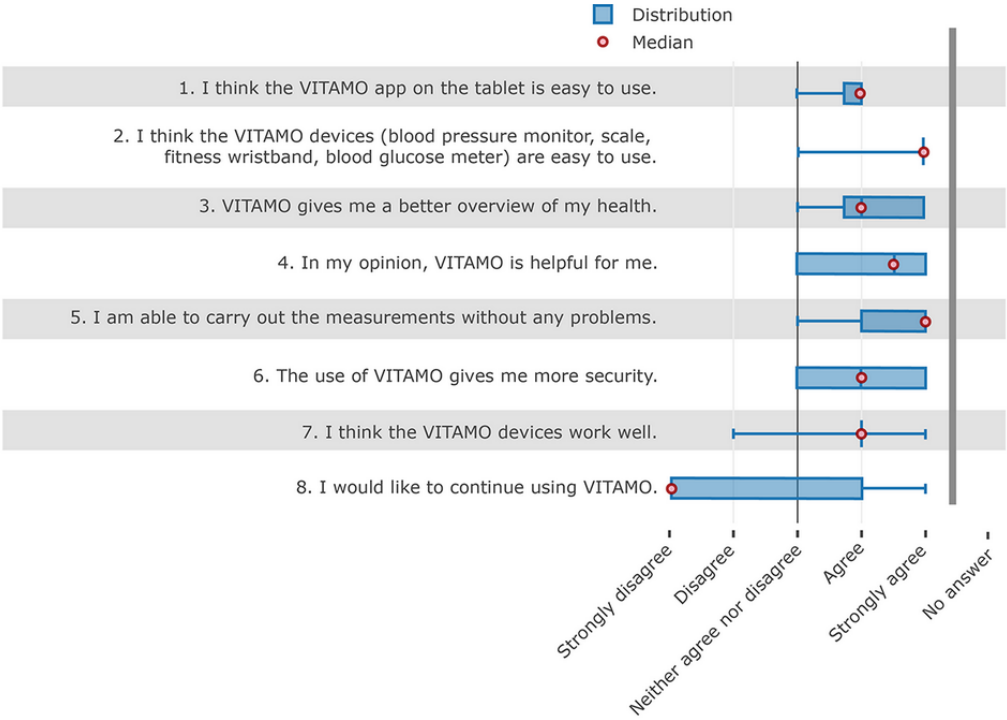
Figure 3. Results of the evaluation survey completed by the participating patients at the end of the pilot phase.



On average, the patients also agreed that the system gives them a better overview of their health status and the system was helpful for them. The participants also stated that the system gives them more security in daily life. It is noticeable that none of the participants assessed the system negatively according to whether it aided functionality (see Figure 3, items 3, 4, and 6).

Further, there were no problems in carrying out measurements with the system. The functioning of the devices was assessed similarly, although greater distribution was observed in the responses (see Figure 3, items 5 and 7).

Although the overall rating by the patients was very positive, the primary question about further use of the system was answered negatively by the majority of patients. The boxplot shows that the answers to this question had the most spread. According to these results, no general conclusion can be derived regarding further use of the system. Patients who had indicated that they wanted to continue using the system felt safer by using the system and stated that the devices worked well. Although half of those who did not want to continue using the system found it very helpful, except for one patient, they did not feel any additional security. According to the open questions, one patient found that VITAMO was very helpful and he felt safer having the system, but he did not want to use it any longer. He also stated that the devices did not always work properly, which might have resulted from a lack of awareness of the distance limitation of BLE transmission. Nurses stated that some patients separated their tablet from the devices in different rooms. Another point that might have led to increased rejection of using the system was that some patients already owned devices for measuring vital functions they were familiar with and thus did not want to change to new devices.

The evaluation of the nursing staff questionnaire was based on the categories of TAM. Thus, the following evaluation was split into the defined TAM categories. All 8 nurse participants returned the questionnaire.

The results of the questions for general attitudes toward IT show that employees were basically familiar with ICT and also used it during their work, but there was no experience with systems for vital parameter monitoring (see Figure 4).

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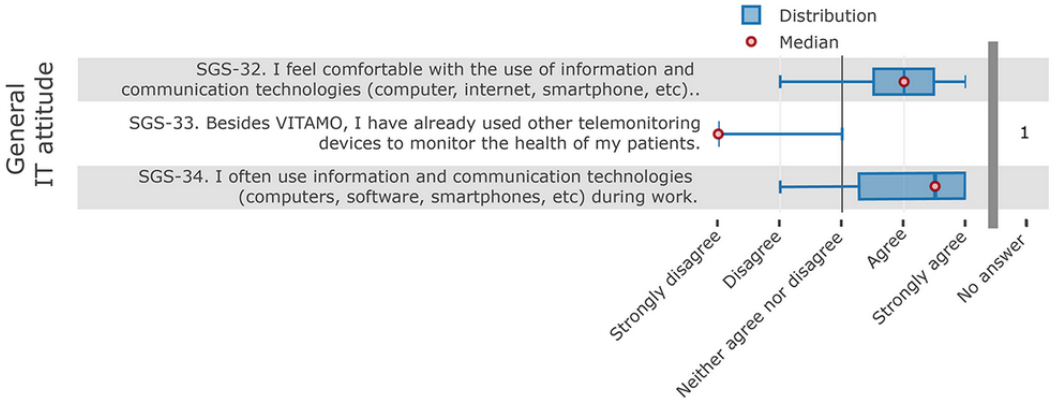
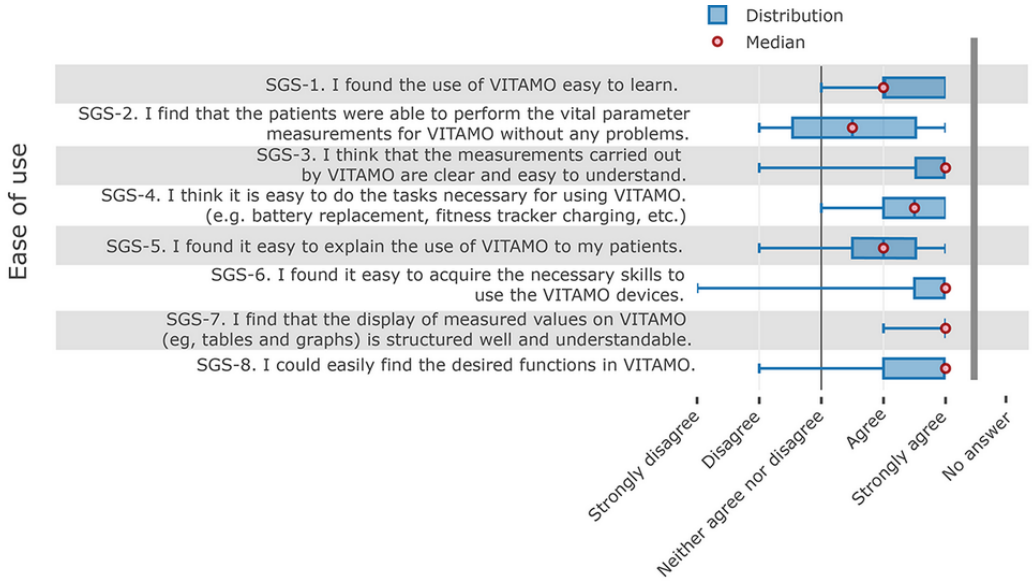
Figure 4. Nurses' responses to the questions about their general attitude towards information technology (IT).



The results from the system's "ease of use" questions show that VITAMO was consistently perceived as rather easy to use (Figure 5). It was easy to learn for the nurses and easy to explain to patients. The resulting vital measurements were also presented clearly, concisely, and comprehensibly. These statements also conform with the results of the group discussion (see section Qualitative Results: Survey), where the simple and clear user interface was positively rated by the nursing staff.

Figure 5. Nurses' responses about the ease of use of the system.



In contrast, the analysis of the perceived usefulness showed a broader distribution of responses and generally a significantly weaker result in terms of acceptance. In particular, the answers to the topics regarding its usefulness for everyday care (see Figure 6, items SGS-11, SGS-16, SGS-17, and SGS-18) revealed that VITAMO did not bring any convincing benefits for everyday care.

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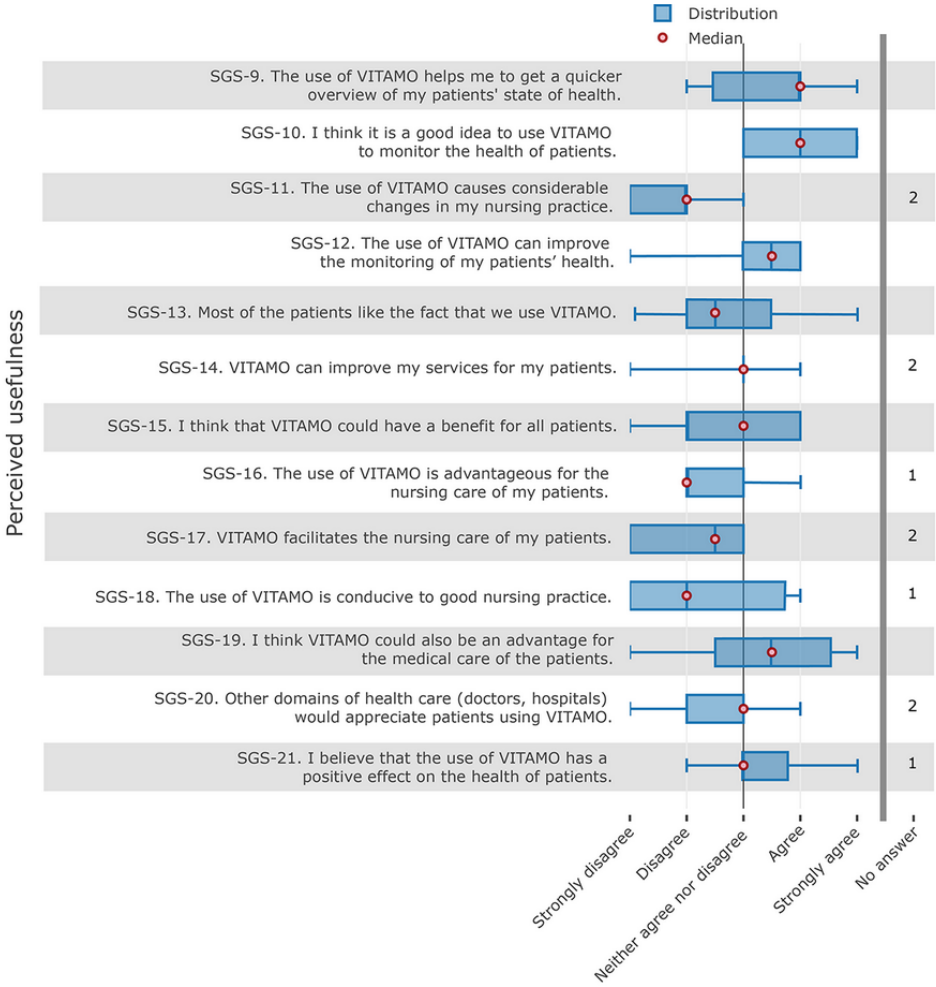
Figure 6. Nurses' responses about the perceived usefulness of the system.



There were inconsistencies in the answers to other questions. For example, nurses agreed on the benefits of getting a quicker overview of the patients' health status or for monitoring the patients' health status (see Figure 6, items SGS-9 and SGS-10). Concerning the direct nursing benefits for the patients, nurses' answers were slightly negative (see Figure 6, items SGS-15, SGS-16, and SGS-17).

The number of "no information" responses selected in the "perceived usefulness" category (n=11) was also higher than for the other categories (total for all other categories, n=5).

Further results on the acceptance and usability were derived from the interview, which are reported in the next section.

The "attitude towards using" category is influenced by perceived usefulness and the ease of use. Thus, telemonitoring is generally welcomed as a future trend (Figure 7, item SGS-27) and such a system is not regarded as a disturbance (Figure 7, item SGS-28). Furthermore, although the use of VITAMO to monitor the health status of patients is regarded as rather interesting, VITAMO could not lead to a more efficient daily nursing routine, according to the participating nurses, which supports the results from the "perceived usefulness" category.

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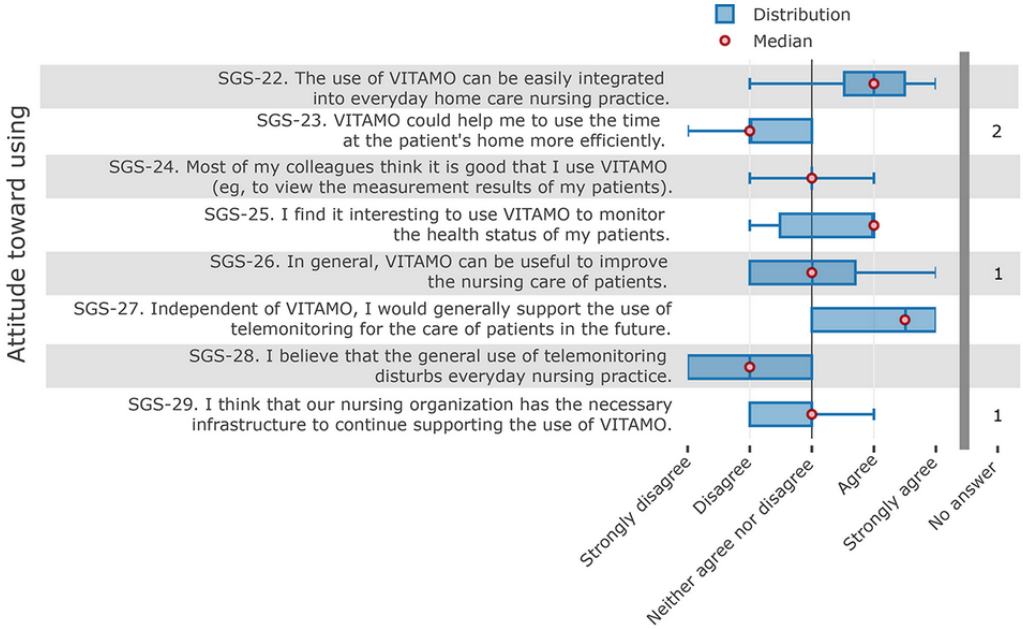
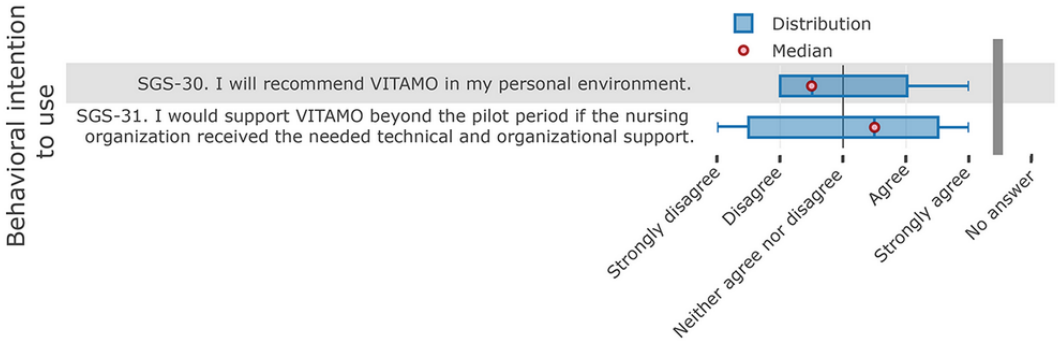
Figure 7. Nurses' attitudes toward using the system.



Following the TAM approach, the "behavioral intention to use" (see Figure 8) shows a discrepancy in the answers. According to the analysis, nurses are somewhat reluctant to recommend VITAMO; however, when the nursing organization receives the needed support, the participating nurses would support the continuity of VITAMO.

Figure 8. Nurses' responses about their behavioral intention to use the system.



Interview

The interview was semistructured and contained open questions, which qualitatively investigated the experiences and opinions of the nurses regarding technical, social, and financial aspects of the pilot study. Notes were taken by the interviewing author for further analysis of the answers. According to the nurses, the software on the tablet and in the web browser was straightforward to use for both nurses and patients. The graphical interface of the system was very appealing, and the graphical representations (eg, trends in blood pressure) were perceived as easy to understand. The tablet was not always easy to use. For some patients, the tiny keys on the side tablet were pressed unintentionally, and the tablet was switched off, which did not influence the overall system but created doubt for the patient on the proper use.

One patient, in particular, had problems with the capacitive touch screen because it did not react to inputs or only with difficulty. According to the nurses, this was presumably due to calluses on the fingers because for a different person it worked as intended; however, the precise reason could not be identified. According to the nurses, patients liked the fact that they did not need much interaction with the tablet to use the system. Thus, one patient no longer used the tablet throughout the test period because the measurements were automatically transferred to the nurses without any tablet interaction.

Uncertainty among the patients was initiated by the Android update message, which was displayed on the screen at regular intervals. During the test phase, it was recommended not to install this update and to postpone it in order to not influence the proper function of the VITAMO app during the pilot phase. Some patients had doubts about doing something wrong by not installing the updates, but it was not possible to disable the Android notification.

The staff rarely had to help the patients with executing the vital sign measurements, except for the blood glucose meter, which required a higher degree of fine motor skills from the patients due to its small size (especially the small test strips). Although patients had problems closing and opening the blood pressure monitor in the beginning, assistance with measuring blood pressure was reduced over time. The fitness tracker was

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criticized for its cumbersome charging (the charger was difficult to mount on the device) and the poor display (brightness was too low, so that the display could rarely be read outdoors). However, proper functioning of the fitness tracker for VITAMO required no direct user interaction with the device. Therefore, the bad display quality had no effect on the measurement results. The weight scale worked without any problems to measure weight. However, the additional function for body composition analysis did not always provide results, even though all provisions were met.

According to the participants, reminders were not used for the patients due to the lack of demand, but reminders were created for the test set, which was also executed accordingly.

Training the patients for the devices was not perceived as time-consuming; all patients were already familiar with vital sign measurements before the pilot study. Due to minor problems with the equipment (especially the tablet, scale, and fitness tracker), additional visits for the patients were necessary, especially at the beginning of the pilot test.

In the interview, the nurses also criticized the limited distance of Bluetooth transmission. However, according to the requirements, the decision to use low distance transmission standards was deliberate as this is common to existing and available products, especially for wearables and smart devices with low power consumption.

The telephone function caused problems with the local IT infrastructure through firewall configurations of the nursing organization at the beginning of the pilot, and a working implementation at the workstation could only be provided at the end of the pilot phase. Thus, a proper evaluation for the telephone function was not considered. As the call was displayed on the tablet or PC, the patients were called back through regular telephone when they tried to use the call function. The actual reasons for calls were mostly related to questions regarding the VITAMO system (eg, transmission errors). According to the nurses, video telephony would also be very interesting and desirable. This function was implemented in VITAMO but could not be activated due to limitations with the transmission of telephone calls through the available internet connection.

According to the nurses, the patients were interested in the devices and conducted the measurements regularly, which confirms the log results in Figure 1. The patients wore the fitness tracker continuously during day and night except for one patient who refused to use the fitness tracker.

The pilot phase showed that incorrect measurements resulting in erroneous data transmission led to uncertainty among the patients, even if the missing measurement results were transmitted automatically or with the next measurement. According to the nurses, it would have been good to provide technical training to the patients to avoid fear (eg, when unimportant but unpreventable system messages occur). The patients also had different expectations from the pilot phase: Some assumed that the system is a final, commercial product that would work as such (eg, no erroneous transmissions), but this could not be guaranteed for this prototype implementation.

No concerns or comments were stated from the patients' families regarding the use of VITAMO. According to the interviews, the nursing organization would also consider the integration of relatives in VITAMO to be useful (eg, to allow relatives to access vital sign measurements).

VITAMO was used by nurses to see the patient's vital parameters during the pilot phase. The frequency of use declined over time in the pilot phase, according to the results of the log analysis. As revealed from the interview, constant monitoring of the vital parameters was not considered necessary for the participating patients due to their rather good state of health. Thus, it was not possible to characterize any additional benefit for monitoring vital parameters via mobile care. Some of the nurses discussed the values with the patients at home during their regular visits.

Some patients also took the measurement results when visiting their primary physician. Different reactions were observed from physicians, ranging from a discussion of the measurement values to a full rejection of a more detailed analysis. However, the impact of VITAMO on other caregiving providers was not part of the present study.

The nurses evaluated the developer support as very good. In addition, the VITAMO system was always accessible, and no downtimes were noticed according to the nurses, which also confirms the log analysis with a server uptime of nearly 100% and about 3 minutes downtime in general caused by the continuous app updates (no longer than seconds for one update). The measured values from the devices were not always immediately visible on the tablet (due to erroneous transmissions), but the system managed to successfully transmit all measured data, even though it was sometimes delayed. During the pilot phase, two VITAMO software updates were installed, but they were not perceived as disturbing or sometimes not even recognized at all.

According to the interviews, the measurement results would be particularly interesting for the nurses. However, the accuracy of the step and sleep activity in particular needs to be interpreted carefully, as the fitness trackers did not provide any measurement accuracy details. This was also determined via the test sets, such as when the fitness tracker recorded too many steps. Any health care–related evaluation was not part of the present study and was not considered for further analysis.

In addition to the problems with the system identified during the pilot test, the nurses provided further suggestions for improvement. A possibility for a (limited) multimedia offering on the tablet would be desirable, which could contain the daily newspaper, obituaries, or videos.

Regardless of the technical implementation of the system and pilot study, participating nurses critically noted that a more specific nursing focus of the project or the VITAMO system would have been desirable. Therefore, more exceptional nursing benefits could have been achieved. According to the nurses, a more extended project period would have been desirable, but only when more precise nursing scenarios were described.

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Discussion

Overview

This paper investigated the technical implementation and acceptance of the telemonitoring system VITAMO, which is intended for use in rural areas and to support mobile care organizations. The focus of the present work was to plan and conduct the field test and evaluate the impact of the developed system on the mobile nursing organization.

The methodology followed the idea of using gathered requirements for creating a suitable concept for supporting mobile nursing. This concept was implemented as a prototype by adhering to defined use cases of mobile care and utilizing existing mobile technology. The implementation followed an agile approach, first developing a working prototype and using this prototype to start the field test. During development and field testing, close collaboration with nurses enabled us to continuously integrate feedback into software updates. The release cycle was determined dynamically, but new versions were usually released every 2 weeks. This agile methodology also considered the fact that further requirements arose or changed during actual use in the field. Following such an approach [12], it was possible to react quickly and efficiently to the changed requirements and continue the test with an updated and stable system. This provided benefits not only for the developer related to continuous feedback on the needs and bugs but also for the end users as they received continuous support and prompt updates.

The combination of quantitative analysis through log inspection and qualitative analysis through the TAM was used to evaluate the results from different perspectives.

The 103-day pilot phase evaluated the prototype system in a real-world environment. The sample of participants was limited to patients of the SGS Reutte. The sample of nurses (n=8) and patients (n=6) was considered sufficient to evaluate the technology environment and feasibility of the system to support mobile nursing, as the research project was not meant to quantify the general effects of telemonitoring systems but to identify the potential of leveraging ICT in the Alpine region for mobile nursing.

Principal Findings

The evaluation of the technology environment revealed that the available mobile internet infrastructure had the potential to ensure the needed connection to the server and to share the realtime data from the vital sign measurements. For the sole data transmission of vital sign measurements, a 2G internet connection was enough. However, telephone calls and the update procedures required better internet speed. Although the data structures were designed in complex structures according to the Fast Healthcare Interoperability Resources standard [11], the emerging data volume for raw, vital signs was low, enabling real-time data synchronization over 2G.

The connection to the server via the mobile network of the tablets worked without interruptions for almost all the devices and transmission tasks in the rural region Reutte except for one tablet, which had occasional connectivity issues. This might have been caused by the automatic switching from LTE to EDGE due to low signal on LTE, which resulted in a short connection loss. However, this automatic switch at the signal borderland between reachable areas had no appreciable effects on the system as all measurements got synchronized over time, albeit not in real-time. The integration of the patient's home Wi-Fi might be a valuable alternative to mobile internet connectivity, especially for regions with low mobile internet connectivity. This would especially be beneficial when the system might be extended with multimedia or communication services, which would result in insufficient available mobile bandwidth.

The evaluation of the patients' utilization of the system mainly consisted of the app's dashboard, which contains an overview of all the most recently determined vital sign measurements. The detail views on each measurement type were rarely accessed. This also conforms with the positive feedback about needing very little interaction with the system to use it. Vital sign measurements were executed by the patients at least once a day throughout the entire test period. Based on these results, VITAMO seems to create patient awareness of monitoring vital signs, and the patients welcomed the system as long as it integrated unobtrusively in their existing environment and daily life. VITAMO was developed as a mobile system because the requirements analysis revealed the advantages of such an approach [10]. The evaluation showed that a strength of the system was the uncomplicated system maintenance and management. As stated by the users, the system offered a convenient user interface through the tablet; however, if one was not interested in such information, the system did not differ from conventional vital parameter monitoring systems or devices. Thus, ambient assisted living systems that were obtrusively integrated into one's home were not considered as comparative approaches [17]. This also affirms the chosen system design, which is based on the idea of a progressive web app for both desktop and mobile platforms in combination with BLE devices [11]. The developed prototype followed the idea of always retaining a stable state; for example, with internet connection loss or Bluetooth transmission errors, measurement data were stored on the related devices and re-sent at the next successful connection. This behavior was recommended for the given setting, as the logs from the field test revealed occasional connection breaks.

The results of the nurses' and patients' attitudes towards VITAMO were predominantly positive, particularly regarding the ease of use and overall usefulness of VITAMO. The tablet was recognized as user-friendly, and the overall opinion of it was positive, even for conceivable future developments such as extending the platform with additional offers and services (eg, daily newspapers, multimedia). The usability findings agree among the different evaluation channels (ie, log analysis, survey, interview).

Despite the overall positive general and technological evaluation, patients and nurses were not convinced to keep using the VITAMO system. Regarding the reason for patients to respond this way, we made assumptions based on the evaluation findings. The participating patients already had devices to measure vital parameters (eg, blood pressure measuring device),

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and no further benefit of automated data transfer of the measurement results was recognized from the patient's point of view. Further, only patients who were able to self-measure vital signs were recruited. This means the participants must have been of good enough health to operate the devices (ie, to put on the blood pressure cuff and start the device). It should be noted that this might bias the results, as participating patients were in a health state where telemonitoring might not reveal a benefit, while people in need of the solution might benefit from it to a higher extent. Log analysis of the server records and survey results with the nurses revealed that the nurses' frequency of system use declined over time. The rather low utilization of the system by nurses might also have affected the patients' attitudes. Apart from self-monitoring of the vital parameters, the project did not include any other scenario such as in the context of using the data for direct medical treatment when visiting a physician. The nurses also expressed that they did not see any direct nursing benefit for themselves (eg, support in their daily work) regarding the continuous recording of patients' vital parameters. To identify the reasons for this attitude, a group discussion was conducted with the nurses. The discussion revealed that the nursing processes were very operational depending on the patient's needs and did not follow a strategic plan. The immediate reaction to unusual measurement results in terms of an alert was deliberately not followed because the developed prototype was not related to a medically certified product. However, the nurses were able to identify any abnormal results including the abstinence of measurements but this was not used to adapt the nursing process during the pilot test. The processes of the nursing organization did not comply with any clinical guidelines for vital sign measurements; therefore, no standardized process was utilized. As a limitation of the present study, the organizational nursing processes regarding the direct interaction between patients and nurses were not deeply analyzed. Further organizational issues occurred such as the utilization of vital signs for medical purposes, as some physicians declined to use the results. Future efforts would need to integrate health-related third-party stakeholders like physicians and relatives to infer a medical benefit. Any medical decision-making was intentionally excluded from this study because the study was intended to investigate the technical feasibility and its impact on mobile care. To use the results to investigate the medical impact on patient outcomes, a bigger sample size is necessary.

The evaluation showed that both patients and nurses recognize the potential of telemedical applications in mobile home care. They also found the technical prototype implementation to be useful in mobile care. Various other projects are reporting valuable benefits on patient outcomes and reduced cost through the use of telemonitoring systems [18-21]. Further investigations of at-home telemonitoring applications have revealed reduced hospital admissions, length of stay, and mortality rates [22].

The evaluation results of VITAMO showed that the home care organization tends to be open to technology support and telemonitoring is perceived as easy to learn and use. However, meaningful use or importance of overcoming future critical developments was not recognized. This is also reflected in the weekly patient access statistics and interview results. Besides, some of the functions such as the reminder function were only used for some tests but not included in real scenarios, although requirements engineering revealed the need for such a feature. This further revealed an inconsistency in the first set of use cases of the project that were motivated through the established nursing processes.

To fully evaluate the acceptance of a telemonitoring system such as VITAMO, users (patients and nurses) need to be aware of the organizational progression and its effects on the care processes. Recent studies have highlighted the essential requirements for supportive telemonitoring ICT to adapt to existing processes [23,24]. However, the results of this study prove the necessity of establishing a compact structure of organizational processes and their aims. These findings could contribute to further investigations on care delivery processes to evaluate the effects on adapting and supporting such processes with ICT.

Conclusions

The present study proves the technical feasibility and user acceptance of using telemonitoring to support mobile nursing even in rural regions such as the Alpine region. The critical impact of demographic changes on the need for home care has already been investigated through several research approaches, and technology has the potential to provide the necessary environment to develop meaningful solutions. Related solutions for mobile care need to leverage new technologies for both hardware (eg, the Internet of Things) and software (eg, progressive web apps). However, the intended stakeholders need to have well-organized, fully aware strategic and interconnected processes to benefit from such ICT solutions in the long term.

Acknowledgments

We would like to acknowledge the mobile nursing organization SGS Reutte for participation and contribution. Further, we would like to acknowledge the Tyrolean Government for the organization and provision of funds for conducting this study. This work was funded by the Tyrolean Government (Land Tirol).

Conflicts of Interest

None declared.

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Abbreviations

BLE: Bluetooth Low Energy
ICT: information and communication technology
INTESI: Integrated territorial strategies for Services of General Interest
IT: information technology
LTE: Long-Term Evolution.

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SGI: service of general interest
TAM: Technology Acceptance Model
VITAMO: VITAl parameter MOnitoring

Edited by E Borycki; submitted 19.11.19; peer-reviewed by P Weber, B Celler, B Sellemann, M Hawley, N Georgi; comments to author 10.12.19; revised version received 02.02.20; accepted 05.03.20; published 23.04.20.

Please cite as:
Schweitzer M, Huber L, Gorfer T, Hörbst A
Experiences With Developing and Using Vital Sign Telemonitoring to Support Mobile Nursing in Rural Regions: Feasibility and Usability Study
JMIR Nursing 2020;3(1):e17113
URL: https://nursing.jmir.org/2020/1/e17113/
doi:10.2196/17113
PMID:

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Original Paper

How the Integration of Telehealth and Coordinated Care Approaches Impact Health Care Service Organization Structure and Ethos: Mixed Methods Study

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Abstract

Background: Coordinated care and telehealth services have the potential to deliver quality care to chronically ill patients. They can both reduce the economic burden of chronic care and maximize the delivery of clinical services. Such services require new behaviors, routines, and ways of working to improve health outcomes, administrative efficiency, cost-effectiveness, and user (patient and health professional) experience.

Objective: The aim of this study was to assess how health care organization setup influences the perceptions and experience of service managers and frontline staff during the development and deployment of integrated care with and without telehealth.

Methods: As part of a multinational project exploring the use of coordinated care and telehealth, questionnaires were sent to service managers and frontline practitioners. These questionnaires gathered quantitative and qualitative data related to organizational issues in the implementation of coordinated care and telehealth. Three analytical stages were followed: (1) preliminary analysis for a direct comparison of the responses of service managers and frontline staff to a range of organizational issues, (2) secondary analysis to establish statistically significant relationships between baseline and follow-up questionnaires, and (3) thematic analysis of free-text responses of service managers and frontline staff.

Results: Both frontline practitioners and managers highlighted that training, tailored to the needs of different professional groups and staff grades, was a crucial element in the successful implementation of new services. Frontline staff were markedly less positive than managers in their views regarding the responsiveness of their organization and the pace of change.

Conclusions: The data provide evidence that the setup of health care services is positively associated with outcomes in several areas, particularly tailored staff training, rewards for good service, staff satisfaction, and patient involvement.

(JMIR Nursing 2020;3(1):e20282) doi:10.2196/20282

KEYWORDS

coordinated care; telehealth; health care organization; staff engagement; staff training

Introduction

Health care services face escalating demands in managing chronic conditions due to significant demographic changes as the population ages, along with increased levels of obesity and sedentary lifestyles [1,2]. One response to these increased pressures is to enhance the level of coordination and integration between different health/social care agencies and staff to

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improve patient care and maximize value for money [3]. Coordinated care has been defined as the deliberate organization of patient care between health and other services to facilitate the appropriate delivery of health care services [4].

Telehealth and telecare are assistive technologies that are increasingly used to support the coordinated care of patients with social care needs or chronic conditions such as diabetes and heart disease. With the advent of COVID-19, the vital role of telehealth in both health emergencies and usual health care delivery has been further highlighted. The use of remote triaging for care and video consultations for disease diagnosis now appear to be indispensable; however, the adoption of telehealth remains limited and variable [5]. These technologies enable exchanges of information between agencies, remote monitoring of health status, and have the potential to facilitate greater independence to ultimately reduce hospital visits and improve outcomes [6-8]. In particular, telehealth has the potential to support the close working of health and social care systems, which is particularly important for the management of elderly patients [9,10].

In reality, however, the potential benefits of integration are rarely achieved, and the delivery of care is often a "loosely coupled" system. The difficulties of achieving integration are due to a number of factors, including increased marketization, lack of managerial knowledge, shortage of care workers, and underfunded social care services [11]. Tuckson et al [12] noted the key trends that will influence the growth of telehealth care delivery, including: continuous innovation in consumer technology, continuous advancement in electronic health records and clinical decision support systems, projected shortages in the health professional workforce, and the growth of consumerism in health care.

As health services evolve to better manage patients using coordinated care approaches and monitoring technologies, staff are required to work in new ways and expand their roles. One key requirement for the success of these initiatives is the involvement of all staff so that they understand not only what is required of them but also that they consider their own stake in the system by having the opportunity to contribute their own ideas. At the same time, clinicians are expected not only to be engaged but also to lead throughout the process [13]. The need for engagement often provides a barrier to true coordination and integration. Although the fundamental importance of multidisciplinary teamwork is acknowledged [14,15], research suggests a "surprising lack of clarity" regarding purpose, objectives, leadership, and performance in many such teams [16]. A qualitative study of UK health professionals working in clinics, hospitals, pharmacies, and surgeries found that they were hampered by a lack of experience and concerns over losing face-to-face contact and missing key care information [17]. Efforts are being made to address these problems; for example, the Interprofessional Teamwork Innovation Model has been shown to facilitate a collaborative environment, enhance communication, and save time [18].

Other models have made explicit the link of good teamwork and effectiveness with innovation in health care delivery [19], and emphasized that engaged staff deliver a better experience for patients, have higher levels of morale, and make fewer errors [20]. To achieve this, health services are challenged to move from a model of "heroic leadership" [21] and traditional care delivery within "specialist silos" [22] to benefit from a positive relationship between shared leadership and team performance [23], with the goal of developing more integrated systems of care and a network of partnerships between services. The COVID-19 pandemic has forced health systems, hospitals, and clinics to implement telehealth rapidly; however, the challenge remains to support health care professionals in such a rapidly changing environment [24].

The current study was carried out as part of the Advancing Care Coordination and Telehealth (ACT) program [25,26], which investigated how health services are designed and configured to implement coordinated care and telehealth approaches. The ACT program explores the organizational and structural processes needed to implement coordinated care services on a large scale, and provides a foundation to overcome current barriers for extensive adoption of telehealth and coordinated care. Five European Union regions worked together to identify best practice in terms of scaling up coordinated care: Basque Country, Scotland, Lombardy, Groningen, and Catalonia. A key driver of the ACT program was to consider the attitudes, perceptions, and role of staff and their engagement in the deployment and configuration of services. Therefore, the key aim of the present study was to understand how the organizational setup influences the perceptions and experience of service managers and frontline staff during the development and deployment of integrated care with and without telehealth.

Methods

Study Design

Five diverse health services agreed to participate in the study, each of which differed in size and treated a wide range of health conditions. Most of these services were designed for older populations for the care of long-term chronic conditions, and incorporated either or both telehealth and coordinated care approaches. A convenience sampling approach was followed; to be included in the study, each service had to use either or both telehealth and coordinated care. To understand the content and structure of the health services under study, a three-stage mixed methodology was used. A quantitative, descriptive baseline questionnaire was completed by service managers to understand the structure and purpose of each European health service. This allowed for the development of a more targeted questionnaire, completed by both service managers and frontline staff, collecting both quantitative data and qualitative responses.

Questionnaires were developed iteratively and reviewed by health care representatives of each European region as part of regular meetings with the ACT program consortia. A concise set of questions was then developed to assess levels of engagement, perceptions, and experience of staff working within the specific health care contexts. Each question was rated on a Likert scale (strongly agree, agree, no opinion, disagree, strongly disagree), followed by open-ended questions allowing staff to describe their experiences in their own words. Topics included changes to daily activities, professional status, the role of

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telehealth and coordinated care in services, long-term vision, the role of feedback, and extent of training. Questionnaires were deployed using participants' first language, with free-text responses translated prior to analysis.

Analytical Approach

Three analytical stages were followed: (1) preliminary analysis allowing for a direct comparison of responses of service managers and frontline staff to a range of organizational issues, (2) analysis to establish statistically significant relationships between baseline and follow-up questionnaires; and (3) systematic examination of free-text responses of service managers and frontline staff using qualitative thematic analysis.

Statistical analysis was undertaken to investigate the relationship between baseline questionnaire responses that described the services and follow-up questions asked to frontline staff. The nonparametric Mann-Whitney *U* test was used to compare categorical (baseline) and continuous (follow-up questionnaire Likert scales) variables. Significance was set at $P<.05$. Only statistically significant results are reported in this paper. A thematic analysis of the follow-up questionnaire free-text responses was conducted to provide further insight into the findings. The three analytical stages allowed for gaining an overall understanding of each health service participating in the study, the degree to which service managers and frontline staff were in alignment with their views, and a more detailed examination of their views regarding key issues.

Results

Response Rates

Table 1 shows the response rates for service managers and frontline staff. The overall response rate was 78% for service managers and 47% for frontline staff, with the highest response rate for service managers and frontline staff combined from the Basque Country (88%), Spain, and the lowest from Groningen, Netherlands (55.5%).

Table 1. Response rates by regions and service level.

Program	Service Managers		Frontline Staff	
	Target	% Response rate	Target	% Response rate
Basque Country (Spain)	6	100	141	76
Catalonia (Spain)	7	57	35	80
Groningen (Netherlands)	4	100	161	11
Lombardy (Italy)	12	66	109	52
West-Lothian (Scotland)	3	100	29	44
All programs	32	78	475	47

Staff Roles in Health Care Services

Table 2 summarizes the responses of frontline staff with respect to the importance of their role and change in their activities, categorized according to their own project managers' responses to the baseline questions. Several factors were found to contribute significantly to frontline staff reporting that their importance within their organization had changed, including the tailoring of training ($P<.001$), existence of a strategy to share benefits ($P=.02$), regular evaluation of staff satisfaction of the service ($P=.01$), support for the service ($P=.046$), rewards for good service ($P=.003$), and involvement of patients in coordinated care ($P=.04$). The frontline staff statement describing daily activities changing significantly since the introduction of a service was positively associated with one service manager question: "Is the content and methods of training tailored to the needs of different professional groups and staff grades?" ($P=.002$).

The free-text responses illustrated how the roles of health professionals are changing. Staff described working with the same criteria, working in a coordinated manner, and using shared medical records, resulting in more efficient care: "To do more with less hours" [frontline staff, Groningen]. Giving more responsibility to different health professionals was linked to a sense of being valued and an increase in status. Staff perceived a decrease in hospital admissions and emergency room visits, thereby optimizing resources. An integrated service approach was viewed as facilitating enhanced control of chronic diseases; extra support by case managers; opportunity to provide more coherent, integral, and individual care; and increased monitoring. There was the possibility of earlier intervention and therefore more proactive treatment, "without having to go through the hoops of all specialties" [frontline staff, Catalonia]. Older adults were more empowered, reducing frailty, enabling people to live on their own for as long as possible:

> *In general I think that the program gives security to the professionals when making decisions; the patient feels more accompanied, improving his or her perception of quality of care and quality of life, and for the organization, it optimizes resources and improves efficiency, efficacy and care.* [frontline staff, Catalonia]

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Table 2. Responses of frontline staff and service managers with respect to the role of staff in organization.[a]

Question	Yes (mean)	No (mean)	*P* value
Frontline staff statement: My importance within the organization has been raised because of this service			
Are the content and methods of training tailored to the needs of different professional groups and staff grades (ie, senior/junior medical staff?)	3.59	3.07	<.001
Is there a strategy to capture and share examples of benefits or helpful working practices?	3.28	3.70	.02
Is staff satisfaction of your service evaluated regularly?	3.62	3.24	.01
Has there been support for your service?	3.32	3.82	.046
Are rewards given for good service?	4.25	3.32	.003
Are patients involved in coordinated care?	3.39	3.06	.04
Frontline staff statement: My day-to-day activities have changed significantly as a result of this service			
Are the content and methods of training tailored to the needs of different professional groups and staff grades (ie, senior/junior medical staff?)	3.82	3.47	.002

[a]Frontline staff responses are rated on a 5-point continuous Likert scale (1= strongly agree, 5=strongly disagree), which are presented according to the binary service manager response (yes/no).

Success in engaging staff and ensuring they felt valued entailed ensuring that messages reached all staff groups and that staff were able to give feedback regarding service development, enabling them to monitor progress and be party to the views of other stakeholders. Of particular importance, according to the free-text responses, was ensuring that the benefits of health care services were communicated and that technology was utilized to establish productive working relationships between different professional teams, for example using videoconferencing sessions between clinics.

Staff Views of Organization: Organizational Responsiveness

Table 3 summarizes the frontline staff responses according to their own service managers' responses to baseline questions regarding organizational change and organizational responsiveness. Several factors contributed significantly to frontline staff reporting that their organization had changed for the better as a result of the introduction of their service. These were tailored training according to staff need ($P<.001$), the use of a strategy to share examples of benefits and good practice ($P=.045$), regular staff evaluation of their service ($P<.001$), rewards for good service ($P=.04$), patient involvement in coordinated care ($P=.02$), a new role in their organization for coordinated care in their service ($P=.004$), and the existence of a business model to support the organizational structures involved in the provision of telehealth ($P=.046$). Two factors contributed significantly to frontline staff agreeing that their organization is responsive to feedback and change: tailored training according to staff experience and need ($P<.001$) and regular evaluation of staff satisfaction of their service ($P<.001$).

A perception of significant organizational change was reported in the free-text responses where health care services were considered to have adopted a patient-centered health care model and a shared decision-making approach, coupled with the decision to invest in a service. Thereafter, there had to be an "acceptance of the need to work in new ways and deliver care nearer to patients in their own home, expanded roles, skills of staff, and blurring of professional boundaries" [service manager, Scotland]. Expanded roles could also be seen elsewhere as an agent for change. For example, where general practitioners had "modified their way to manage chronic patients by proactive medicine" [service manager, Lombardy].

In terms of telehealth/telecare implementation, one service had adapted with the formation of a team to deal with requests for access to telecare into a wider "care at home service," allowing a streamlined approach to support hospital discharge. Another service manager reported a "seamless" adoption due to additional services offered by general practitioner offices alongside telemedicine services, coupled with the "adequate training" of staff [service manager, Lombardy]. Elsewhere, change was observed in the ways in which staff work more than changes in the organization itself:

> *There is a paradigm shift in the care model that is catching on the staff. Although the organization still has some way to adjust the ways of working and evaluating their services to this shift in delivery. There is much work ahead.* [service manager, Basque Country]
>
> *It's difficult to change in a short time the way to work, so it's a long process that we're doing but it's not finished.* [service manager, Lombardy]

Change was perceived to be gradual, incremental, and iterative, and was also restricted by the nature of services. For example, with pilot programs, change is restricted due to a narrower focus, and a shorter timeframe and scale of a project.

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Table 3. Frontline staff and service manager views of organization.[a]

Question	Yes (mean)	No (mean)	*P* value
Frontline staff statement: The organization has changed for the better as a result of the program			
Are the content and methods of training tailored to the needs of different professional groups and staff grades (ie, senior/junior medical staff?)	3.87	3.43	.001
Is there a strategy to capture and share examples of benefits or helpful working practices?	3.60	3.95	.045
Is staff satisfaction of your service evaluated regularly?	4.09	3.50	<.001
Are rewards given for good service?	4.25	3.62	.04
Are patients involved in coordinated care?	3.72	3.37	.02
Is there a new role or function in the organization for coordination of care in your service?	3.56	4.13	.004
Is there a business model to support organizational structures involved in the provision of telehealth?	4.22	3.68	.046
Frontline staff statement: The organization is responsive to feedback and changes occur quickly			
Is the content and methods of training tailored to the needs of different professional groups and staff grades (ie, senior/junior medical staff)?	3.47	2.97	.001
Is staff satisfaction of your service evaluated regularly?	3.66	3.07	<.001

[a]Frontline staff responses are rated on a 5-point continuous Likert scale (1= strongly agree, 5=strongly disagree), which are presented according to the binary service manager response (yes/no).

Organizational Commitment to Broadening Services

Table 4 summarizes the views of frontline staff regarding their organization incorporating telehealth and/or coordinated care, categorized according to their own service manager's responses to baseline questions. The factors contributing significantly to frontline staff views were: tailored training for different staff groups (*P*=.006), rewards for good service (*P*=.004), patient involvement in coordinated care (*P*=.006), use of financial incentives to encourage telehealth adoption (*P*=.007), use of financial incentives for positive outcomes (*P*=.002), and adhering to a business model to facilitate financial alignment and incentives (*P*=.03).

In the free-text responses, frontline staff commented on how coordinated care approaches were benefitting their patients. They described how patients were more supported, such as when they are assigned a contact person (eg, a case manager) who guided them through the service. This improved their overall experience of care markedly:

> *The service is truly patient-centered and provided within the patient's own home with their family and carers around them. This avoids the distress experienced during a hospital admission and the exposure to the risk of hospital acquired infection. The patients, when asked, express home treatment as their preference in most cases.* [frontline staff, Scotland]

When sufficiently trained and rewarded, staff were more likely to view coordinated care approaches as fostering relationships between different care providers such as nursing home staff, primary care, and hospitals, or better cooperation between general practitioners, district nurses, and elderly medicine specialists in order to provide better care:

> *To provide specialized care for people with complex needs by offering coordination with specialized care teams.* [frontline staff, Catalonia]

> *For myself, the most positive elements are that everyone involved are working together for the good of the service user and organization. Everyone is working as one* [frontline staff, Scotland]

Staff commented positively on the value of new technologies in health care, both for patients and frontline staff: "Being able to respond quickly to emergencies and [provide] reassurance for users" [frontline staff, Scotland]; "Telecare is adaptable and centered around the individual—it is less intrusive. It provides reassurance for individuals and their families" [frontline staff, Scotland].

Where there was also shown to be a strong business case, telehealth/telecare was seen to cut costs and reduce hospital visits.

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Table 4. Frontline staff and service manager responses to organizational commitment.[a]

Question	Yes (mean)	No (mean)	*P* value
Frontline staff statement: The organization wishes all appropriate clinical services to include telehealth and/or coordinated care			
Are the content and methods of training tailored to the needs of different professional groups and staff grades (ie, senior/junior medical staff?)	3.91	3.62	.006
Are rewards given for good service?	4.44	3.37	.004
Are patients involved in coordinated care?	3.82	3.52	.006
Are there financial incentives to use telehealth?	3.46	4.11	.007
Are financial incentives related to outcomes?	3.46	4.25	.002
Is there a business model to facilitate financial alignment/ incentives	3.46	3.96	.03

[a]Frontline staff responses are rated on a 5-point continuous Likert scale (1= strongly agree, 5=strongly disagree), which are presented according to the binary service manager response (yes/no).

Future Role of Organization

Table 5 summarizes the frontline staff responses to three questions regarding the future role of the organization categorized according to their own service managers' responses to baseline questions. Two factors contributed significantly to frontline staff reporting that telehealth/coordinated care was an important aspect of future initiatives to improve health care delivery: use of rewards for good service (P=.05) and the involvement of patients in coordinated care (P<.001). Three factors contributed significantly to frontline staff agreeing that there is recognition that the approach of their service is the future direction for their organization: the use of tailored training (P<.001), the existence of a guideline or protocol (P=.047), and barriers to implementing the service (P<.001). Two factors contributed significantly to frontline staff reporting that everyone recognizes that the approach of their service will bring long-term benefits: tailored training for different professional groups (P<.002) and regular evaluation of awareness of their service amongst staff (P=.046).

Table 5. Frontline staff and service manager responses to the future role of organization.[a]

Question	Yes	No	*P* value
Frontline staff statement: Telehealth/coordinated care is an important aspect of future initiatives to improve care delivery			
Are rewards given for good service?	4.56	4.11	.05
Are patients involved in coordinated care?	4.24	3.67	<.001
Frontline staff statement: Everyone recognizes that the approach of this service is the future direction of the organization			
Are the content and methods of training tailored to the needs of different professional groups and staff grades (ie, senior/junior medical staff?)	3.78	3.36	.001
Is there a guideline or protocol?	3.51	3.81	.047
Were there any barriers to implementing the service?	3.58	3.57	<.001
Frontline staff statement: Everyone recognizes that the approach of this service will bring long-term benefits			
Are the content and methods of training tailored to the needs of different professional groups and staff grades (ie, senior/junior medical staff?)	3.83	3.44	.002
Is staff awareness of your service evaluated regularly?	3.73	3.43	.046

[a]Frontline staff responses are rated on a 5-point continuous Likert scale (1= strongly agree, 5=strongly disagree), which are presented according to the binary service manager response (yes/no).

The free-text responses suggest that all service managers viewed their service(s) as fitting in with the broader health care aims and objectives of their organization, such as having electronic patient records for the whole population, or in a more overarching sense: "it enables the integration and coordination among care delivery levels in chronic diseases like heart failure" [service manager, Basque Country]; "Yes it does totally fit with the strategic plan, the social accountability, the mission and values of the organization" [service manager, Catalonia].

When asked about any negative aspects of their service, some service managers reported none, but others noted that a rush to implementation did not take into account the time required to introduce new initiatives and to ensure the involvement of a large number of professionals.

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Difference in Views Between Frontline Staff and Service Managers

Both service managers and frontline staff answered the same follow-up questionnaire statements discussed in the previous sections, allowing for a direct comparison of their views. Service managers held uniformly more positive views than frontline staff. As expected, the latter were more likely to report a significant change in their day-to-day activities when compared to the service managers. However, while the majority of service managers considered their organization to be supporting the implementation of telehealth, a significant proportion of frontline staff held no opinion, and a minority disagreed or strongly disagreed with the statement.

Service managers were more likely to view their organization as supporting coordinated care implementation, that their organization had changed as a result of a new service, that their organization wishes all clinical services to include telehealth/coordinated care, and that the approach of the service would bring long-term benefits and was the future direction of the organization. Frontline staff were markedly less positive in their views regarding the responsiveness of their organization and pace of change. Service managers and frontline staff were closer in agreement that their organization was training all staff in the implementation of a service, which was conspicuous as the single area in which both staff and managers held similar views.

Discussion

Pivotal Role of Staff Training

The quantitative data presented provides evidence that telehealth technologies are becoming increasingly embedded in frontline services. Participants considered how telehealth reassured patients and provided the opportunity for health professionals to intervene in real time, act quickly, and provide flexible care. Similarly, study participants suggest that coordinated care approaches are increasingly becoming part of daily practice. They perceived that coordinated care provided enhanced control of chronic disease and the opportunity to offer more coherent, integral, supportive, and individualized care. The findings also supported the view that coordinated care fosters relationships between different care providers such as nursing home staff, primary care hospitals, or better cooperation between the general practitioner, district nurse, and elderly medicine specialist to offer better care.

The findings clearly emphasized the importance of training, and in particular training tailored to the needs of different professional groups and staff grades involved in coordinated care or telehealth. Tailoring training was positively associated with favorable perceptions of professional status, changes in daily activities, the view that a health care organization had changed for the better, agreement that an organization wants all clinical services to include telehealth or coordinated care, and agreement that a service is the future direction of an organization. All regions reported that training had been provided to equip staff with the knowledge and skills required to deliver their coordinated care or telehealth services. Topics covered in the training varied as much as the services themselves; however, training was not always tailored to the needs of different professional groups and staff grades. To maximize benefit, training should be provided as part of telehealth and coordinated care implementation; be practical, purposeful, and timely; and encourage a patient-centered approach to foster positive patient-health care professional relationships [27].

Previous research shows that staff require not only access to appropriate resources and adequate staffing levels [16], but also an organization that supports personal development [28] and provides training aligned to staff roles to fulfill the demands of working within multidisciplinary health care teams [29]. Such support is not simply part of an initial roll out but rather an ongoing dialog between frontline professionals and managers [30] in health care settings actively promoting a learning climate [31]. Most services in this study reported that staff awareness was evaluated regularly and that those findings were acted upon.

Rewards for good service, staff satisfaction, and patient involvement in coordinated care featured prominently in this study. The former two could arguably be linked to staff training and continuing professional development. The latter is perhaps indicative of the need for all involved in the care process, including patients, to be included in the successful evolution of health services. Of note was the finding that the views of service managers were markedly more positive than those of frontline staff, suggesting that the positive messages conveyed from the top do not necessarily resonate with those working in the services. Perhaps unsurprisingly, all service managers viewed their service as fitting in with the broader health care aims and objectives of their organization, whereas frontline staff showed more variation in their responses. For effective implementation of coordinated care and telehealth, the views of these two groups of staff need to be in better alignment.

Significant perception of change was reported where health care services adopted a patient-centered health care model and a shared decision-making approach, coupled with the decision to invest in a service. Staff reported how their working practices had changed as a result of the introduction of new services. Such change was more likely to be evident among frontline staff if they had received tailored training. Change was also reported in contexts for which professionals have expanded or adapted their roles. However, the capacity for change could be restricted by the type of service, particularly smaller-scale pilots.

The qualitative, free-text responses highlighted how the roles of health professionals are changing, particularly with the use of coordinated care approaches and telehealth integrated into care pathways to optimize resources. These approaches were considered to allow for earlier intervention, proactive treatment, and independent living. Part of the considerable, but gradual, organization change, according to the responses, was the move to patient-centered health care with staff working in complex, multidisciplinary teams. This required an acceptance of the need to work together in new, innovative ways. Overall, staff viewed their services, which incorporate telehealth and coordinated care, as fitting in with the broader health care aims of their organization.

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Limitations

Both the types and the sizes of services analyzed in this study varied considerably, raising the question as to whether the integration of the data was appropriate. The current approach attempted to obtain a broad view with an intention of identifying overarching trends. Thus, it is not surprising that both service size and type were diverse, as these are Europe-wide real-life examples of the practice of integrative care. Furthermore, several services showed low response rates (Table 1), but these were nevertheless included so as to provide a comprehensive view of the range of services studied. This does produce some statistical weaknesses to the study.

The baseline and service manager questionnaires were used for descriptive analysis due to the low number of responses. The one service manager per service structure also meant that the service managers were identifiable, allowing for the possibility of respondents vetting their answers and considering the implications of making negative comments, thus resulting in bias. The baseline questionnaire was used to group (classify) the various services allowing for statistical comparisons on (intermediate) outcomes across different programs. For statistical analysis, only nonparametric testing (Mann-Whitney *U* test) was used.

Data were collected at a specific point in time, allowing for only a snapshot of experience. However, attempts were made to triangulate the different types of data collected at different time points. Limitations with terminology were also identified as part of a large pan-European study where it was assumed that terms to describe health services conveyed similar meanings across different cultural contexts. The analysis of free-text responses collected from frontline staff and service managers provide insight into the views of professionals working in the various services under study; however, it should not be considered as a comprehensive overview of the spectrum of views from all staff from all services. More in-depth qualitative studies featuring health care professionals are needed. A longitudinal study exploring the experiences of nurses and healthcare staff reported that the changes instigated due to telehealth implementation elicited a sense of threat. Such experiences, captured over time, would be unlikely to be detected in a study of this nature [32].

Evolving Services, Evolving Roles

This analysis presents a snapshot of a diverse range of European health services attesting to use coordinated care or telehealth. It also provides new insight into the challenges faced by health care organizations in terms of embracing change, integrating new technologies, and fostering closer relations between health and social services in order to meet the challenge of caring for aging populations. This then places the onus to change on staff, particularly those on the frontline. Those at the “sharp end,” who are often most aware of how problems can be addressed, can feel “powerless to bring about change” [16]. Nevertheless, health care interventions have demonstrated how small changes can generate significant improvement for patients, staff, and hospital performance [33]. Increased availability and visibility of specific health care professionals and closer working relationships between different professional groups are required, in addition to conferring greater responsibility on those required to coordinate specialist primary care teams and to case manage patients through myriad health and social services, which would help to ensure the continuity of care and appropriate utilization of resources.

Such change, both in terms of routine and emergency care [5], demands the refinement of decision-making protocols in complex care situations and defining the specific levels and intensity of care needed. Continuous feedback is required between professionals, service operators, and project teams to ensure that evolving needs are met and that change is made incrementally in addition to active participation by multidisciplinary teams in the planning, coordination, and modes of data collection within their service. For example, this may include the use of specialist discharge planners to ensure patients transit appropriately through care pathways [34], or a dedicated fund to forge integrated working of health and social care teams [13] as part of whole-systems change.

Although telehealth presents exciting opportunities for patients, carers, and health professionals, this fast-moving field demands the constant evolution and adaptation by all involved actors. As telehealth becomes more embedded and intrinsically linked with care and service delivery, so must the quality of evidence to ensure that clinicians can confidently make decisions that patients and carers will trust and adhere to [12]. This can help health services to adapt when telehealth and coordinated care approaches are most needed as we face the challenges of COVID-19 [5,24]. Staff increasingly accept the need to work in new ways and deliver care beyond conventional care settings and within patients’ homes. They are working within and between ever more fluid boundaries of health and social care; within this context, the need for specialized training tailored to staff needs is increasingly salient. This requires organizational commitment to training and development of clinical staff, not only in leadership [20] but at all levels. This will ensure that a diverse range of professional groups can deliver the highest levels of innovation in patient care [28], and consequently improve the quality, safety, and effectiveness of health care delivery [31].

Acknowledgments

The members of the ACT Program are Phillips Healthcare: Cristina Bescos, Christoph Westerteicher; Phillips Research: Steffen Pauws, Helen Schonenberg; Aristotle University of Thessaloniki: Pantelis Natsiavas, Dimitris Filos, Christos Maramis, Ioanna Chouvarda, Nicos Maglaveras; University of Hull: Samantha Nabb; IDIBAPS-Hospital Clinic Barcelona: Josep Roca; AQuAS-Agencia de Qualitat Barcelona: Joan Escarrabill, Montserrat Moharra; Imperial College London: John Cleland; Guy's and St Thomas' NHS Trust London: Nicholas Hart; Kronikgune-Centro de Investigacion en Cronicidad, Basque Country: David

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Monterde, Joana Mora, Esteban de Manuel Keenoy, Sara Ponce; University Medical Center Groningen: Erik Buskens, Maarten M H Lahr; Telbios S. p. a., Milan: Maria Romano, Marco Nalin, Ilaria Baroni; NHS 24 Scotland: Andrea Pavlickova, Jill Rasmussen; University of Würzburg: Stefan Störk, Chris Wahl.

Conflicts of Interest

None declared.

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Abbreviations

ACT: Advancing Care Coordination and Telehealth

Edited by E Borycki; submitted 15.05.20; peer-reviewed by A McLean, D Tuden, H Akram; comments to author 01.07.20; revised version received 23.08.20; accepted 27.08.20; published 09.10.20.

Please cite as:
Davidson R, Barrett DI, Rixon L, Newman S, ACT Program
How the Integration of Telehealth and Coordinated Care Approaches Impact Health Care Service Organization Structure and Ethos: Mixed Methods Study
JMIR Nursing 2020;3(1):e20282
URL: https://nursing.jmir.org/2020/1/e20282/
doi:10.2196/20282
PMID:

©Rosemary Davidson, David Ian Barrett, Lorna Rixon, Stanton Newman, ACT Program. Originally published in JMIR Nursing Informatics (https://nursing.jmir.org), 09.10.2020. This is an open-access article distributed under the terms of the Creative

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Original Paper

Experiences of Complex Patients With Telemonitoring in a Nurse-Led Model of Care: Multimethod Feasibility Study

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Abstract

Background: Telemonitoring (TM) interventions have been designed to support care delivery and engage patients in their care at home, but little research exists on TM of complex chronic conditions (CCCs). Given the growing prevalence of complex patients, an evaluation of multi-condition TM is needed to expand TM interventions and tailor opportunities to manage complex chronic care needs.

Objective: This study aims to evaluate the feasibility and patients' perceived usefulness of a multi-condition TM platform in a nurse-led model of care.

Methods: A pragmatic, multimethod feasibility study was conducted with patients with heart failure (HF), hypertension (HTN), and/or diabetes. Patients were asked to take physiological readings at home via a smartphone-based TM app for 6 months. The recommended frequency of taking readings was dependent on the condition, and adherence data were obtained through the TM system database. Patient questionnaires were administered, and patient interviews were conducted at the end of the study. An inductive analysis was performed, and codes were then mapped to the normalization process theory and Implementation Outcomes constructs by Proctor.

Results: In total, 26 participants were recruited, 17 of whom used the TM app for 6 months. Qualitative interviews were conducted with 14 patients, and 8 patients were interviewed with their informal caregiver present. Patient adherence was high, with patients with HF taking readings on average 76.6% (141/184) of the days they were asked to use the system and patients with diabetes taking readings on average 72% (19/26) of the days. The HTN adherence rate was 55% (29/52) of the days they were asked to use the system. The qualitative findings of the patient experience can be grouped into 4 main themes and 13 subthemes. The main themes were (1) making sense of the purpose of TM, (2) engaging and investing in TM, (3) implementing and adopting TM, and (4) perceived usefulness and the perceived benefits of TM in CCCs.

Conclusions: Multi-condition TM in nurse-led care was found to be feasible and was perceived as useful. Patients accepted and adopted the technology by demonstrating a moderate to high level of adherence across conditions. These results demonstrate how TM can address the needs of patients with CCCs through virtual TM assessments in a nurse-led care model by supporting patient self-care and keeping patients connected to their clinical team.

(JMIR Nursing 2020;3(1):e22118) doi:10.2196/22118

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KEYWORDS

telemonitoring; adherence; patient experience; complex patients; normalization process theory; implementation; mobile phone

Introduction

Multimorbidity, defined as the presence of more than one chronic condition in an individual [1], has been increasing, particularly in patients with ≥4 to 5 conditions [2]. The associated risks of patients with chronic conditions include frequent hospitalizations, which can lead to increased risks of hospital-acquired infections and longer length of stay [3-5]. Previous qualitative research highlights numerous struggles patients experience in trying to manage their conditions [6], including a high treatment burden in self-managing their care, attending multiple appointments, polypharmacy, and adhering to complex care regimens [7,8]. As defined, multimorbidity does not account for common dispositions, such as frailty or aging, which may contribute to ineffective management and unanticipated outcomes. Patients with complex chronic conditions (CCCs) include both those with multimorbidity who also face complex social challenges such as socioeconomic vulnerability [9]. The layers of physical, mental, and social conditions cause extensive clinical variability in this patient population.

Several studies have found that nurse-led models enable patients to spend more time with clinicians and coordinate care under a more comprehensive and holistic approach, rather than just a single-disease focus [10-12]. Previous studies have also concluded that nurse-led models of care are feasible to deliver comprehensive chronic disease management [10,12-15] due in part to the broad scope of nursing practice, holistic approach, and interprofessional team of providers among other factors. A recent study focusing on patients with CCCs demonstrated that nurse practitioner (NP)–led care models provide sufficient quality and competency in diabetes and multimorbidity care [16]. Other studies have also found that nurse-led models of care are a potential mechanism to serve chronic populations, particularly when technology can complement patient self-care at home [15,17].

Several systematic reviews have shown that the use of telemonitoring (TM) can lead to improved health outcomes [18-23] and reduced hospital readmissions [18,24-26]. TM has also been shown to reduce all-cause mortality from heart failure (HF) [19,22,23,27], improve hemoglobin A_{1c} in patients with diabetes mellitus (DM) [28-31], improve blood pressure (BP) for patients with hypertension (HTN) [28,32,33], and reduce respiratory exacerbations in patients with chronic obstructive pulmonary disease [24]. Studies also indicate that TM can improve shared decision making [34,35] and patient experience with care [15,36]. However, several large TM trials have also reported mixed results [23,31,37-40]. It is possible that inconsistent findings are not only because of the technology itself but also because of the specific chronic conditions, combination of conditions, or lack of conditions targeted in the research. The model of care delivery in which the technology is implemented may also influence overall adherence. In particular, TM for patients with CCCs has not been widely studied in nurse-led models of care.

To address this gap, we evaluated the feasibility and perceived usefulness of the *Medly* TM system in a nurse-led care model for patients with CCCs. Feasibility is defined as the extent to which a new innovation can be successfully used or carried out within a given agency or setting [41]. The results of the implementation from the perspectives of the care team will be presented elsewhere. To the best of our knowledge, this is the first implementation of a TM system specifically targeting patients with CCCs within a nurse-led model of care. Our study was guided by the following central research question: What is the feasibility and perceived usefulness of a multi-condition TM platform in an integrated nurse-led care model?

Methods

Study Design Overview and Setting

A pragmatic, multimethod 6-month feasibility study was conducted for patients with CCCs in a nurse-led care clinic in Southern Ontario. The needs of patients and their families were identified in a previous qualitative study that informed the clinic's ongoing optimization [15]. Referral criteria to the NP-led CCC clinic included patients with multimorbidity; at least one hospitalization or more than two emergency visits within the last 6 months; and a length of stay, acuity of admission, comorbidities, and emergency department visits score >5 of a total of 14 [42]. The TM feasibility study commenced approximately 12 months after the clinic launch. Patients with HF, HTN, and/or DM involved in the study were asked to take frequent physiological readings at home via *Medly*, as per Table 1. All research activities were undertaken with approval from the William Osler Office of Research Ethics (#18-0061), the University Health Network Research Ethics Board (#18-5667), and the University of Toronto Research Ethics Board (#37660).

Table 1. Frequency of telemonitoring readings per condition and required measures per telemonitoring algorithm.

Condition	Frequency of readings	Physiological measures
Heart failure	Daily	Blood pressure, heart rate, weight, and symptoms
Hypertension	×1 every 2 weeks	Blood pressure
Diabetes	×1 per week	Blood sugar

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Theoretical Framework

A pragmatic worldview was taken to evaluate the social construction of feasibility in multi-condition TM using the normalization process theory (NPT) by May [43-46] and the Framework of Implementation Outcomes (IOs) by Proctor et al [41]. The relationship between the 4 constructs of NPT (coherence, cognitive participation, collective action, and reflective monitoring) was evaluated using a multimethods approach in the context of the patient's experiences of using the TM platform in the nurse-led care model. NPT was used to map the implementation process of multi-condition TM in patients with CCCs from the patient's perspective (Textbox 1), whereas the IOs were used to determine the success or failure of the implementation using the constructs of acceptability, appropriateness, adoption, and fidelity (Textbox 2). The outcome constructs of cost, penetration, and sustainability were not specifically assessed as this study focused on the evaluation of feasibility through the patient experience and not on the model of care delivery (ie, service outcomes) or health outcomes (ie, client outcomes).

Textbox 1. Normalization process theory constructs and definitions.

- Coherence

Sense making and understanding the purpose of the potential of the telemonitoring (TM) intervention

- Cognitive participation

Commitment and decision from patient (and caregivers) to commit to the work of the intervention

- Collective action

The work that patients (and caregivers) do to engage with the TM intervention

- Reflexive monitoring

Reflection and appraisal of the TM intervention

Textbox 2. Implementation Outcomes constructs and definitions by Proctor.

- Appropriateness

Perceive relevance or compatibility of the innovation for a given setting or perceived fit of the innovation to address a particular issue

- Acceptability

Perception among patients that a given intervention (ie, telemonitoring [TM]) is agreeable or satisfactory

- Adoption

Initial decision or action to use an intervention (ie, TM)

- Feasibility

Extent to which a new intervention can be successfully used within a given setting

- Fidelity

Degree to which the intervention (ie, TM) was used as intended in practice

The TM Intervention

Medly is a smartphone-based chronic disease TM platform that was developed by researchers at the University Health Network in Toronto, Ontario [27,47-49]. The central component of *Medly* is an app that enables patients to monitor physiological measurements (ie, BP, weight [WT], blood sugar, etc) with wireless home medical devices and to answer simple symptom questions. Readings are processed through a clinically validated algorithm embedded in the app, which is contextualized to an individual's target range. Patients receive real-time self-care instructions, and their clinicians are alerted at the earliest signs of readings outside their individually curated normal range. Using the *Medly* app, patients were able to view graphical trends of each physiological reading over time. To assist with adherence, an automated phone call was implemented based on the required frequency of each condition's algorithm. This call was only sent out if patients missed a reading and could be disabled on patients' request. Participants were provided with all the necessary equipment, including a smartphone, home medical devices such as a weight scale or BP monitor, and batteries. In this case, *Medly* was designed to monitor HF, HTN, and DM (Figure 1).

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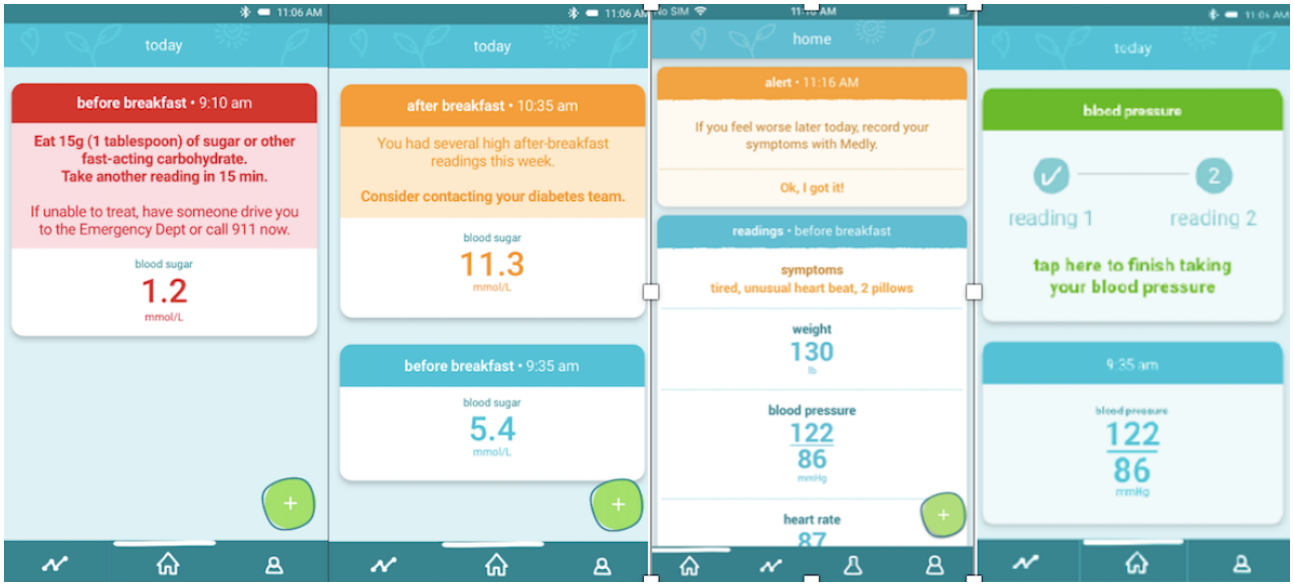
Figure 1. Screenshots of the Medly app for patients with a complex chronic condition.



Participant Sampling and Recruitment

Between May and July 2019, patients were recruited through convenience sampling during their routine visit to the nurse-led clinic. Researchers did not specifically identify patients with a specific combination of conditions, as the intent was an evaluation of feasibility. A sample of 15 to 25 participants based on specific inclusion criteria was deemed to provide sufficient data to explore the feasibility of TM in a nurse-led clinic, including reaching saturation for the patient interview data [50,51].

Patients were eligible to participate if they (1) were aged at least 18 years; (2) were able to take home measurements as intended; (3) were diagnosed with HF, HTN, or DM and one additional chronic condition; and (4) could understand English. Patients were excluded if they had visual or cognitive impairments that would prevent them from using the system or if they were already enrolled in a TM program. The NP identified which of the 3 conditions (HF, HTN, and/or DM) or a combination of conditions should be monitored for each participant. On written consent, the patient was provided with the necessary equipment and given an in-person training session on how to use the TM equipment. The NP set the specific algorithm ranges for each patient through a clinical dashboard. Patients were followed up with the *Medly* system for 6 months.

Quantitative Data Collection and Analysis

Patient adherence to taking readings was quantitatively assessed by analyzing the server logs of the TM system. Adherence was used as a measure to indicate TM's acceptability in this context and as an indicator of the perceived usefulness of TM. In this case, adherence was used as a pertinent implementation factor to determine feasibility [41] and was evaluated by measuring the frequency of TM readings for each condition (Table 1). For HF, as patients were instructed to take daily readings, adherence was measured as the percentage of days readings were taken over 6 months. For HTN, as per the algorithm, adherence was measured as the percentage of time patients took 2 consecutive BP readings at least once every 2 weeks. For DM, adherence was defined by taking readings at least once per week during the 6-month study.

Questionnaires were administered at the start and end of the study. Questionnaires included 3 sections: (1) the 36-Item Short Form Survey (SF-36) was used as a baseline indicator to evaluate the overall health status [52] of our participant group, (2) a series of technology questions were utilized to better understand the demographics of whom multi-condition TM is feasible within a nurse-led model, and (3) the participants' level of comfort with technology. Determining statistical significance in a small feasibility study was not the goal of including the SF-36 tool but rather to contextualize patient health status data in this care model. A chart review was conducted to collect basic demographic information (ie, age, sex, marital status, education level, etc). Sociodemographic data and clinical histories for all participants were summarized using a descriptive analysis.

Qualitative Data Collection and Analysis

All participants were invited to participate in a poststudy interview, each lasting between 30 and 60 min. Interviews were conducted onsite or over the telephone upon study completion. A semistructured interview guide was developed, informed by the 4 constructs of NPT (Multimedia Appendix 1) [43,44,53]. Participants were asked to describe their experiences and perspectives on using the TM system. Caregivers were not asked any specific questions during the interview but were able to participate in the discussion. All interviews were audio taped and transcribed verbatim for analysis.

An interpretative descriptive approach was used to guide the qualitative analysis [54,55], as this approach examines a clinical phenomenon with the goal of identifying themes and patterns among subjective perspectives while also accounting for variations between individuals [56]. The process of inductive thematic analysis followed the method outlined by Thorne et al [54], starting with an initial reading of each transcript. Subsequent readings included coding salient ideas and inductively deriving conceptual themes, first within and

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subsequently across transcripts. Detailed notes and codes were grouped according to emerging themes. The inductive process was conducted independently by 2 researchers (KG and AS) who came together to discuss emerging codes. Disagreements were discussed together and with the larger research team to reach consensus. Together, inductive codes were then compared with the implementation process constructs (NPT [43,44,46]) and the outcomes of patient experience (IOs by Proctor et al [41]) to structure the evaluation of the feasibility of this care model [41]. Saturation occurred at a point at which the codebook stabilized, a consensus was reached between the 2 researchers, and no additional codes or themes were identified in the data [57,58].

Results

Study Participants

In total, 26 participants identified by the team agreed to participate. Of the 26 participants, 18 were put on HF monitoring, 1 on DM, 1 on HTN, 5 on HF+DM, and 1 on HTN+DM. The remaining 8 patients were removed from the TM system for several reasons, including winter relocation (n=1), rehabilitation admission (n=1), unanticipated language barrier (n=1), inability to use a smartphone touchscreen (n=4), and death (n=1).

Table 2 presents the characteristics of the participants who completed the study. Overall, 65% (17/26) of the participants used the system for the full 6 months. The age of the participants ranged from 44 to 91 years, with a mean age of 73.8 (SD 13.3) years. All the study participants had more than 3 chronic conditions, with some participants having more than 8 conditions in total. The total number of medications ranged from 8 to 19 per participant. This feasibility study was conducted in a geographic area that had a high percentage of recent immigrants, with more than 42% of the city's residents being born outside Canada [59]. Approximately 60% of the participants were identified as non-white. The level of education also varied widely across participants, with 35% having not completed high school and 35% having completed a college or university degree. With regard to technology experience, 11 of the 17 (65%) participants who completed the questionnaire stated that they owned a cellphone (n=4) or smartphone (n=8), whereas 3 participants did not specify which kind of device (Table 3). Only one participant had previously used a TM system, although it was not smartphone-based TM or multi-condition-based TM. Despite more than half of the participants owning a cellphone or smartphone, the comfort level across the participants was mixed. In the end, the response rate for the prestudy questionnaire was fairly high (16/17, 94%) but lower for the poststudy (10/17, 59%) questionnaires. One participant did not complete a prestudy questionnaire. An evaluation of the SF-36 data did not find any meaningful results, likely because of the low poststudy response rate.

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Table 2. Characteristics of participants who completed the study.

Characteristics	Values, n (%)
Sex	
Female	9 (53)
Male	8 (47)
Ethnicity	
White	5 (42)
Non-White	12 (58)
Age (years)	
40-49	1 (6)
50-59	3 (18)
60-69	3 (18)
70-79	4 (23)
80-89	4 (23)
90-99	2 (12)
Marital status	
Never been married	2 (12)
Married or living with a partner	6 (35)
Separated or divorced	2 (12)
Widowed	6 (35)
Missing or unknown	1 (6)
Highest completed level of education	
Less than high school	6 (35)
High school	4 (24)
Trade or technical training after high school	1 (6)
College or university undergraduate	6 (35)

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Table 3. Participants' experience with cellphones or smartphones.

Technology questions	Response, n (%)
Own a cellphone or smartphone (n=17)	
Yes	11 (65)
No	6 (35)
If so, which kind? (n=11)	
Cellphone	4 (36)
Smartphone	4 (36)
Unknown	3 (27)
Comfort level using a smartphone or cellphone (n=17)	
Not comfortable	4 (23)
Somewhat comfortable	3 (18)
Comfortable	3 (18)
Very comfortable	4 (23)
Unknown	3 (18)
What features do you use on a smartphone? (n=17)	
Voice calls or text messaging	8 (47)
Internet	6 (35)
Video	3 (18)
Apps or games	4 (23)
Other	0 (0)
If you own a smartphone, what activities do you use it for? (n=17)	
Email	4 (23)
Information seeking	5 (29)
Scheduling	2 (12)
Information storage	6 (35)
Recreation	5 (29)
Other	3 (18)
Unknown	2 (12)

Adherence Results

Of the 17 patients who completed the study, 13 patients used the HF module, 1 patient used the HTN module, 2 patients used the HF+DM modules, and 1 patient used the HTN+DM modules. One participant (MCCP008) was initially monitoring HF and DM but was later offboarded from the DM component because of a change in health status.

Adherence to each condition was evaluated independently, irrespective of the combination of conditions. The adherence for each patient with HF is displayed in Table 4. The evaluation of adherence to HF was divided into 2 categories: the number of days patients took just the physiological readings (BP/HR/WT) and the number of days patients took all required physiological readings and completed symptom questions (full set). Although individual usage patterns varied across the participants, patients took physiological readings (BP/HR/WT), on average, over 77.2% (142/184) of days of the expected reported days. Of the patients with HF, 56% (9/16) were adherent to physiological readings over 80% of the days on TM, and 31% (5/16) were adherent over 90% of the days on TM. One patient (MCCP0017) took a full set of readings over 99% (183/184) of the days on TM. When evaluating the percentage of days that patients took all 3 physiological readings and symptom questions (ie, full set), the percentage dropped to 69.0% (127/184).

Overall, adherence in the HTN module was 55% (29/52) on average. HTN adherence was defined as taking at least one reading every 2 weeks. However, participants using the HTN component of the system, on average, took readings more frequently than required by the algorithm (Figure 2). DM adherence was on average 72% (19/26) defined as taking at least one reading per week (Figure 3).

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Table 4. Heart failure adherence of physiological measures versus full set (N=184).

Study ID	Number of days taking BP[a]/HR[b]/WT[c], n	Percentage of days taking BP/HR/WT, n (%)	Days taking full set, n (%)	Percentage delta for adherence, %
MCCP002	163	163 (88.6)	155 (84.2)	−4
MCCP005	134	134 (72.8)	122 (66.3)	−7
MCCP006	167	167 (90.8)	163 (89.6)	−2
MCCP007	147	147 (79.9)	137 (74.5)	−5
MCCP008	112	112 (60.9)	105 (57.1)	−4
MCCP009	177	177 (96.2)	177 (96.2)	0
MCCP0012	178	178 (96.7)	96 (52.2)	−45
MCCP0013	28	28 (15.2)	11 (5.9)	−9
MCCP0014	146	146 (79.3)	143 (77.7)	−2
MCCP0017	181	181 (98.4)	179 (97.3)	−1
MCCP0018	157	157 (85.3)	151 (82.1)	−3
MCCP0019	50	50 (27.2)	12 (6.5)	−21
MCCP0022	170	170 (92.4)	165 (89.7)	−3
MCCP0024	139	139 (75.5)	121 (65.8)	−10
MCCP0025	160	160 (87.9)	156 (84.8)	−2

[a]BP: blood pressure.
[b]HR: heart rate.
[c]WT: weight.

Figure 2. Total number of blood pressure readings on the hypertension modules. BP: blood pressure.

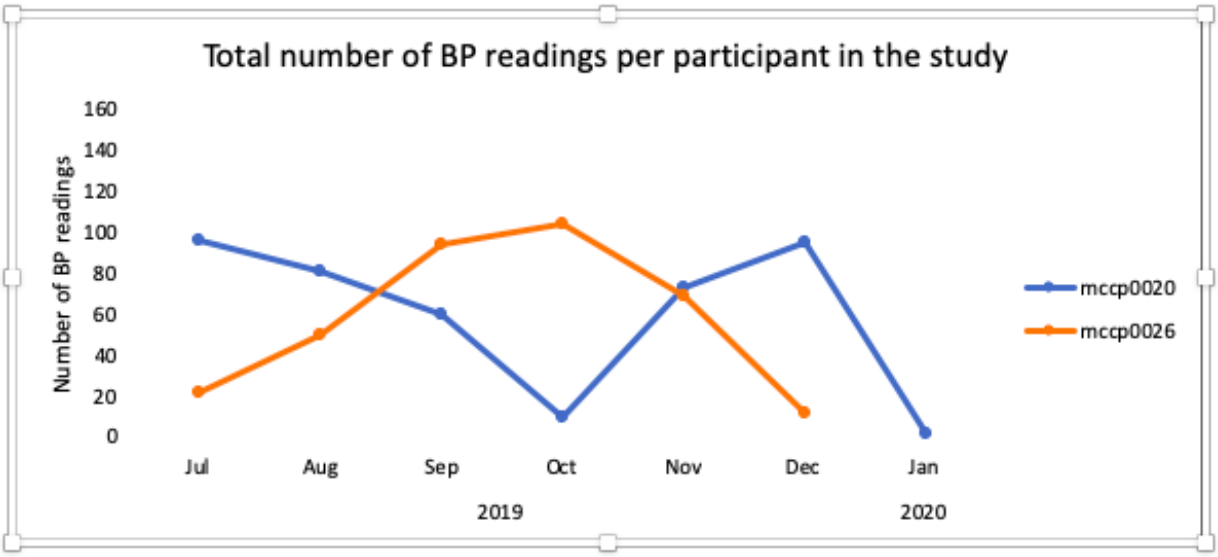

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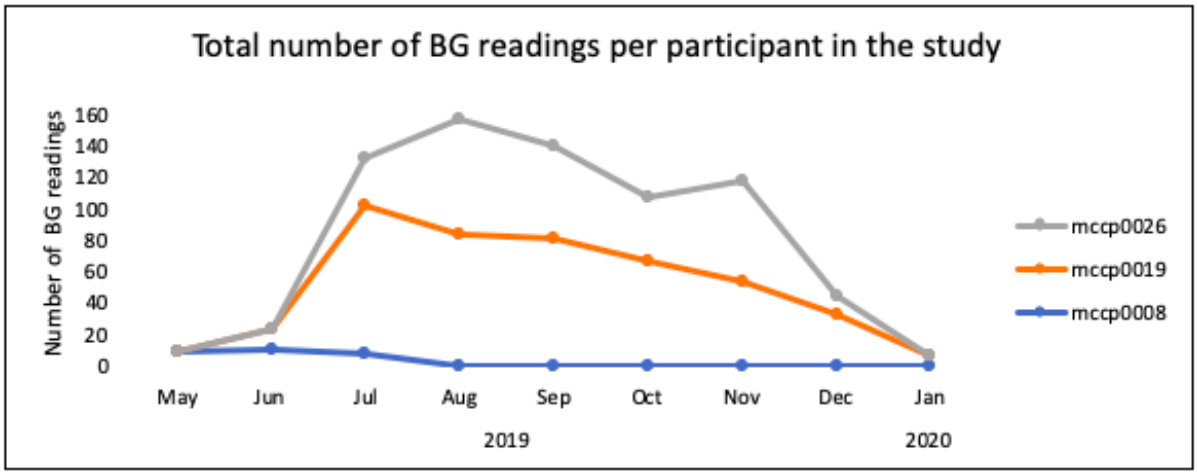
Figure 3. Total number of blood glucose readings on the diabetes mellitus modules. BG: blood glucose.



Results From Qualitative Data

The qualitative findings of the patient experience can be represented by 4 main themes and 12 subthemes. The main themes were (1) making sense of the purpose of TM, (2) engaging and investing in TM, (3) implementing and adopting TM, and (4) perceived usefulness and perceived benefits of TM in CCCs. The themes and subthemes were mapped together with the constructs within NPT and IOs as shown in Table 5.

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Table 5. Mapping of overarching themes and subthemes to the normalization process theory and the Implementation Outcomes framework by Proctor.

Theme and subthemes	Quotes	Normalization process theory construct	Implementation Outcomes construct by Proctor
Making sense of the purpose of TM[a]		Coherence	Appropriateness
	"We were keeping a log book and it wasn't consistent but we were still trying to do that...The NP would have me email her the sugar readings. So I would have to transpose all that information into an email... they would review it when we go visit them." (MCCP0019)		
Engaging and investing in TM		Cognitive participation	Acceptability
Comparing the old ways of working to use TM	"We did] nothing. If we felt sick we'll go to the doctor. We took blood pressure now and again, but not on a regular basis, not like this." (MCCP0025)		
Connected devices support individual capacity and gain investment for patient buy-in of TM practices	"I think it was we actually really liked that it was connected, because it gave me a peace of mind. At least I know, okay, if something goes wrong, there's somebody there to call her. Someone is kind of checking on me." (MCCP0026)		
Accepting the technology	"Yes, it was easy. Yeah it does everything for you. You just have to turn the phone off and press the button the blood pressure cuff or step on the weight scale and it does everything." (MCCP009)		
Implementing and adopting TM		Collective action	Adoption
Adjusting routines around TM	"You get up, you put your housecoat on, you go to the bathroom, you get the scale out from under the sink." (MCCP007)		
Frequent clinical monitoring; reinforced routine adherence	"It's good. It's good to know that somebody is out here watching too not negatively. If they were watching to condemn me for what I'm doing – but they're watching with my best interests." (MCCP002)		
The support of caregivers and caregiver participation	"Yeah, so it's one hundred percent good to have help from family members." (MCCP0019)		
Evaluating perceived usefulness and perceived benefits of TM in CCCs[b]		Reflexive monitoring	Feasibility and fidelity
Improvement to ongoing self-care practices	"You don't know whether it's good or bad, but with Medley they give that guideline to live with – within" (MCCP002)		
Enabling immediate action on abnormal readings and trends	"I know if the reading comes up in orange—that's the orange. If it comes up in orange, check. If it gets worse during the course of the day check the clinic. And I know that feels good. I feel good. Yeah, I feel good, so that is very helpful, that is very, very helpful." (MCCP002)		
Concerns moving forward without TM	"Yeah. I like knowing someone's keeping an eye on me. Certainly no one else will keep an eye on me now. [After I you mean?] Yes, there's no one now...I just liked it, that's all, knowing, they were there looking out for me." (MCCP0024)		
Symptom questions were not always relevant for patients with CCCs	"There were times [when it was] kind of like a grey area...She's not always feeling great and you enter the information based on the prompts and some of those prompts alerted the nurse at the hospital and we would get a phone call. And sometimes to me they were kind of unwarranted... Was she dizzy? Well she feels dizzy a lot of times. She's usually OK." (MCCP0019's caregiver)		

[a]TM: telemonitoring.

[b]CCC: complex chronic condition.

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Theme 1: Making Sense of the Purpose of TM

The first theme synthesizes participants' accounts of how they made sense of TM, from the initial introduction to the technology to understand its purpose to enable a more structured method of physiological monitoring to connect patient information to the clinic. Participants described the process of measuring physiological readings such as BP or blood sugar at home to track their conditions for their care team. Participants were familiar with the process of keeping a logbook to track readings taken between appointments:

> *We were keeping a log book and it wasn't consistent, but we were still trying to do that...*
>
> *The nurse practitioner would have me email her the sugar readings. I would have to transpose all that information into an email for her... other than that everything was just in the log book and they would review it when we go visit them.* [MCCP0019]

One participant described how the ability to go back and look at previous readings made sense in terms of alleviating the challenge of maintaining up-to-date logs at home (ie, appropriateness). Often, manual tracking did not work because of inconsistent patient-provider communication or the inability to recall context-specific readings.

Theme 2: Engaging and Investing in TM

By comparing the patients' current care practices at home (ie, logs) and envisioning new work of taking digital remote readings, patients began to engage in using TM. Instead of calling in readings, by taking readings through the app, they were sent automatically to the clinic. This supported the relational work necessary to gain buy-in from patients to accept the technology and to invest time in a remote way of care.

Comparing the Old Ways of Working to Using TM

Before the introduction of the TM intervention, there was significant variability in the frequency of participants taking physiological readings at home routinely. Almost all participants described taking physiological readings on occasion at home, in a doctor's office, or at a local pharmacy. One participant described their monitoring processes before beginning TM as irregular:

> *[We did] nothing. If we felt sick we'll go to the doctor. We took blood pressure now and again, but not on a regular basis, not like this.* [MCCP0025]

One patient participant noted that she had difficulty making in-person appointments, often canceling because of the weather conditions or too many appointments. By engaging with TM, she could still receive care remotely, avoiding winter driving conditions. This contributed to increased investment in a connected TM system:

> *It's hard to make appointments in this weather because you don't know what I have to come through from [city name]. You can have a big weather difference between here and there... It's hard to make every appointment with so many. I've had two this week already. Another at 2 and then 230 today, plus one yesterday.* [MCCP0024]

Connected Devices Support Individual Capacity and Gain Investment for Patient Buy-In of TM Practices

Having the devices connected directly to the clinic supported buy-in from patients through increased patient-clinician communication, thereby building their capacity at home (ie, saving time, providing new information to manage their care, and connecting with their personal clinicians). The ability to visualize live data and provide reassurance that someone was looking out for their health generated recurring engagement with TM and an investment to continue using the system at home:

> *We were keeping a log book and it wasn'tconsistent but we were still trying to do that and we're going to have to go back to that unfortunately after this... Having this was better for us and at least for the hospitals because they could see live data right there in their systems.* [MCCP0019]

Accepting the Technology

Several participants were hesitant about the process of learning TM. Initially, several participants described the smartphone as challenging. Some participants seemed to rely more on help from family members or other informal caregivers to use TM than others:

> *So, the phone itself was a bit of a challenge at first. I thought "How do I go back? Where's the back button?" All I had to do it phone you, but I figured it out... That was a little bit of a frustration...sometimes it's better learning on your own.* [MCCP0024]

Overall, most patients engaged and accepted the technology over time, describing it as *easy to use*. The tasks required to complete a morning reading aligned with what their care team, particularly the nurse, was already asking them to do at home.

Theme 3: Implementing and Adopting TM

This theme describes the process of enabling the patient's work to implement TM at home and how these practices led to a decision to adopt the intervention seamlessly into their normal routine.

Adjusting Routines Around TM

The patient's *work* of using TM frequently became a part of their everyday routine. Along with getting up, going to the bathroom, and taking their medication, taking readings was described as a normal step in this everyday process:

> *In the morning time when I wake up and go to the bathroom, I take my water tablet before I eat, to pass the water out. Then I test my pressure, weight, and the heart rate using Medly.* [MCCP006]

On the basis of the readings, patients would adjust the tasks they had done every day, for example, monitoring fluid intake or restricting salt intake.

Frequent Clinical Monitoring and Reinforced Routine Adherence

Participants described that they perceived someone was looking out for them (ie, nurse) and taking care of them in the virtual

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background (ie, nurse-led team). The registered nurse acted as a central point of contact within the care model that could address varying symptoms, cross-condition needs, and concerns. This created a mechanism that reinforced routine adherence and continued use of the TM system over time. Some participants described feeling more confident of their health knowing that someone was watching him and would reach out if something was wrong:

> *One thing I know is that I'm being watched. I'm being monitored. It's nice. If something is wrong they'll know too and Medly will get in touch. It makes you more aware of what's going on inside your body.* [MCCP0025]

When the clinicians would call to follow up on an abnormal reading or missed reading, participants described it as reassuring and helpful. Participants came to rely on immediate feedback not only from the team but also from the self-care messages delivered by the app:

> *Whenever something was wrong, the nurse would call, so it was very helpful... But like I said a couple times they just called us because of a reading they got.* [MCCP0022]

Support of Caregivers and Caregiver Participation

Participants were trained to use the TM system individually before starting the study. Although a caregiver was not required for use, 11 of 17 (65%) participants had support at home. During the poststudy interviews, it was clear that caregivers heavily participated throughout the TM process, despite whether the support was necessary:

> *The blood pressure taking–I have arthritis, I have rheumatism... It's hard for me to do anything with my fingers. So it was good to have somebody to help me that way.* [MCCP0014]

> *But if I have any problems with the cell phone, I got from Medly, I will call my wife and she would play with it because I don't have to know all this.* [MCCP002]

Theme 4: Evaluating Perceived Usefulness and Perceived Benefits of TM for CCCs

In conclusion, all participants seemed to appraise the TM system as if it was already an embedded part of their daily routine in normal life. Participants described improvements in self-care knowledge, such as being able to identify when something was not right even if they felt no physical symptom differences. This enabled action on abnormal readings they may not have identified without *Medly*. Participants shared that clinicians would often quickly reach out to discuss abnormal findings. Participants described a strong desire to continue monitoring, even after the study ended. Despite high adherence rates, several technical issues presented minor challenges.

Improvements to Ongoing Self-Care Practices Using TM

One participant described his self-care practices before TM as just a *guessing game* (MCCP007) without clear direction or understanding how to improve this own care at home:

> *I was just winging it because I didn't know anything about it at all, I weighed myself, but there was no concept behind that... now with the weight and the blood pressure together and the correlation that goes that... that aspect indicating my health [overall], it is, it was beautiful it helped me keep myself in check.* [MCCP007]

By taking readings daily, patients described getting to know their target range (ie, reflexive monitoring). Participants described how the device data kept them informed, improving their knowledge of their condition, and how they could keep track of their health over time (ie, feasibility).

Enabling Immediate Actions on Abnormal Readings and Trends

All participants referenced how *Medly* could identify when a reading or trend was not right. Many patients specifically noted using the color to identify the severity of an alert as well as the graphs within *Medly* to help identify abnormal readings:

> *When something is not right, your reading comes up a different color and you know something is wrong, but you can wait and retake it or you try it again on the next day.* [MCCP0020]

Although participants described differing preferences in how they identified abnormal readings, they described the actions they took to manage these situations:

> *...with Medly, when it comes up in a different color it tells you "go to see somebody if it gets worse or if you feel worse." And what I like about it is it tells you what do to.... If your weight is not what it should be it tells your weight… I know if the reading comes up in orange, check it. If it gets worse during the day, I check with the clinic. So that is very, very helpful.* [MCCP0022]

Although patients described being able to more clearly identify when something was not right while using TM, many patients still relied somewhat on the nurse-led team to identify abnormalities:

> *They did call because they were concerned and then we did come into the clinic later that day. So maybe it was a good thing to have Medly that particular time.* [MCCP0019]

When a reading measures outside of the individual tailored range, participants received algorithm-based self-care messages. However, several participants found that clinicians within the model, usually the nurse, would call the patients first:

> *Because they're usually pretty good. If there is a real critical [reading], they'll try to get us right away.* [MCCP0026]

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There were times participants even described their intention to call the nurse in the clinic; several participants noted that the nurse followed up with them before they could reach out.

Concerns Moving Forward Without TM

Participants expressed strong concerns about having to go back to managing their conditions at home without *Medly*, even to the point where they were willing to pay for the program out of pocket, or ask what store they could purchase the devices immediately. Participants described a sense of anxiety, knowing that no one would be monitoring their readings going forward:

> *Yeah. I like knowing someone's keeping an eye on me. Certainly no one else will keep an eye on me now. [After Medly you mean?] Yes, there's no one now...I just liked it knowing, they were there looking out for me.* [MCCP0024]

Symptom Questions Were Not Always Relevant for Patients With CCCs

Several patients described the daily symptom questions as not always relevant or specific enough to isolate subtle changes in their symptoms:

> *There were times [when it was] kind of like a grey area...She's not always feeling great and we enter the information based on the prompts and some of those prompts alerted the nurse at the hospital. We would get a phone call. And sometimes, to me, they were kind of unwarranted... Was she truly dizzy? Well she feels dizzy a lot of times. She's usually OK.* [MCCP0019's caregiver]

Discussion

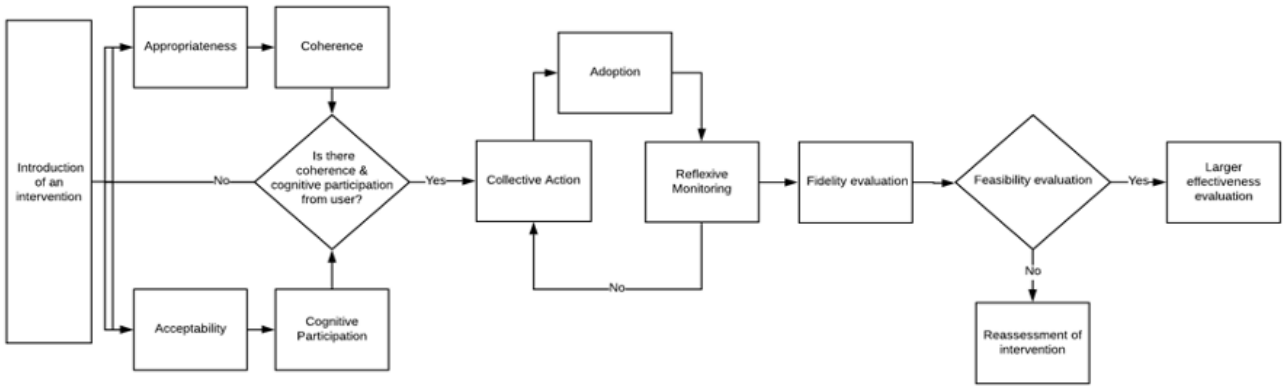
Principal Findings

This study provides a detailed evaluation of the feasibility and perceived usefulness of a multi-condition TM platform using the experiences of patients with CCCs in an integrated nurse-led model of care. Study findings revealed that patients were highly adherent to self-monitoring using multi-condition TM, irrespective of which conditions were monitored at home. A virtual connection to the nurse-led team enabled patient acceptance of this new way of tracking readings at home and engaging in their care using multi-condition TM. By choosing to adopt TM into a daily routine, patients perceived that someone was looking out for them, reinforcing routine adherence and enabling patients to evaluate abnormal readings and trends. Participants perceived TM as useful, describing improved self-care knowledge and acting on information provided by TM in tandem with their nurse-led care team. Evidence of *new normal* practices was clear (ie, high adherence rates and the patient's detailed descriptions of perceived usefulness of TM), such that ending the study affected this new normal routine.

Theoretical Contribution

NPT and the IOs framework were used for the structural evaluation of feasibility based on the patient's experience using TM in nurse-led care (Table 5). Using the results, a conceptual framework was developed to visualize the patient experience in light of these constructs (Figure 4).

Figure 4. Mapping normalization process theory to Proctor's Implementation Outcomes in a feasibility study to evaluate multi-condition in nurse-led care.



Simultaneous Process of Coherence and Cognitive Participation

The introduction of multi-condition TM for patients with CCCs in nurse-led care stimulated a simultaneous evaluation of acceptability (Does it make sense to the users?) and appropriateness (Does it fit?). Given these patients had frequent health system encounters that involve evaluating ongoing assessment of physiological indicators, TM of critical physiological measures aligned well with existing care plans (ie, coherence). The results indicated that patients did not always feel physical differences in their health when readings measured outside of their clinically indicated range, leading to often unanticipated condition exacerbation. Participants described the TM system as appropriate, suggesting that they understood the purpose of TM as part of their normal work, aligning with the NPT construct of cognitive participation that identifies how patients engaged with TM, accepting the technology in part as a replacement for traditional care practices. Patients accepted the idea of their *new work* in TM, in part because these devices were connected to the nurse. In many cases, an appointment was not necessary because of the virtual connections made

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through the TM to the clinic, creating further patient engagement and willingness to accept TM.

A Cyclical Evaluation of Collective Action and Appraisal

Participants described an ongoing cyclical process in which the collective actions required to adopt TM resulted in a cycle of evaluation and readoption (ie, construct of reflexive monitoring) over time. In some cases, implementing TM requires embedding new routines at home or adjusting existing ones. Patients described clinicians, particularly the nurse, calling to check-in on questionable readings. Given the strong support of caregivers in our participant group, NPT might suggest that caregivers played an integral role as contributors to the relational work required in adopting TM technology (ie, collective action). The collective actions, which demonstrated engagement in the care process, reinforced patients' reflections on the value of the technology to be positive. This led to further engagement, greater collective action, involvement of family caregivers, and overall feasibility, such that patients wanted to continue TM use after the study.

Adherence to TM in CCCs

The results indicated an average adherence rate of 77.2% (142/184) in HF monitoring, 55% (29/52) in HTN monitoring, and 72% (19/26) in DM monitoring. Previous research has found varying adherence rates, typically between 40% and 90%, to TM in HF [47,60,61]. Another study found that the average adherence rate to BP monitoring and blood sugar monitoring was 59.7% and 50.2%, respectively [61]. In addition, other previous studies have found an initial drop in patient adherence during onboarding, followed by a steadier adherence rate over time [47,48,60]. In this case, an initial drop in adherence did not occur. A consistent overall adherence rate supports the feasibility of this multi-condition TM system. When comparing patients with HF who were adherent to physiological readings versus those who completed a full set including symptom questions, the average change in adherence was less than 10%. This suggests that the majority of patients in this cohort were adherent to both readings and symptom questions.

Although the adherence rates reported in this study are comparatively high, we anticipate that they are likely higher than reported. Similar to other *Medly* studies [47], we did not have functionality, which would enable researchers to automatically account for periods when patients were unable to take readings for legitimate reasons (eg, admitted to hospital, traveling, device replacement, etc). Patients were asked to notify the team if they were going to miss a reading. In many cases, the clinical team was notified in advance, suggesting that adherence rates are higher than reported findings. It is also possible that a subset of the incomplete readings, such as missing symptom questions, was because of the Bluetooth connectivity issues. Although patients may have taken a set of readings, it is possible that a loss in network connectivity could have reported a missed reading on that day.

Considerations of Fidelity in Multi-Condition TM

The fidelity of the intervention was considered to contribute to the overall evaluation of TM feasibility in nurse-led care. The degree to which the intervention was delivered as intended is defined as intervention fidelity [41]. In this study, patients did not always complete the symptom questions, contributing to a difference in the adherence between a physiological reading and a full set across participants with HF and therefore lower fidelity to the original intervention. For patients with HF, adherence to completing the symptom questions was lower than completing only the physiological measures. Symptom questions may not have been completed for 3 reasons: (1) questions were not reflective of significant changes on a day-to-day basis, (2) questions were not relevant to how they felt that day (ie, determination of self-management), or (3) symptoms that are perceived as important to patients with CCCs may not be reflected in single-disease protocols. Therefore, the patient experience in the context of the combination of conditions monitored is important in evaluating the intervention's fidelity in nurse-led care.

Feasibility

On the basis of the patient experience, a multi-condition TM platform is feasible for patients with CCCs in an integrated nurse-led care model. Patients accepted and adopted the technology as demonstrated by a high level of adherence. Historically, the adoption and use of technology have had greater benefits in younger populations compared with older adults who may be less familiar with new technologies [62]. However, the wide age range across participants of both genders suggests the ability to use *Medly* does not appear to be associated with age or technology experience in this case. Although patients described being able to more clearly identify when something was not right while using TM, our results found that patients still relied somewhat on the clinical team to identify abnormalities. This contributed to adherence and continued use. This reliance on a clinical connection to their clinical or nurse-led team has been demonstrated in other research [15,63,64].

Implications for Research and Future Directions

There are several implications for future multi-condition TM apps as well as scaling up existing programs that focus on populations with CCCs. Attempts to tailor specific symptom questions have already been initiated in other eHealth technologies such as the electronic patient-reported outcome tool [65]. Further research should be conducted to explore the content and frequency of symptom questions in CCCs. Given the lower level of adherence to symptom questions in this study, an evaluation may suggest subtle changes to the question content or the frequency of questions required by the algorithm. Future research could explore these adjustments within the *Medly* platform as well as other TM platforms.

More research is needed to explore the extent of caregiver support in TM as well as identify the criteria for suitable enrollment of certain patient subgroups that require caregiver support. It is possible that TM interventions for patients with CCCs could be expanded if the implications of caregiver support and the role of caregivers are more broadly understood.

Finally, given the historically high rates of health care utilization in complex populations and the need for physical distancing

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because of infectious diseases such as COVID-19, TM solutions that improve patient experience should be explored as viable solutions to avoid in-person appointments while continuing to monitor complex patients closely, manage care needs remotely, and mitigate unanticipated visits to the emergency department.

Strengths and Limitations

The strengths of this study include the depth of the interview data collected as well as the rigorous approach to analysis using 2 trained qualitative coders and 2 theoretical frameworks (NPT and IOs). Interviews were candid, and diverse participants appeared to be forthcoming in their experiences using TM and perspectives on how to move forward with TM in nurse-led care. Given the nature of evaluating the initial feasibility of TM in nurse-led care for this population, the use of NPT and IOs worked well. There is an opportunity to use other well-known theoretical frameworks in future research, such as the Unified Theory of Acceptance Use of Technology 2 that undertakes a deeper dive in constructs such as price value, hedonic motivation, and effort expectancy in a program implementation.

There are several limitations to this study. First, the heterogeneous sample size was small (n=26), with only few patients using TM to monitor more than one condition. In an effort to capture the broad spectrum of CCCs, we did not attempt to randomize our sample. Only a small number of participants monitored HTN or DM exclusively. It is possible that different adherence results may have been experienced with more multi-condition TM participants. Second, as participants were conveniently sampled based on the recruitment criteria and not randomly selected, a selection bias is possible within the study sample. Third, a defective phone battery in several phones during the study generated the illusion of nonadherence, but for legitimate reasons. Owing to delayed shipping, these participants were unable to synchronize readings from the devices to the phone, likely lowering the apparent adherence data. Due to the low response rate of the SF-36, we were unable to incorporate it into our analysis. Finally, participants were only followed up for 6 months; therefore, adherence after the study period remained unknown as well as an optimal duration of TM in this population.

Conclusions

Patients with CCCs perceived TM within a nurse-led care model to be feasible based on their experience using a multi-condition TM platform for 6 months. Overall, this study found promising adherence rates across the 3 conditions monitored by TM in this study. Patients monitoring HF demonstrated the highest rates of adherence at 77.2% (142/184) of the days in the study period. The qualitative results enabled an exploration of the feasibility of multi-condition TM, which could then be mapped to the constructs of NPT and IOs. Given the experiences of patients with CCCs, TM via multi-condition platforms in nurse-led care models should be considered to meet the growing need for virtual care interventions to support remote care of CCCs in the future.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Patient interview questions.
[DOCX File , 16 KB - nursing_v3i1e22118_app1.docx]

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Abbreviations

BP: blood pressure
CCC: complex chronic condition
DM: diabetes mellitus
HF: heart failure
HTN: hypertension
IOs: Implementation Outcomes
NP: nurse practitioner
NPT: normalization process theory
SF-36: 36-Item Short Form Survey
TM: telemonitoring
WT: weight

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Edited by E Borycki; submitted 10.07.20; peer-reviewed by R Booth, C Jacob, J Walsh; comments to author 10.08.20; revised version received 17.08.20; accepted 23.08.20; published 29.09.20.

Please cite as:
Gordon K, Dainty KN, Steele Gray C, DeLacy J, Shah A, Resnick M, Seto E
Experiences of Complex Patients With Telemonitoring in a Nurse-Led Model of Care: Multimethod Feasibility Study
JMIR Nursing 2020;3(1):e22118
URL: https://nursing.jmir.org/2020/1/e22118/
doi:10.2196/22118
PMID:

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Original Paper

Academic Nurse-Managed Community Clinics Transitioning to Telehealth: Case Report on the Rapid Response to COVID-19

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Abstract

Background: In response to the COVID-19 pandemic, many health care organizations have adopted telehealth. The current literature on transitioning to telehealth has mostly been from large health care or specialty care organizations, with limited data from safety net or community clinics.

Objective: This is a case report on the rapid implementation of a telehealth hub at an academic nurse-managed community clinic in response to the national COVID-19 emergency. We also identify factors of success and challenges associated with the transition to telehealth.

Methods: This study was conducted at the George Mason University Mason and Partners clinic, which serves the dual mission of caring for community clinic patients and providing health professional education. We interviewed the leadership team of Mason and Partners clinics and summarized our findings.

Results: Mason and Partners clinics reacted quickly to the COVID-19 crisis and transitioned to telehealth within 2 weeks of the statewide lockdown. Protocols were developed for a coordination hub, a main patient triage and appointment telephone line, a step-by-step flowchart of clinical procedure, and a team structure with clearly defined work roles and backups. The clinics were able to maintain most of its clinical service and health education functions while adapting to new clinic duties that arose during the pandemic.

Conclusions: The experiences learned from the Mason and Partners clinics are transferable to other safety net clinics and academic nurse-led community clinics. The changes arising from the pandemic have resulted in sustainable procedures, and these changes will have a long-term impact on health care delivery and training.

(JMIR Nursing 2020;3(1):e24521) doi:10.2196/24521

KEYWORDS

telehealth; telemedicine; COVID-19, nurse practitioners; safety net clinics; community clinics; nurse; clinic; transition

Introduction

The COVID-19 pandemic has been rapidly transforming the US health care system. Within a few weeks of the lockdown, telehealth has been deployed across the country at a breathtaking speed. Prior to the pandemic, telehealth growth was incremental, and as of 2019, telehealth services have only been used by 8% of Americans [1]. Under the COVID-19 crisis, US insurers have quickly expanded coverage to include all telehealth visit types, including those from home [2]. Most states have relaxed their licensure requirements for care delivered across state boundaries [3]. In addition to allowing for the broad reimbursement of televisits, the Department of Health and Human Services has waived the enforcement of Health Insurance Portability and

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Accountability Act (HIPAA) regulations to allow the use of consumer audio and video communication for telehealth visits [3].

With these changes, telehealth is being leveraged with enormous speed and scale, turning into the forward front line in the battle against the pandemic [4]. In the emerging literature on telehealth, most studies have been focused on telemental health [5] or highly specialized health care, such as neuropathology and palliative care [6,7], and these studies typically come from large health care organizations [8]. To date, almost no studies have reported on the adoption of telehealth in academic nurse-managed community clinics, which serve the dual mission of training health professionals and caring for communities.

Prior to the pandemic, the adoption of telehealth in academic nurse-managed community clinics was slow for 2 reasons. First, health professional training requires substantial interaction time between faculty members and students. The procedures for facilitating teaching during clinical encounters have not been developed to encompass the audio-visual interface of telehealth. Second, these community clinics typically serve vulnerable populations, such as immigrants and low-income residents without health insurance. Many of these patients are slow adopters of eHealth tools, and some have limited access to high-speed internet [9,10]. This study aimed to address the current literature gap with the following objectives: (1) document the rapid implementation of a telehealth hub in an academic nurse-managed community clinic in response to the national COVID-19 emergency, (2) identify challenges and key factors for the successful transition to and dissemination of telehealth in these community clinics, and (3) explore strategies that ensure the sustainability of the telehealth program in these community clinics and their dual mission of providing treatment and teaching health professionals.

Methods

Study Setting

The academic nurse-managed clinic described in this study is the George Mason University Mason and Partners clinic. Since their establishment in 2013, Mason and Partners clinics have served the uninsured and immigrant communities within the Prince William and Fairfax counties in Northern Virginia. Across 10 sites, these clinics offer a bridge-care model, providing health care, school physicals, screenings, immunizations, and mental health services for vulnerable populations located in low-income and medically underserved areas. Nurse practitioners who have full independent practice authority in Virginia provide care in teams comprised of registered nurses, social workers, and students at undergraduate, graduate, and doctoral levels. The teams provide direct care, prescription and medication management, chronic care management through patient panels, and referrals to community services. Prior to the pandemic, Mason and Partners clinics served over 4000 patients annually and trained more than 250 nursing, social work, public health, health administration, and health informatics students a year. In 2019, prior to the pandemic, Mason and Partners clinics received federal funding for telehealth equipment with a focus on chronic disease and substance use disorder.

Data Collection and Analysis

We conducted semistructured individual interviews with the key operational and clinical staff of Mason and Partners clinics involved in the telehealth transition. An interview guide was prepared priori, covering topics on the transition process, challenges and solutions during the transition, lessons learned, and next steps. All interviews were conducted via web-based meeting interface and lasted for 30-60 minutes. Participants gave oral consent before the interview. During the interviews, we took detailed notes, which were summarized into major themes. The study protocol was approved by the Institutional Review Board of George Mason University.

Results

Identification of Needs and Decision Making

On March 16, 2020, George Mason University suspended all on-campus activities and transitioned to web-based education. Mason and Partners clinics suspended clinical operations in local sites, such as public schools and county specialty behavioral health centers, which had been shut down. Clinic buildings were also closed. The clinic leadership team held emergency conference calls to discuss a contingency plan. The Mason and Partners team recognized the following needs: (1) continuous health care would be critical for Mason and Partners patients, given their lack of insurance and alternative sources of care, high prevalence of chronic conditions, and social needs; (2) interprofessional health education should be continued for all health professional students; and (3) the health and safety of Mason and Partners staff was paramount, but the supply of personal protection equipment was limited. Given the pressing needs and constraints, the leadership team made the decision to transition clinic operations to telehealth operations integrated with web-based education. Mason and Partners clinics were reorganized, with 1 location continuing to accept walk-in appointments for new and current patients and the remaining clinic sites transitioning to telehealth.

Protocol Development

After the decision to transition to telehealth was made in response to the pandemic, the leadership team developed the following clinical operation protocol: (1) the walk-in clinic was open twice a week; (2) the screening and waiting area was moved to the parking lot; (3) a staff member took patients' temperatures and asked about their potential exposure to COVID-19; (4) patients with high temperatures and patients exposed to COVID-19 were given information on testing or referred to the emergency room; (5) patients without symptoms of COVID-19 and patients who were not exposed to COVID-19 were directed to the clinic, which they could enter from a well or sick entrance, depending on their health status; and (5) all staff members wore masks, and patients were given masks if they did not have one.

With regard to telehealth operations, the Mason and Partners leadership team used the HIPAA-compliant Zoom for Healthcare platform (Zoom Video Communications, Inc) to conduct patient

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consultations and team meetings. All care providers could access the electronic health record (EHR) system from home via virtual private network. Nursing students could consult with patients on Zoom under the supervision of a faculty member. It was anticipated that a telehealth visit would take longer than the average in-person visit, so the number of patients a Mason and Partners clinic could serve per day decreased.

Current Operation of Telehealth Services

Each Mason and Partners team member has access to a tablet preloaded with HIPAA-compliant apps, consent forms, and teaching packets. Patients make appointments via a main phone line for Mason and Partners clinics. During the phone call, a staff member performs an initial assessment of the patient. Following the Centers for Disease Control and Prevention guidelines, patients with COVID-19 symptoms are directed to the emergency room for immediate care and self-quarantine. New patients are asked to go to the walk-in clinic for their first appointment, and a telehealth appointment is scheduled with current patients while providing them with instructions on how to set up Zoom for a televisit. Before the telehealth appointment, a medical assistant calls the patient, helps the patient set up Zoom, and obtains their consent for treatment. When the "room" is ready, the clinical team joins the call. During the consultation, the patient, medical assistant, and nurse practitioner student provider have their webcams on; the nurse practitioner faculty supervisor and 2-3 students are silent observers that have their webcams turned off and audio muted. Each consultation lasts 45-60 minutes, including the initial set-up period.

A typical day at the Mason and Partners clinic begins with a prehuddle, which is when the team meets on Zoom to discuss the workload and plan the day. The day ends with a posthuddle, which is when the team exchanges thoughts and reviews the cases of the day. The telehealth team consists of an administrative lead, nurse practitioner student, nurse practitioner faculty members, and 2-3 interprofessional students (ie, social work, psychology, health informatics, and health administration students). The administrative lead organizes huddles and provides administrative and technical assistance for the team. All clinic teams have umbrella support from a social work lead and subject matter experts.

Challenges and Solutions

Several challenges were identified during the transition to telehealth at Mason and Partners clinics. First, as safety net resources shrink during the pandemic and lockdown, free community clinics are crucial for underserved communities. However, due to limited supply of personal protection equipment, only 1 Mason and Partners clinic was open for in-person appointments. Second, more than 60% of telehealth patients needed a translator, and some did not own a smart phone or computer. As such, setting up videoconferences was challenging for these patients. Bilingual medical assistants worked diligently with patients to set up video connections whenever possible and provide phone calls as an alternative. Health care providers learned to be attentive while communicating with patients via an interpreter on Zoom. Third, without direct contact with patients, nursing and other interprofessional students were learning to communicate with patients through web-based platforms. Several health services offered in the face-to-face care model, including physical assessment and point of care lab testing, are not available in telehealth. Finally, the pandemic has created the need for new service lines, including COVID-19 sample collection. In response to a local health department request, Mason and Partners clinics added a telehealth service for homeless individuals and families who are temporarily sheltered in local hotels.

Factors for Success and Sustainability

After reflecting on the transition to telehealth, the leadership team identified factors for successful transition and sustainability. Under the current extraordinary circumstances, all Mason and Partners team members recognized the need to continue service and embraced change. Effective teams need to be adaptive, flexible, and communicative. The leadership team acted promptly in response to the crisis and crafted detailed protocols before telehealth service implementation. Early implementation underwent several Plan-Do-Act response cycles, resulting in small adjustments. Protocols were developed for a coordination hub, a main patient triage and appointment phone line, a step-by-step flowchart of clinical procedure, and a team structure with clearly defined work roles and backups. Mason and Partners strives to maintain quality service and conserve limited resources. Despite the relaxation of federal requirements, Mason and Partners clinics use HIPAA-certified telehealth equipment and a secure EHR system.

Next Steps

At the time of manuscript writing, Mason and Partners clinics have implemented several updates. With regard to clinical practices, we have started collecting samples for free COVID-19 testing in collaboration with the state health department. A new telehealth kiosk is also being set up in a rural partner site. This kiosk is equipped with peripheral diagnostic instruments to conduct physical exams for immediate reading by the health care providers in distant locations. Once this is piloted, Mason and Partners will expand telehealth services to a larger network of rural patients and collaborative sites. Meanwhile, programs for telemental health and the social needs of underserved populations are under development. With regard to training, the interprofessional education model has been further refined to involve social work and psychology students; all health professional students will receive more training for consultations on telehealth. Mason and Partners clinics will continue the telehealth program, even after the pandemic.

Discussion

This is one of the first case reports on an academic nurse-managed community clinic transitioning to telehealth in response to the COVID-19 pandemic. This study is limited in the following aspects: (1) since Mason and Partners clinics may not be representative of other academic nurse-managed clinics in the country, the generalizability of this study may be limited; (2) we only interviewed a small number of key informants in the transition leadership team and may have missed a few elements in the transition; and (3) due to time constraints, we were not able to assess patient outcomes, patient satisfaction,

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provider satisfaction, and other indicators of health care quality in the new telehealth model.

Despite these limitations, this study showcases how a safety net clinic with the dual mission of providing education and service continues to function amid shutdowns and social distancing, thereby serving vulnerable communities and easing the burden on emergency rooms. The changes initially instigated by the pandemic are likely to be sustained and become the new normal of future health care. These changes have shaped clinical practice, health professional education, telehealth technology, community outreach, and health care policy.

In the new normal of telehealth, care providers and patients are forced to communicate through the internet. For care providers, this means developing new skills in web-based rapport building, diagnosis, and counseling; it also means remotely accessing and updating EHRs and remotely operating telehealth equipment. The new health professional training curriculum needs to incorporate these new skills [11]. Telehealth workflow should also be designed to minimize team burden and improve efficiency.

The rapid implementation of telehealth relies on robust technology support. We need telehealth equipment to be secure, low cost, portable, good quality, and high utility. For example, a telehealth kiosk with diagnostic peripheral equipment enables rapid testing and diagnosis. Ideally, videoconferencing technology should integrate effective interpreting services for patients who do not speak English. Telehealth consulting interfaces should allow for easy multiparty consultation and unobtrusive observation.

As of 2018, only 34% Americans have ever accessed EHRs [12]; people with lower levels of education and income are slow in adopting eHealth tools and have been left behind in the eHealth movement [9,10,12]. As high-speed internet access has become a new social determinant of health [13], providing no-cost or subsidized internet access for low-income populations should be prioritized, as it would become a prerequisite to accessing health services [12]. In the efforts to reduce health disparities, targeted interventions are needed to improve eHealth literacy in underserved communities, especially for skills regarding the use of smart phones or tablets for telehealth.

Under the COVID-19 crisis, many telehealth-related regulations have been relaxed to allow for rapid transition. As the pandemic wanes, we will have the opportunity to revisit these regulations and weigh the flexibility needed for care providers to adapt care delivery in novel ways against the requirements for ensuring high-quality care and reduced fraud and abuse. New quality tools are also needed to look beyond face-to-face encounters, from patient experience measures to coding practices.

In conclusion, the COVID-19 pandemic has posed unique challenges to health care delivery, and telehealth is well suited for continuous health services in the social distancing era. The experience of an academic nurse-led community clinic provides an example of a safety net and educational clinic successfully institutionalizing telehealth. Despite physical distancing, Mason and Partners clinics are socially connected and continue to serve the dual mission of providing service and education.

Acknowledgments

The study was supported with funding from the following sources: Health Resources Service Administration, Nurse Education Practice, Quality, and Retention (UK1HP31716, principal investigator: RES), United States Department of Agriculture Distance Learning and Telemedicine Grants (RUS-19-02-DLT, principal investigator: RES), and Health Informatics Education Fund (principal investigator: YAH).

Conflicts of Interest

None declared.

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Abbreviations

EHR: electronic health record
HIPAA: Health Insurance Portability and Accountability Act

Edited by E Borycki; submitted 22.09.20; peer-reviewed by C Liang, S Sabarguna; comments to author 22.10.20; revised version received 29.10.20; accepted 30.10.20; published 01.12.20.

Please cite as:
Sutter R, Cuellar AE, Harvey M, Hong YA
Academic Nurse-Managed Community Clinics Transitioning to Telehealth: Case Report on the Rapid Response to COVID-19
JMIR Nursing 2020;3(1):e24521
URL: https://nursing.jmir.org/2020/1/e24521/
doi:10.2196/24521
PMID:33496682

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Review

Predicted Influences of Artificial Intelligence on the Domains of Nursing: Scoping Review

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Abstract

Background: Artificial intelligence (AI) is set to transform the health system, yet little research to date has explored its influence on nurses—the largest group of health professionals. Furthermore, there has been little discussion on how AI will influence the experience of person-centered compassionate care for patients, families, and caregivers.

Objective: This review aims to summarize the extant literature on the emerging trends in health technologies powered by AI and their implications on the following domains of nursing: administration, clinical practice, policy, and research. This review summarizes the findings from 3 research questions, examining how these emerging trends might influence the roles and functions of nurses and compassionate nursing care over the next 10 years and beyond.

Methods: Using an established scoping review methodology, MEDLINE, CINAHL, EMBASE, PsycINFO, Cochrane Database of Systematic Reviews, Cochrane Central, Education Resources Information Center, Scopus, Web of Science, and ProQuest databases were searched. In addition to the electronic database searches, a targeted website search was performed to access relevant gray literature. Abstracts and full-text studies were independently screened by 2 reviewers using prespecified inclusion and exclusion criteria. Included articles focused on nursing and digital health technologies that incorporate AI. Data were charted using structured forms and narratively summarized.

Results: A total of 131 articles were retrieved from the scoping review for the 3 research questions that were the focus of this manuscript (118 from database sources and 13 from targeted websites). Emerging AI technologies discussed in the review included predictive analytics, smart homes, virtual health care assistants, and robots. The results indicated that AI has already begun to influence nursing roles, workflows, and the nurse-patient relationship. In general, robots are not viewed as replacements for nurses. There is a consensus that health technologies powered by AI may have the potential to enhance nursing practice. Consequently, nurses must proactively define how person-centered compassionate care will be preserved in the age of AI.

Conclusions: Nurses have a shared responsibility to influence decisions related to the integration of AI into the health system and to ensure that this change is introduced in a way that is ethical and aligns with core nursing values such as compassionate care. Furthermore, nurses must advocate for patient and nursing involvement in all aspects of the design, implementation, and evaluation of these technologies.

International Registered Report Identifier (IRRID): RR2-10.2196/17490

(JMIR Nursing 2020;3(1):e23939) doi:10.2196/23939

KEYWORDS

nursing; artificial intelligence; machine learning; robotics; patient-centered care; review

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Introduction

Artificial Intelligence

Artificial intelligence (AI) is a branch of computer science that focuses on building machines that can perform tasks that typically require human intelligence, such as decision making, speech recognition, visual perception, and language translation [1]. AI health technologies (AIHTs) are becoming increasingly prevalent in clinical settings worldwide, and global spending on these technologies is predicted to exceed US $36 billion by 2025 [2]. Given their potential to enhance workflows and guide clinical decision making, AIHTs are predicted to directly and indirectly transform the nursing profession in various ways.

Nurses are the largest group of health professionals, and they currently practice in diverse settings and roles across the 5 domains of nursing activity identified by the Registered Nurses' Association of Ontario (RNAO; ie, administration, education, clinical practice, policy, and research) [3]. Within the nursing profession, the delivery of person- and family-centered compassionate care is a core and valued component of nursing theory and practice [4-6] and is reflected in numerous nursing practice frameworks [7-9]. Compassionate care helps nurses to shift their focus from simply completing tasks to engaging fully with patients by recognizing and responding to their individual needs, promoting well-being, and forming therapeutic relationships essential to effective care [10,11]. It is anticipated that emerging trends in AIHTs will change the nature of the nurse-patient relationship [2]. Therefore, strong nursing leadership is required to drive this change and ensure the continued delivery of high-quality, person-centered compassionate nursing care [12]. Recent studies and expository papers have begun to explore the influence of AIHTs on nursing roles, workflows, processes, and patient care. However, no published scoping reviews have mapped the breadth and depth of evidence concerning the current or predicted influences of AIHTs on the nursing profession and compassionate nursing care. Furthermore, there is limited research on nurses' roles in influencing the implementation of AIHTs and the co-design of these technologies to protect patients' safety and privacy and preserve person- and family-centered compassionate care. Without an understanding of the existing evidence on this topic, nurses will not fully appreciate the implications of AI for nursing practice, policy, administration, and research. It is critical for nurses to gain a broader understanding of these emerging technologies to shape the future of the profession and influence decisions about aspects of nursing care that can be safely performed by AIHTs.

Background

The increased adoption of AIHTs in health care, driven partially by growing consumer demands for digital health technologies in clinical practice [13], may present a new means of addressing health challenges in the 21st century by enhancing workflows and supporting clinical decision making [14]. Over the last few decades, the volume of technology has increased significantly in many health systems around the world, and consequently, the impact of technology on the nursing role has become an increasing focus within nursing research [15]. There is an undeniable relationship that exists between human beings, technology, and the environment [16], and these relationships need to be further examined through the lens of nursing practice to effectively leverage AIHTs to augment the patient experience and health outcomes [17].

Within the nursing profession, many different types of AIHTs are already being used or trialed, including predictive analytics that use machine learning (ML), virtual health care assistant apps, and robotic devices. ML is a subset of AI that uses algorithms to derive knowledge from data and interpret the data without being explicitly programmed [2]. As more data are presented to the ML application, the computer learns from the data and corrects the output [2]. Predictive analytics that use ML technology can identify patterns in data and predict future patient outcomes such as a patient's risk of developing pressure ulcers [18]. Predictive analytics have been integrated into smart health care technologies to predict health status changes among patients in hospitals and community-based settings, enabling nurses to proactively intervene and initiate appropriate interventions [19]. Nurses in a Canadian home health organization use virtual health care assistant apps (chatbots) to support persons who have been diagnosed as having mental health conditions [20]. Furthermore, in Japan, where approximately 30% of the population is older than 65 years, nurses use AI-powered robots in long-term care (LTC) homes and hospital settings to assist patients with activities of daily living and to provide social interaction [21].

As AIHTs become increasingly prevalent within clinical practice settings, nurses in all roles and across all domains will need to consider the influence of these technologies on the nurse-patient relationship and on the nursing profession more broadly. Furthermore, to ensure that the nursing-AI relationship promotes person-centered compassionate care, it will be important to understand how nurses may contribute to the co-design of AIHTs. This scoping review explores how AIHTs influence the complex relationships between nurses and their patients as well as nursing practice across the domains of clinical practice, policy, administration, and research.

Objectives

A scoping review was conducted to summarize the findings of 4 distinct research questions that explore the relationships between nurses, patients, and AIHTs [22]. Given the number of articles included in the scoping review, the decision was made to divide the results into 2 stand-alone papers to improve clarity. This review summarizes the findings of 3 of those research questions, specifically exploring the influences of emerging trends in AIHTs on the nurse-patient relationship and the nursing domains (Textbox 1). The fourth research question discusses the influences of emerging trends in AIHTs on nursing education, and the results of that research question were conducive to a stand-alone paper on that topic, which is forthcoming (Buchanan C et al, unpublished data, 2021).

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Textbox 1. Research questions addressed in this review.

The following questions were addressed:

1. What influences do artificial intelligence–driven digital health technologies have, or are predicted to have, on the patient or caregiver experience of compassionate care delivered by nurses?
2. What influences do emerging trends in artificial intelligence–driven digital health technologies have, or are predicted to have, on all domains of nursing practice (ie, administration, clinical care, education, policy, and research)?
3. What involvement do nurses have, or are predicted to have, in the co-design of artificial intelligence–driven digital health technologies?

A scoping review methodology was deemed appropriate for this topic because of the emerging nature of AI in nursing and the exploratory nature of scoping reviews, intended to address broad research questions [23,24]. To the best of the authors' knowledge, no scoping reviews have mapped existing evidence on the relationship between AI, nursing, and the nurse-patient relationship.

Methods

Scoping Review

This scoping review followed the framework developed by Arksey and O'Malley [24] and further advanced by Levac et al [23], which is composed of 6 stages: (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) charting the data; (5) collating, summarizing, and reporting the results; and (6) consultation [24]. The scoping review was registered in the Open Science Framework database [25], and a protocol outlining the full methods can be found published elsewhere [22]. This reporting of the scoping review is guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist [26].

Steering Committee Formation

A 14-member steering committee was established to identify the research questions, inform the search strategy, and provide consultation throughout the scoping review [22]. The committee was cochaired by 2 doctorally prepared nurses with independent research programs focused on health informatics and the integration of AI and digital health technologies in nursing (RB and TR). All committee members had considerable knowledge or expertise with the use or implementation of AI or digital health technologies in nursing or the health system. The members included a patient advocate with lived experience and nurses from a variety of settings (eg, hospital care, home and community care, and LTC), domains (eg, administration, clinical practice, research, education, and policy), and roles (eg, nurse executives, nurse informaticians, nurse managers, professional practice leaders, and frontline nurses).

Identifying the Research Questions

The research questions and search strategy were developed through consultation with the steering committee. The latter was refined with the assistance of an information specialist at a large academic teaching hospital library (Multimedia Appendix 1). Using a Boolean combination of keywords and medical subject headings, MEDLINE, CINAHL, EMBASE, PsycINFO, Cochrane Database of Systematic Reviews, Cochrane Central, Education Resources Information Center, Scopus, Web of Science, and ProQuest were searched for peer-reviewed literature published between January 1, 2014, and October 17, 2019, which focused on AI and nursing [22]. A targeted website search was also performed to locate the relevant gray literature. Google search strings were developed by the information specialist, and the following websites were searched: World Health Organization, National Health Service, Office of the National Coordinator for Health Information Technology, Institute for Research on Healthy Public Policy, Canada Health Infoway, Canadian Association of Schools of Nursing, and Healthcare Information and Management Systems Society.

Identifying Relevant Studies

A screening guide was developed by the 2 reviewers (CB and LH), and 2 levels of screening were performed using predefined inclusion and exclusion criteria [22]. During title and abstract screening, articles were independently assessed and included if they were deemed relevant to the concepts of *AI* and *nursing* [22]. Next, full-text papers were independently reviewed and assessed for their relevance to 1 of the 4 research questions [22]. Conflicts were resolved through discussion, and when a disagreement arose, a third independent reviewer (RW) assessed whether the publication met the inclusion criteria [22].

Study Selection

To be included for question 1, articles had to have a clear focus on AIHTs, health professionals, and caring. Although the authors initially planned to only include articles relevant to AIHTs, nursing, and compassionate care, there was a paucity of literature regarding the impact of AI on compassionate care and nursing specifically. Consequently, the inclusion criteria were refined after consultation with the cochairs. Articles that discussed AIHTs, health professionals, and caring were used to address question 1, and the findings were generalized to nursing and compassionate care. The reviewers agreed on a clear definition of *compassionate care* before screening, defined as an empathetic response that involves engaging fully with patients by recognizing and responding to their individual needs, promoting well-being, and forming therapeutic relationships essential to care [10,11]. Articles that discussed *care* that pertained to this definition were included whether or not the article explicitly used the term *compassionate care*. Similarly, articles that referred to health professionals in general were also included if the information was relevant to nursing practice, even if there was no explicit reference to nurses [22]. To be included for question 2, articles had to address how AIHTs are currently influencing or are predicted to influence the domains of nursing as outlined by the RNAO [3], specifically, clinical practice, policy, administration, and research [3]. Finally, for

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question 3, articles had to discuss how nurses have been involved in the co-design of AIHTs or what nurses can contribute to the design of these technologies.

Charting the Data

Standardized data charting forms for each research question were created by the 2 reviewers and tested with a representative sample of articles [22]. Once it was determined that consistency in data charting was achieved between the reviewers, data from each included article was charted by one reviewer and verified by the second reviewer [22]. Information on the author, year, study design, country, aim/purpose, population, type of AIHT discussed, key findings related to each research question, and relevance to compassionate care was charted. Findings were recorded by study type in separate data charting forms for each research question (ie, qualitative vs quantitative study designs and expository papers).

Collating, Summarizing, and Reporting the Results

An inductive approach was used to categorically summarize the findings from the included papers to answer each research question [22]. Each paper was reviewed several times, and CB, LH, and RW discussed the findings and came to a consensus on identifying categories for each research question based on commonalities observed. The findings from quantitative and qualitative articles as well as expository or review papers were analyzed as a collective group of research. The categories were then summarized in the form of a data package and sent to members of the steering committee for review.

Consultation

Overall, 2 virtual steering committee meetings were held to provide feedback on the categories and implications of the findings. As stated by Levac et al [23], consultation should be an essential component of the scoping review methodology, and preliminary findings (ie, the scoping review categories identified) can be used as a foundation to inform the consultation. Levac et al [23] have suggested that consultation allows for knowledge transfer and exchange with stakeholders in the field, and stakeholders can offer additional information, perspectives, meaning, and applicability to the scoping review. Thus, the virtual steering committee meetings allowed for discussion of the findings and categories with the committee members, and feedback was received regarding how the identified categories may be applicable or relevant to clinical practice, policy, administration, and research.

Results

Overview of Studies

Overall, 131 articles were retrieved from the scoping review for the 3 research questions (118 from database sources and 13 from targeted websites; Multimedia Appendix 2). Specifically, there were 51 articles pertaining to research question 1, 98 articles pertaining to research question 2, and 16 articles pertaining to research question 3; however, it is important to note that some articles addressed multiple research questions. The results included all types of studies (quantitative, qualitative, mixed method, systematic reviews, and scoping reviews) as well as gray literature including reports, editorials, and opinion pieces (Multimedia Appendix 3 provides more details [2,13,14,18,21,27-152]). A total of 16 included articles were also cited in the systematic and scoping reviews that were included.

Emerging Trends in AIHTs

Emerging AIHTs discussed in the literature included robots (eg, socially assistive robots [SARs], humanoid robots, and mobility robots), predictive analytics, clinical decision support systems (CDSSs), smart homes, and virtual health care assistant chatbots. It was found that nurses are already using robots in their clinical practice, across multiple patient populations, for various tasks, such as to assist with exercise sessions for older adults or rehabilitation patients [27,28]; to serve as a distraction tool for pain management [29-31]; and to facilitate conversation and rapport, conduct interviews, and deliver patient education [27,33,34,36-39, 41, 42].

The literature also discussed life-like virtual health care assistant chatbots that have been used in clinical practice settings to support nursing practice and provide persons seeking internet-based mental health care with information about resources and additional support [43]. One article discussed advancements in sensory and processing developments that provide virtual health care assistant chatbots with greater capabilities, enabling them to detect, interpret, and express emotions as well as detect other behavioral signals of humans they interact with (eg, facial gestures and body posture/movement) [43].

Research Question 1: Nursing, Compassionate Care, and AI

Although there is consensus in the literature that emerging trends in AIHTs will impact nursing care [2,44], there was a paucity of literature on the potential impacts of AIHTs on compassionate nursing care specifically. Consequently, articles that discussed AIHTs and caring were used to address this research question, and the findings were generalized to compassionate care. The vast majority of included articles examined the influence of robots on the delivery of care (Multimedia Appendix 3).

Multiple articles predicted that by using robots to assist with some care activities, nurses may have more time to spend in getting to know their patients' preferences, responding appropriately to their needs, and building stronger therapeutic relationships [35,45-48]. In addition, several articles discussed how health professionals, including nurses, have used SARs to gain a deeper understanding of their patients [34,49]. For instance, within LTC settings, SARs have been used to stimulate memories of residents with dementia, allowing health professionals to explore the residents' past experiences, personality, and identity [34,50,51]. Health professionals have also used SARs to provide emotional support and reduce loneliness among older adults in aged care facilities [36,52] and provide comfort to patients at the end of life [34]. Using SARs during activities with residents may increase the level of engagement between health professionals and residents as they participate in these interactions together [51]. In one case study and one qualitative descriptive study, health professionals and

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students noted that the use of SARs has led to deeper relationships and increased rapport between health professionals and residents [28,34].

Other articles provided anecdotal evidence suggesting that AIHTs could potentially have detrimental effects [34,52-57]. When health professionals used SARs with residents in LTC, some patients have become agitated and others have become distressed when nurses have taken the robot away from residents [52,53]. If nurses use robotic devices to monitor adherence to treatment, one article suggested that this has the potential to cause embarrassment or anger among patients, weakening the therapeutic relationship and creating tension [54]. In addition, using robots with patients was viewed as infantilizing older adults [34,55,56]. Several other articles also noted that health professionals such as nurses could be considered guilty of intentionally deceiving patients if the patients are not able to recognize that the robot is not real [53,56,57]. Authors writing from this perspective suggest that AIHTs may negatively impact the patient and caregiver experience of caring and are apprehensive about the potential effect of this technology on nurses' ability to engage in caring interactions with patients [34,52-57].

Research Question 2: Implications of AI on Clinical Practice, Administration, and Policy

AI has potential implications on various established domains of nursing. The results of this question and their implications on the domains of clinical practice, administration, and policy are outlined in the following sections.

Clinical Practice

There is a consensus among authors that AIHTs will not directly replace nurses in the near future [2,13,14,48,58]. However, it is envisioned that there will be new nurse-patient interactions involving AIHTs in clinical practice that may augment nursing practice and the delivery of safe, high-quality care [14]. These emerging nursing-AI interactions will necessitate the reconceptualization of nursing practice, resulting in new nursing roles, new virtual care delivery models, and new workflows [2,48,59]. In addition, there will likely be increased demand for virtual health care assistant chatbots to support remote patient monitoring and virtual models of care [42,59,60].

It is also reported that AIHTs have the potential to streamline workflow processes and improve the accuracy and efficiency of care provided in diverse clinical settings [14]. Specifically, it is presumed that AIHTs have the potential to decrease nurses' physical and cognitive workload [61]. A few articles reported that robotic devices and other AIHTs can be used to collect demographic and health-related information, including patient histories, allowing nurses more time for patient care [31,62,63].

In the LTC sector, there is evidence that robotic devices have been used to assist nurses in meeting residents' hygiene and care needs (eg, toileting, lifting/transferring, and meal delivery), demonstrating the potential for these tools to reduce nursing workload in this clinical setting [21,64-67]. AIHTs such as CDSSs have also been used by nurses in this sector to tailor the residents' plan of care based on their preferences for activities and personal care, thereby enhancing person-centered care and maximizing the staff's time [68].

In the hospital sector, AIHTs such as predictive algorithms and CDSSs have been shown to improve decision making and nursing activities (eg, documentation), allowing more time for patient care [69-76]. For example, one study noted that a predictive algorithm used for the identification of nursing diagnoses reduced the time spent on decision making from 35.5 min to 19.8 min [61]. Multiple articles also noted that predictive algorithms can assist nurses with faster detection of patient changes and more efficient timely care [77-79].

Administration

The literature reviewed identified many applications of AIHTs in administration. For example, AIHTs may be used to schedule nursing tasks and assign patients to rooms [66]. AIHTs may also help to reduce the documentation burden [80] and assist with the scheduling of patient appointments [73]. One article suggested that modifications to the administration and scheduling of staff in LTC settings are needed to accommodate the emerging AIHTs [81]. It is also predicted that some administrative tasks that are currently performed solely by regulated staff will become more complex and require some automation [14,82]. Furthermore, new administration roles for nurse leaders are predicted to emerge [13]. One article predicted that nurses may act as case and information navigators [13] using AIHTs to assist in organizing and prioritizing patient care transitions through the health system.

Policy

Several authors suggested that with the integration of AI, new policies will be necessary to address concerns related to patient safety and ethical practice [14,43]. One such concern relates to unintended consequences associated with the use of AIHTs that might potentially impact patients' health and well-being [43]. For example, patients may be harmed because of technology failures or malfunctioning of robots [37]. Furthermore, without adequate protection of data, patient privacy could be jeopardized [35]. In addition, there were concerns in the literature about the use of predictive analytics to guide clinical decision making. Unlike other risk prediction tools that show how risk scores are calculated, when using predictive analytics, it is not always possible to identify the factors used in the clinical assessment and determination of risk [58]. Therefore, who would be deemed responsible if an error were to occur was not clear [43].

The importance of identifying and addressing real or potential health inequities related to AIHTs was also noted in the literature [62]. For instance, although these technologies have the potential to enhance access to care and health service delivery, they may also accentuate health inequities by increasing the digital divide [62]. Due diligence is required to ensure that vulnerable populations and people in rural and remote areas have access to continuous coordinated care [62]. In reality, people in rural and remote areas may have a greater need for virtual care and remote patient monitoring than people living in urban areas [83].

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Research Question 3: Nursing Research and Co-Design of AIHTs

Although 2 articles noted that nurse researchers are in a natural position to contribute to the research on and development of AIHTs to ensure a smooth transition from development to clinical practice [70,84], this scoping review found minimal information regarding the current involvement of nurses in the research and co-design of these technologies.

In addition, 2 articles mentioned examples of projects where nurses partnered with engineers and programmers to develop robots [2,85]; however, there was no explanation of the specific roles and responsibilities nurses assumed while contributing to these projects. One study noted that although the involvement of nurses in the conceptual, research, and developmental stages of any new product or system is integral, nurses are often involved in testing or evaluating a product when major functional changes to the technology may not be possible [85]. Although nurses are frequently employed by engineering companies in the sales or marketing of products, they are less involved in research and development activities [85].

The literature also described several barriers that could influence the involvement of nurses in the co-design process and other barriers that may impede the implementation of these technologies. Communication barriers may arise because of nurses and information technology (IT) experts being unfamiliar with each other's field of practice [86]. In addition, nurses may not be familiar with the technical terms used by IT experts, and IT experts may not understand nursing concepts. In one study, both groups learned to overcome communication barriers by avoiding the use of technical jargon and by meeting frequently to reduce communication errors [86]. At an organizational level, the cost of hiring doctorally prepared nurses to lead innovative projects and a lack of organizational support for the inclusion of nurses in a data science strategy may also prevent involvement in co-design [70].

Multiple articles discussed the skills, knowledge, and expertise that nurses can contribute to the co-design of AIHTs [2,63,85-87]. Nurses uniquely understand the complexities of the health care environment [63], including what works, what does not work, and what can be done to improve patient experiences and health outcomes [85]. Given the key role nurses play in supporting the physical and psychological health of persons and families, nurses are in a unique position to advocate for the needs and preferences of patients [87] and identify the ways patients are best served by technology [88].

Discussion

Overview

The principal aim of this review is to summarize the findings of 3 research questions that explored emerging trends in AIHTs and their potential influence on the roles and functions of nurses and the delivery of compassionate care over the next 10 years and beyond. The implications of the findings for clinical practice, policy, administration, and research are discussed in more detail in the following sections.

Nursing Practice

As mentioned previously, there is a dearth of literature on the topic of compassionate care, nursing, and AI. Most of the included articles focused on robots and caring within health care in general, and there were mixed findings about the potential influence of AIHTs on the delivery of compassionate nursing care.

The integration of AIHTs into health organizations will have significant implications for nurses across all domains of practice. Implications for clinical practice were reported in the literature, with some articles discussing the potential for robots to reduce nursing workload by assisting with activities of daily living [21,64-67]. One potential unintended consequence of this emerging trend is the concern that nurses may actually spend less time with their patients or be given a larger patient workload as a result. Therefore, the implementation of these AIHTs in any practice setting must be closely monitored to ensure that nurses and other health professionals use them to augment and enhance care and not replace it.

Strong and proactive nursing leadership in all roles, sectors, and domains will be required to effectively implement these technologies in ways that preserve person-centered compassionate care. The new and evolving nursing care delivery models that are envisioned will require strong leadership from nurse executives, who will play a significant leadership role in identifying the requisite competencies for direct care providers who will be using AIHTs in practice.

New opportunities may arise for nurses to work as care coordinators, using AIHTs such as robots to assist with patient care activities or as case managers who remotely monitor a caseload of patients using smart home technology [13]. Nurses have been encouraged to imagine the possibilities that can be actualized through the convergence of nursing, technology, and caring [64,153]. Several articles in this review suggested new possibilities for the delivery of compassionate nursing care. For instance, using robotic devices to assist nurses may result in patients having their needs met in a timelier manner and the enrichment of the nurse-patient relationship [34,46-48]. Furthermore, in LTC settings, health professionals have reportedly used SARs to enhance resident care by reducing loneliness and improving mood among persons diagnosed as having dementia [36,55] and to provide comfort to patients at the end of life [34].

However, concerns have been raised that the use of robots in clinical practice is deceptive for some patients [57], creates tension [54], infantilizes older adults [34,55,56], and may promote culturally insensitive care [89], which could serve to weaken the therapeutic relationships among nurses and those they care for. Given these mixed findings, it is crucial that nurses understand the needs and preferences of residents, families, and caregivers before introducing SARs, and they must continuously monitor how the resident is responding to the robot [34,55]. Clarifying expectations about robots has been suggested as a means of preventing deception [53].

Finally, the delivery of person-centered compassionate care necessitates cultural sensitivity, and nurses must recognize the

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inability of robots to recognize cultural cues and respond appropriately [89]. It may be useful to hold forums for nurse leaders that will stimulate discussion about the best implementation approaches. This approach could help ensure that AIHTs are integrated into nursing practice in a way that aligns with compassionate care and other nursing values.

Nursing Policy

The results of this review identified the need to develop new policies to support the integration of AIHTs into nursing practice in ways that will promote patient safety and high-quality care. The integration of AI in nursing will require strong leadership to develop new policies and procedures to support new models of care, new nursing roles, new workflows, and potential changes to the nursing scope of practice. For example, it will be necessary for regulatory bodies to develop or revise standards of practice that articulate nurses' accountabilities for clinical judgment and decision making when using predictive analytics. To address these concerns, professional codes of ethics and standards of practice will require clear stipulations that the use of digital health technologies such as AI are intended to augment rather than replace nurses' clinical judgment [2,90]. In the United States, the American Nurses Association's *Code of Ethics for Nurses with Interpretive Statements* has begun to address this concern by stating, "Systems and technologies that assist in clinical practice are adjunct to, not replacements for, the nurse's knowledge and skill" [154]. In addition, policies are needed to promote patient safety and ethical practice because patients are at risk for harm related to technology failures [37], and privacy breaches could jeopardize patient information [35]. Finally, to ensure AIHTs do not accentuate health inequities, policy makers will need to ensure that there is adequate telecommunication infrastructure in remote areas so that AIHTs can be used in these settings [62].

Nursing Administration

The results of the review found numerous implications for nursing administration. Some articles discussed the use of AIHTs to assist nurses with automated analysis of patient data [69-76]. Other administration applications of AIHTs included scheduling nursing tasks [66], reducing documentation burden [80], and assisting nurses with triaging patients through AIHT computer systems [14], which could potentially aid in streamlining workflow processes and improving the efficiency and accuracy of patient care provided. It is also predicted that the integration of AI in nursing will give rise to new nursing care delivery models and new nursing administration roles [48].

Nursing Research

The paucity of literature has shown that the study of AI and compassionate care is still in its infancy, and more research on this topic is required. In addition, given that most research conducted on the topic of AIHTs and caring has focused on the use of robots, future research should explore how other types of AIHTs may influence the delivery of compassionate care. As AIHTs become increasingly integrated into nursing practice, it is also essential that increased support and funding is provided to identify best practices for optimal implementation across the care continuum. In collaboration with other health disciplines, nurses are in an ideal position to lead research on AI and compassionate care, given that compassionate care is a core tenet of the nursing profession.

Several authors have described the clinical and research expertise nurses can bring to the co-design of AIHTs [70,84]; however, this scoping review found minimal information regarding the current involvement of nurses in co-design. Our findings align with those of other authors who have noted the paucity of information regarding how nurses are involved in the co-design of AIHTs [91,92]. Given the valuable contributions nurses can bring to the co-design of these technologies, nurse executives should advocate for the establishment of clinical nursing informatics officers in health organizations to guide the procurement, design, and implementation of AIHTs. Increased nursing input in the co-design of AIHTs will help ensure that these technologies serve to enhance the delivery of compassionate care and not hinder it. Furthermore, nursing leadership will be needed at both the executive and staff nurse levels to promote nursing and patient engagement in co-design activities focused on AIHTs.

Limitations

Several limitations must be considered when interpreting the findings. Because of accessibility issues and organizational licensing restrictions, computer science and engineering databases were not searched for this scoping review, which may have led to research gaps. It is recommended that future reviews on the topic of AI and nursing use these databases. Non-English papers were excluded from this review, and the reference lists of included studies were not searched. Thus, it is likely that this review missed some relevant articles. In addition, as mentioned previously, for research question 1, the reviewers generalized the findings from articles that discussed *nursing and caring* to *nursing and compassionate care* because of the paucity of literature specifically pertaining to compassionate care. This approach uses an element of reviewer judgment while screening articles and may have influenced the final articles included in the review. Finally, the reviewers did not use Cohen kappa to calculate interrater agreement during title and abstract screening and instead used a percentage agreement (97% agreement). Although this was done for feasibility purposes, it is recognized that percentage agreement is not as reliable as Cohen kappa.

Conclusions

AI has already begun to shape nursing roles, workflows, and the nurse-patient relationship. To our knowledge, this is the first scoping review to have mapped the breadth and depth of evidence concerning the current and predicted influences of AI technologies on compassionate care and the domains of nursing. With the anticipated growth of AI in nursing, the findings of this review will help nurse leaders at all levels and across all sectors to proactively shape the nursing-AI interface, ensuring alignment with core nursing values that promote ethical, safe, high-quality, and person-centered compassionate care for patients, families, and caregivers.

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Acknowledgments

The authors would like to thank the steering committee for their ongoing contributions to this project: Jocelyn Bennett, Vanessa Burkoski, Connie Cameron, Roxanne Champagne, Cindy Fajardo, Cathryn Hoy, Vicki Lejambe, Lisa Machado, Shirley Viaje, Bethany Kwok, Kaiyan Fu, and Angela Preocanin. The authors also gratefully thank Marina Englesakis, information specialist at the University Health Network in Toronto, and Erica D'Souza for her assistance with project coordination. This project was jointly funded by Associated Medical Services (AMS) Healthcare and RNAO. The authors thank Doris Grinspun, chief executive officer (CEO) of RNAO, and Gail Paech, CEO of AMS Healthcare, for their support and contributions to this project.

Conflicts of Interest

None declared.

Multimedia Appendix 1
MEDLINE search strategy.
[DOCX File , 719 KB - nursing_v3i1e23939_app1.docx]

Multimedia Appendix 2
PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram.
[DOCX File , 16 KB - nursing_v3i1e23939_app2.docx]

Multimedia Appendix 3
Table of article characteristics.
[DOCX File , 64 KB - nursing_v3i1e23939_app3.docx]

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Abbreviations

AI: artificial intelligence
AIHT: artificial intelligence health technology
AMS: Associated Medical Services
CDSS: clinical decision support system
CEO: chief executive officer
IT: information technology
LTC: long-term care
ML: machine learning
RNAO: Registered Nurses' Association of Ontario
SAR: socially assistive robot

Edited by E Borycki; submitted 11.09.20; peer-reviewed by A Silva, E Mancinelli; comments to author 22.10.20; revised version received 05.11.20; accepted 06.11.20; published 17.12.20.

Please cite as:
Buchanan C, Howitt ML, Wilson R, Booth RG, Risling T, Bamford M
Predicted Influences of Artificial Intelligence on the Domains of Nursing: Scoping Review
JMIR Nursing 2020;3(1):e23939
URL: https://nursing.jmir.org/2020/1/e23939/
doi:10.2196/23939
PMID:

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Original Paper

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

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Abstract

Background: The growing number of patients with complex chronic conditions presents an urgent challenge across the Canadian health care system. Current care delivery models are overburdened, struggling to monitor and stabilize the complex needs of this growing patient population.

Objective: This qualitative study aimed to explore the needs and perspectives of patients and members of the care team to inform the development of an innovative integrated model of care and the needs of telemonitoring (TM) for patients with complex chronic conditions. Furthermore, we explored how these needs could be successfully embedded to support this novel model of complex chronic care.

Methods: A qualitative description design was utilized to conduct and analyze 29 semistructured interviews with patients (n=16) and care team members (CTM) (n=13) involved in developing the model of care in an ambulatory care facility in Southern Ontario. Participants were identified through purposive sampling. Two researchers performed an iterative thematic analysis using NVivo 12 (QSR International; Melbourne, Australia) to gain insights from examining multiple perspectives of different participants on complex chronic care needs.

Results: The analysis revealed 3 themes and 13 subthemes, including the following: (1) adequate health care delivery remains challenging for patients with complex care needs, (2) insights into how to structure an integrated care model, and (3) opportunities for TM in an integrated model of care. Participants not only identified continued challenges in accessing and navigating care in a fragmented and disconnected delivery system but also identified the need for more self-management support. Patients and CTM described the structure of an integrated model of care, including the need for a clear referral and triage processes and composing a tight-knit circle of collaborating interdisciplinary providers led by a nurse practitioner (NP). Finally, opportunities for TM in an integrated model of care were identified, including increasing access and communication, the ability to monitor specific signs and symptoms, and building a clinical workflow around TM-enabled care.

Conclusions: Despite entrenched health care service delivery models, a new model of care is acutely needed to care for patients with complex chronic needs (CCN). NPs are in a unique position to lead TM-enabled integrated models of care. TM can facilitate frequent and necessary monitoring of patients with CCN with more than one condition in integrated models of care.

(JMIR Nursing 2020;3(1):e15691) doi:10.2196/15691

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KEYWORDS

models of care; complex patients; multimorbidity; telemonitoring

Introduction

Background

Globally, approximately at least 1 in 3 adults suffer from multiple chronic conditions [1]. Nearly 40% of Americans have two to three chronic conditions, and 30% have four or more [2]. In Canada, it is estimated that 25% of the population has three or more chronic conditions [3]. In 2011-2012, 5% of the population accounted for nearly 65% of all health care spending in Canada, with heart failure (HF) and chronic obstructive pulmonary disease (COPD) being the diagnoses most responsible for acute care admissions [4]. Using the Ontario administrative data, another group found that high-cost users in the top 5% accounted for a greater admission rates, longer hospital stays, and alternate-level-of-care designations as compared with non–high-cost users [5]. Previous research demonstrates that adults who have high health care costs because of multimorbidity are also more likely to require more costly care in subsequent years [4,6].

Health Care Delivery

Traditionally, health care delivery has focused on disease specialization [7,8] (eg, individual conditions) creating vertical integration of services and forming silos, often leaving behind the broader context of multiple risk factors and multiple chronic conditions. Current practice models are overburdened and often under-resourced to comprehensively and holistically address, monitor, and stabilize the complex health care needs of this high-cost, high-risk population. Comprehensive clinical management and patient care can be complicated by complex interacting medical and psychosocial issues. Adding to this care challenge, clinical guidelines are typically only available for individual conditions [9]. Thus, finding evidence-based holistic strategies, rather than a single-condition approach, to promote health and manage chronic conditions is essential to meet the needs of patients with complex chronic needs (CCN) [10]. The challenges in addressing the needs of patients with CCN have resulted in growing calls for major change to the delivery of clinical care [11,12]. Ontario has recently put forth a new provincial strategy heavily focused on integrated care, a fundamental shift from previous health care delivery approaches. However, the reality of integrating care still depends in part on the needs of patients, carers, providers, administrators, and researchers in the context of their individual experiences [7]. Exploring these perspectives in the context of informing a new model of care to manage these multiple and interacting needs is necessary to move forward on improved integrated services.

Previous research has concluded that the most effective interventions to improve the care of patients with CCN include a combination of multipronged care strategies [10,13]. Many of these strategies may benefit from support of information and communication technologies such as mobile health (mHealth) and telemonitoring (TM). TM allows patients to collect health information at home and for these data to be automatically sent to providers at a distant location. Thus, TM provides an opportunity to challenge traditional care delivery approaches and to leverage a patient's ability to self-manage their condition(s) at home [14-18].

Telemonitoring

Several systematic reviews have concluded that the use of TM can lead to improved clinical outcomes [14,18-21] and reduced costs for various chronic conditions [17,19,22]. For example, TM has been shown to reduce all-cause mortality in HF [20,23], improve hemoglobin A_{1C} in patients with diabetes [24,25], improve blood pressure in patients with hypertension [24], and reduce the frequency of respiratory exacerbations in COPD [22]. One study showed a significant decrease in depression and anxiety using a secure telephone and video service [25]. However, several large HF TM trials have reported mixed benefits and, in some cases, null results [26,27]. It is possible that the effect is not only because of the technology itself but also because of which conditions or lack of condition(s) are targeted in the research. For example, the majority of TM research is delivered in specialty care settings focused on a single condition, such as HF care delivered at a specialty clinic. Direct integration with practices and systems may also be to blame for inconsistent trial results [27]. Previous research has concluded that "interventions targeted either at specific combinations of common conditions or at specific problems for patients with multiple conditions, may be more effective than a single disease intervention approach" [28].

Objectives

Unfortunately, there are limited examples of mHealth interventions developed specifically to support people with multiple CCN. This research presents a unique opportunity to contribute to this small but growing area of research to begin to develop a TM-enabled integrated care model informed by the needs of patients with CCN. Our study was guided by two research questions:

1. What are the needs and requirements of patients and their providers to develop an integrated model of care for patients with CCN?
2. How should TM be implemented and embedded in an integrated clinic model for patients with CCN?

Methods

Setting

Data collection was conducted at a large, ambulatory facility in Southern Ontario, Canada. This facility was recently funded to develop an integrated and comprehensive chronic disease management clinic to improve health care delivery and outcomes for patients with CCN. The goal of the clinic is to comprehensively address, stabilize, and clinically optimize short-term CCN using an integrated team-based approach. To support this goal, the intent was to study and implement TM in this clinic.

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Participants

Aligned with the vision of Margarete Sandelowski, a qualitative description design was utilized to incorporate multistakeholder perspectives into a new, unique model of care for patients with CCN. This approach was most appropriate for identifying varying needs and nuances of experience with which a TM system could be embedded and contribute to care delivery [28,29]. This approach was utilized to conduct qualitative semistructured interviews with patients and members of the care team [30,31]. As model development was in progress at the time of the interviews, researchers were interested in identifying how patient and provider needs could inform the integrated clinic model. Between June 2017 and September 2018, participants were recruited through purposive sampling during a soft launch period. All potential CTM consented to participate in this study. Team members including 2 physicians, 2 nurse practitioners (NPs), 2 registered nurses (RNs), 2 pharmacists, 1 social worker, and 4 administrators were recruited via email to ask if they would be interested in discussing their experiences in caring for patients with CCN. Interviews were conducted in person onsite or over the telephone, based on the preference of the care team member participant. Informed and written consent was obtained before all interviews. Patient participants were eligible to participate if they were at least 18 years old, were diagnosed with HF or diabetes as well as at least one other chronic condition, and could communicate in English [32,33]. The other conditions included hypertension, COPD, obesity, Parkinson disease, asthma, dyslipidemia, anemia, coronary artery disease, chronic kidney disease, stroke, osteoporosis, arthritis, gout, depression, or anxiety. Eligibility criteria for the model (outside of this inclusion criteria) included patients with multiple comorbidities, one or more inpatient hospitalization or two or more emergency visits within the last 6 months related to the chronic conditions, and a Length of stay, Acuity of admission, Comorbidities, Emergency department visits (LACE) score greater than 5 Exclusion criteria for this clinic included diagnoses of chronic pain, cirrhosis, dialysis, transplant, and severe dementia and long-term care residents. Patients were identified by NPs and recruited by the study coordinator (KG). Informed and written consent was obtained by the study coordinator. In some cases, a family member or caregiver signed the consent form if the patient was unable to sign independently. Given the role of caregivers in managing the needs of patients with CCN, the caregiver was invited to stay or asked to leave during the interview based on the patient's preference. Caregivers were not asked any specific questions during the interview. None of the patient or team member participants had ever utilized a monitoring technology or system.

All research activities were undertaken with ethics approval from the William Osler Office of Research Ethics (number 17-0008) and the University of Toronto Research Ethics Board (number 34581).

Qualitative Interviews

A semistructured interview guide was developed to facilitate an open and abductive discussion around CCN (Multimedia Appendix 1). The guide consisted of open-ended questions and exploratory prompts. At the beginning of each interview, the interviewer explained the objectives of the study ("to better understand the needs of patients with CCN and the needs of their CTM"). Prompts were used to dive deeper into the needs of the participants based on their experiences [29]. Team members were similarly asked to describe their perspectives related to managing patients with CCN in the context of the care model. Four care team interviews were conducted just before the soft launch of the model, and all patient interviews were conducted after the launch of the model. Participants were given the opportunity to ask questions at any time. Initially, 10 interviews were planned; however, additional interviews were conducted in both groups until data saturation was reached, meaning no new relevant information was discovered [34], and the sample size sufficiently answered the research questions [29]. Patient interviews lasted on average between 22 and 45 min, and care team interviews lasted between 28 min and just over 1 hour. The study coordinator had no relationship to the participants. All interviews were audio-taped and professionally transcribed verbatim.

Analysis

A qualitative description approach was used to thematically analyze the interview transcripts. Data were analyzed by two researchers (KG and PW). The two authors read and reread the transcriptions to become familiar with the data and to pull together detailed analysis of their contents. Initial codes were identified and synthesized into categories and themes. We coded questions around the needs, the model, and TM (deductive), but the subthemes emerging from these areas emerged from the data inductively. NVivo software version 12 was used to organize and inductively form a coding matrix based on the data. Both researchers independently coded the transcripts and met to discuss the findings. Analysis was iterative over a prolonged period of time (>1 year) as codes were reviewed and discussed until a consensus was reached. The transcripts were considered all together by looking at the data within each thematic grouping across participants. No follow-up interviews were conducted in this study.

Member checking is a technique used to explore the credibility and resonance of the results with the participants [35]. A member check of the synthesized analyzed codebook was undertaken by sharing codes, categories, and themes with five team member participants after the initial interviews [35]. These participants provided in-person feedback after the soft launch of the model.

The lead author (KG) is an RN who has worked extensively with patients with CCN. The second coder (PW) is trained as qualitative researcher with a background in implementation. Throughout the process, we acknowledged our experiences by creating memo logs and discussing our interpretations of the data, particularly during coding. This provided an important opportunity to reflect upon our implicit assumptions and potential biases during the analysis and writing process.

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Results

Overview

The needs and perspectives of patients (7 female and 9 male) and team members (12 female and 1 male) were organized into three core themes with relevant subthemes.

Theme 1: Adequate Health Care Delivery Remains Challenging for Patients With Complex Care Needs

Patients and care team participants described the management of their needs as, at times, being challenging and complex. Patients with CCN experience challenges such as multiple providers, multiple care sites, accessing comprehensive services, navigating care services, and utilizing self-management tools. Both participant groups suggested that these challenges are not well aligned within the current health care delivery model. Patients with CCN frequently cross care specialties and care sectors. Team members echoed the experiences of the patients in terms of the challenges in providing comprehensive care to this patient population with CCN.

Continued Lack of Access to Care Services

Patients overwhelmingly described a lack of timely access to important health care services when needed, including family physicians and specialists in the current care model. As one patient noted:

> *Sometimes it takes up to a week to see my family doctor.* [Patient (PT) 05]
>
> *I've had diabetes for quite a number of years. I was diagnosed with heart disease, and blood pressure problems two years ago... sometimes, you know, you want to get a doctor's appointment and you can't get in.* [PT 04]

Team members similarly experienced difficulties in scheduling sudden needs-related appointments in family medicine, for example, during an acute exacerbation of their conditions:

> *Unless it's absolutely urgent you can't get an appointment very quickly and it at least takes a month to get an appointment.* [CTM 01]

Even when patients are able to access an appointment quickly (whether with a family physician or a specialist), team members acknowledge that the time allotted per patient in a visit (typically 5-15 min) is insufficient to comprehensively address, assess, and treat a patient with multiple, and often interacting, complex needs. They acknowledged that these limitations place an added burden on the patient and reliance on self-management.

Challenges Navigating a Fragmented System

Several participants described their perceptions of complexity as contributing to their experiences of care fragmentation. For example, multimorbidity, such as the number or combination of conditions, was mentioned as a contributing factor to complexity, leading at times to fragmentation. As one patient stated:

> *It feels like all the health problems join each other.* [PT 01]

Other needs, often unrelated to any one specific medical condition such as sleep apnea, anxiety, or depression, were not typically addressed in family medicine or specialty care, thus contributing to complexity and splintered care experiences. Navigating through a fragmented delivery system, even when timely access to individual services is available, seems to remain a significant challenge without a clear point of contact. According to CTM, communication is particularly poor when coordinating between multiple providers and managing many medications:

> *I think part of the problem is they've got prescriptions from multiple providers and that's where the difficulty lies... a cardiologist will say this, the endocrinologist will say that, if they're followed by nephrology they might have a completely different set of instructions and so how do you coordinate the specialists' care plans or the specialists' treatment plans and make is [sense] for a patient?* [CTM 02]

Contributing to a sense of fragmentation is the gap in communication between patients and their inner circle in between visits:

> *Sometimes we just pawn patients off and we really don't know what happened because there is no communication until we see them for the next visit two or three months later.* [CTM 08]

Therefore, the lack of face-to-face time with providers, in addition to fragmented communication, can lead to frustrating and unfruitful interactions from the perspective of some of the patients interviewed:

> *Sometimes if you ask a lot of questions, it's almost like they lose patience with you. The heart doctor, sometimes I wonder if he's frustrated [of] me asking these questions, and it's that I get confused because I think, well, you're my heart specialist. Shouldn't [I] be getting all this information?* [PT 05]

Lack of Technology Interconnectedness

The continued lack of interconnectivity within monitoring technologies was identified by patients as particularly challenging. One story provided by a patient describes how their monitoring device could only be interpreted at one hospital with no ability to share that information to their wider care network. Another patient discussed how his glucometer could not send readings automatically to his providers. Abnormal readings were only identified when he brought the device in at the next appointment:

> *They have to wait until I get the meter back [to the clinicians]. As far as having sort of a running inventory of what's going on, they have no way of knowing. They're sort of out in the cold, waiting for me to come along and present them with a unit that says, hey, you missed this one [a reading], you missed that one.* [PT 06]

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Desire for Self-Management Tools in a Provider-Centric System

Patients expressed that they lacked access to tools such as educational resources or technologies needed to independently self-manage their care needs. CTM indicated that having time to discuss a patient's self-management goals and barriers would enable a foundation to build self-management education in an integrated patient-centered care model. When describing the available tools and services for patients with CCN, several patients felt that their current providers lacked treatment options to meet their needs. In many cases, interacting and competing symptoms were too overwhelming to coordinate a lasting solution:

> *My family doctor...during my last visit, stood in front of me and said, "well, I don't know what I can do for you anymore, I've run out of alternatives," which made me feel that I needed something more, some whole evaluation of what was actually going on with me.* [PT 06]

Although CTM value the notion of patient-centered care, they acknowledge that the current model of care remains too provider-centric vs patient-centric to support patients in the engagement of self-management:

> *The point of care around collaborative and self-care planning... we really want to move away from being the clinical expert and being provider centric. We want to really be saying, our engagement with you as a patient or as a family member is about partnership and I think that's critical when it comes to self-management.* [CTM 07]

Theme 2: Insights Into Structuring an Integrated Model of Care

As part of the needs assessment, participants were asked specifically about how they could envision a care model that would meet their needs. In particular, researchers were interested in understanding how patients with CCN could be identified and referred into this type of care model, which type of providers should be a part of an integrated team, and how long should patients be followed up in this unique care model.

Need for a Structured Referral and Triage Process

Team members felt strongly that a structured identification, referral, and triage process should be based on the patient's complex care needs, the number of diagnosed conditions, and recent emergency department visits/hospitalizations. Team members described the types of patients who would benefit from this new integrated model of care, such as high-risk patients streamlined for early discharge and patients who had at least two previous visits to the emergency department in the past 6 months:

> *Looking at patients who are readmitted within 28 days to hospital, recurring admissions, recurring ED visits. We're going to try to focus on those people who obviously need the help and figure out a way to get referrals from those, tracking those people.* [CTM 01]

Working with primary care, local emergency departments, and urgent care facilities within the care network was also important in identifying high-risk patients in need of immediate stabilization but not necessarily hospitalization. Several participants acknowledged that there was no pathway for patients with CCN to obtain frequent monitoring and stabilization except going back to the family physician:

> *I think we're going to see the patients for whom the primary care provider just feels, I can't make all the connections. I need to send them somewhere for stabilization then I want them to come back with a care plan that makes sense for me.* [CTM 02]

Creating a Circle of Care

Both patients and CTM spoke of the potential advantages of creating a circle of care around the patient in this new care model. Specifically, a relatively tight-knit circle of collaborating multidisciplinary providers (ideally in one physical location) was described as an optimal model:

> *A lot of the patients can be managed by the RN. So, the NP will stabilize them, establish an initial plan of care and then the RNs could be almost seen to be as care navigators, so bringing in the dietician, social worker, kinesiologist when it's needed but I see that team developing an initial care plan for the patient. Having them come back maybe every two to three months, seeing if we can stabilize them but eventually they'd be discharged back to primary care.* [CTM 02]

Several CTM strongly felt that a multidisciplinary team–based approach would most support the unique needs of patients with CCN. When probed, they identified specific roles such as nursing, social work, pharmacy, and dietary services as being important roles to include in creating an integrated team-based clinic for patients with CCN. Specialists, such as cardiologists and internists, were seen as being necessary peripheral resources that they could utilize when clinically necessary, outside of the routine or immediate integrated care management in this model. These specialists were viewed as critical contributors when the complex needs of the patient are in more advanced states or out of the NP's scope of practice. Participants viewed family physicians as outside of this internal integrated model of care, so they could organize their needs in one place, in the period between hospitalization and repatriation to family medicine:

> *Even if you don't think you need it, I think when you get that complex there's usually social work type issues depending on the social status of the patient...[Specialists] to me are sort of the outer circle of care.* [CTM 02]

Patient and provider participants unanimously felt confident in the role of an NP as the central clinical and coordinating provider. Team members noted that the role of the NP could be as a gatekeeper coordinating complex care between family medicine and specialty care services. This circle of care was described as not to replace the patients' current providers but rather to bring together and better coordinate services around the patients' complex needs through more frequent monitoring:

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> *We are trying to avoid multiple people and multiple visits...I see the gatekeeper as being the NP [at the] point of entry to understand all the specialty needs of the patient... and then the team all having a chance to review that patient's care.* [CTM 12]

> *It's good, the attention [from the NP]—normally I feel like I have to, like, just view and try to get in the most important stuff down, you know, just... health stuff, but it's that whole thing of being on-edge for not having time to talk about something [my needs].* [PT 16]

As the implementation was underway, we were interested if there were other providers that could contribute expertise to this novel care model. In several cases, a respiratory therapist was identified as a role that could greatly contribute to the patient's care, particularly for patients with COPD and asthma. Family members were also identified as critical members in this new model of care for both participant groups.

Length of Clinic Enrollment

Overall, the team members felt that a needs-based approach should be taken when determining how long patients should be enrolled in this unique care model for complex management:

> *It depends on the patient need. We are thinking 6 months. But with the complex cases, elderly, multiple complex things going on with the patients we would extend it, probably 12-18 months.* [CTM 12]

When probed, 6 to 12 months was seen as an estimated average period for stabilization of complex needs and to repatriate care back to the family physician:

> *It's not a forever clinic. So you stabilize and try and get a solid plan in place, and then they're discharged... I personally think six months might be a good goal... hopefully you can get a plan that will stabilize.* [CTM 04]

Overall, most patients were unsure of the right amount of time for optimal stabilization, but some of them felt strongly that it should be based on their individual needs at the time.

Theme 3: Opportunities for Telemonitoring in an Integrated Model of Care

Participants were interested in the potential opportunities for TM in an integrated care model for patients with CCN. The ability to utilize TM to enable communication within the circle of care and between patients while improving access to care through frequent monitoring was a strong incentive. Participants described an alignment with monitoring physiological metrics already routinely measured as part of self-care. For example, a patient with HF is typically instructed to record daily weight and/or blood pressure readings as part of their care plan. TM could also present new opportunities to monitor more than one condition from a distance and facilitate face-to-face video visits, where more context around a specific reading could be provided and communicated to the team. However, team members felt a new clinical workflow would be required to facilitate this TM-enabled triage and workflow.

Enabling Communication Within the Circle of Care

The ability to communicate within the circle of care (eg, on ongoing patient monitoring, clinical assessment, patient evaluation, and care improvement) was identified as one of the strongest potential incentives for using a TM system by team members. As one care team participant noted, the ability to see a daily trend could inform clinical discussions as an integrated team:

> *[The ability] to see if there's a trend and letting the team know, okay maybe we should sit down and talk about this patient, I think we need to bring them in sooner...[It] allows us to more closely check their status to see if whether or not we should bring them in earlier or should consider admitting the patient.* [CTM 09]

Increasing Access to Care Through Frequent Monitoring

Not all participants were aware of TM and even fewer had experiences with this type of technology. However, both groups discussed the potential opportunities of TM for patients with CCN. Several participants noted the opportunities for more frequent monitoring such as an opportunity for early identification of HF patient decompensation and coordination of care within the integrated team. One team member even postulated how improving access to care services utilizing TM could reduce avoidable visits to the emergency department or hospital:

> *I think it enhances accessibility to the clinic and patients with chronic medical problems are always unpredictable. You never know when an event is going to take place so I think that if they had accessibility...but you can prevent medical crises, you can prevent presentations to emergency... if they could access because sometimes it's just a quick question or sometimes it's more serious.* [CTM 03]

Important Telemonitoring Features

Patients identified how TM could be a useful technology for monitoring metrics they already routinely measure such as blood pressure, weight, and blood sugar. Patients also expressed an interest in the ability to monitor symptoms such as difficulty in breathing, sleep patterns, and anxiety. Many existing TM systems alert clinicians if the parameters fall outside a target or normal range, and participants had different preferences with respect to the modality for receiving these alerts (eg, email, text, and call):

> *For me, it [TM] could help, it would really help me to manage my conditions better, my diabetes readings, my cholesterol readings, my high blood pressure. It probably would alert me when things are coming pretty close to the edge, you know? I think I'd benefit from it.* [PT 01]

Similarly, team members described the perceived usefulness of monitoring specific symptom trends and mental health conditions (eg, depression and anxiety) known to be prevalent in this population:

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> *We also see a lot of mental health and depression is very common with patients with chronic disease and it affects the patient's ability to self-manage...so having some sort of help mental health wise, I think, this [telemonitoring] would really help. I would say the majority of our patients do have depression and some people have some complex mental health issues.* [CTM 01]

In addition to an ability to track condition-specific parameters, team members identified the need for features that facilitate communication processes and care coordination. For example, several team members noted that patients would benefit from a comment section or face-to-face video, where more context around a specific reading could be provided and communicated to the team:

> *Having room for comments to explain if they are having a symptom, and they can explain what's new or what's different so that we could figure out why is this happening at this time... These are just values and they mean nothing without the context.* [CTM 10]

Building a Clinical Workflow Around Telemonitoring-Enabled Triage

Providers felt that clinical notification and alerts could be managed by an RN. Several team members discussed the opportunity to utilize a triage process similar to that of routine clinical practice, for example, triaging calls or TM alerts as clinically necessary to the most appropriate clinical provider (RN to the NP and NP to the physician) on a case-by-case basis:

> *I actually think the RN should be alerted—and she can triage what the situation is and depending on the situation she can notify the NP.* [CTM 01]

Team members felt it was important to identify explicit criteria and create a formal triage process for alerts within the workflow in advance of implementing a TM system for it to effectively support this integrated model of care. In particular, they felt it is within the scope of practice of an RN to act on the information provided by the patient through TM. Participants also felt that operating procedures that outline these explicit criteria should be based on the context of the clinic and an individual's workload. For example, participants questioned the responsibility of monitoring on evenings and weekends:

> *There needs to be clear criteria for why you would notify the physician. I'm speaking now as a physician, so that you know up front the reasons and you've agreed with the reasons and they're acceptable to you. I think the way that doctors triage in their mind is different than let's say the way that the pharmacist might triage... or the dietician, and so the team has to decide in advance when different members are going to be notified and about what they're going to be notified.* [CTM 13]

Potential Challenges

Participants identified several potential challenges to utilizing TM in this population, including tech-savviness and physical constraints (eg, vision impairments and manual dexterity concerns). Language was also identified as a potential challenge to consider when implementing TM in an integrated model of care for patients with CCN. Both participant groups suggested that language translations should be tailored to the population.

Promoting Self-Management

Finally, providers spoke of how TM might influence a patient's accountability in managing their own care by connecting more frequently with their care team:

> *I think for sure the connection to the clinician, that virtual connection is invaluable to the patient. Not only from feeling secure and feeling that someone's there to help...I think just that information that's being collected, that helps the patient understand their disease and their response to disease as well. They become more knowledgeable about what's going on with them.* [CTM 04]

Some patients suggested it would help them manage their conditions better while hopefully avoiding unnecessary exacerbations, but none of them specifically mentioned accountability:

> *For me, it [TM] could help, it would really help me to manage my conditions better, my diabetes readings, my cholesterol readings, my high blood pressure. It probably would alert me when things are coming pretty close to the edge, you know? so I think I'd benefit from it.* [PT 01]

However, participants maintained that although the need for engagement is important in self-management, TM may not be for everyone. Patients suggested that those familiar with technology may be more inclined to participate in a TM program. Several patients also suggested that regardless of their current conditions, those familiar with technology may adhere to taking TM measurements differently.

Discussion

Principal Findings

This paper provides an overview of the needs of patients and clinicians in developing an integrated care model for patients with CCN and the needs of TM. Study findings revealed that significant gaps remain in meeting the needs of patients with CCN in current health care delivery practice [36,37]. Patients continue to navigate a fragmented care system [36] between primary care and siloed specialty care, creating challenges to timely access and care management. Previous literature has well documented this *complexity challenge* to include the lack of availability, ineffective needs-based accommodation, and poor accessibility for those managing multiple conditions across fragmented care sectors [38]. The complexity framework describes complexity as the number of diagnosed conditions (eg, multimorbidity), and also encompasses dimensions of other interconnected care needs such as biopsychosocial factors, sociopolitical factors, and the physical environment [39]. For example, Wagner's Chronic Care Model provides key insights that focus on quality of life, function, and on disease control while tailoring treatment to the individual's needs [40]. Our

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findings resonate with these studies by describing complexity in part because of multimorbidity (eg, relevant to the complexity of managing multiple, interacting conditions, and self-management concerns), complexity in terms of health care utilization (the lack of access, high cost, and readmission rate), and complexity because of psychosocial factors (mental health and other cultural factors). Furthermore, Wagner's framework supports a collaborative, integrated care model that relies in part on the reorganization of health care *delivery system design* to support patients with CCN [40]. Identifying these needs and reorganizing care delivery will transform these gaps into practice opportunities that start to frame needs-based care for patients in an integrated model.

An integrated NP-led model of care focused specifically on patients with CCN would align with sustained calls for a common trajectory of multimorbidity and chronic disease management that focuses on patients from a more holistic and needs-based perspective [9,37]. Our findings suggest that a colocated model with a primary clinical contact can address the challenges faced by patients and clinicians in ambulatory care. Collaboration and coordination depend on an individual clinician who acts as a central coordinator of a patient's needs as well as the needs of the interdisciplinary team to care for the patient. Other authors have described the need for *a connector* to *manage health*, someone for patients with CCN to rely on in times of critical need within the system [41]. Haggerty further suggests this individual should be one with the most comprehensive clinical knowledge of the patient. On the basis of our interviews, NPs are in this unique position to lead comprehensive and frequent management of complex needs [42]. Findings revealed that participants felt confident in the NP's role to facilitate complex care within an integrated model. In fact, several participants described their reliance on the NP and integrated team to manage their needs, despite likely entrenched knowledge of traditional models of care delivery (eg, primary care and specialty care) and conventional leadership roles of medical providers (eg, physicians and nurses). In Canada, although NPs have been in practice since the early 1970s [43], role recognition outside of primary care [44] and funding [45] remain significant barriers to clinical practice, role familiarity, and scope expansion. Integrated colocated models of care are historically entrenched within primary care. A recent systematic review found 38 primary care articles that referred to colocated teams [46]. However, our findings suggest this level of care coordination is not consistent in either primary or specialty care for patients with CCN, thus creating gaps. To be clear, our intention is not to suggest a replacement to primary care but to detail findings that suggest a more step-down approach to ambulatory care for patients with CCN, particularly after an emergency department visit or hospitalization. Flexibility in building new models of care is required to position this type of unique model of complex care between traditional primary care and specialty care delivery.

Furthermore, this study identified the need for a comprehensive care approach within the model for nontraditional conditions such as specific mental health conditions (eg, anxiety and depression) in patients with CCN. And yet, recent evidence suggests this may be an oversimplification. Previous studies have suggested that closely linking physical and mental health in an integrated care model could inadvertently undermine the mental health treatment if physical management becomes privileged in care plan [47]. Along with others, we suggest embedding designated mental health providers within an integrated care model for patients with CCN to establish a therapeutic approach to care integration.

Finally, the identification of electronic health technologies that could be used to support innovative models of care through user-centered design is equally important for patients with often multiple CCN [48]. Both participant groups were interested in the idea of utilizing TM to support the needs of patients with CCN. Specifically, potential benefits included increasing accessibility to care services while providing a tool to improve self-management. Although this resonates with previous research on the value of TM for single chronic conditions [19-21,23,49], our findings suggest that TM needs to facilitate the management of more than one condition to be relevant within a colocated integrated model. These findings build on this literature, identifying features valuable to patients specifically with CCN, including the ability for patients to comment on specific readings or symptoms and face-to-face conferencing to reduce the need for in-person visits [50]. TM aims to support patients in the self-management of their condition(s) and improve communication and coordination within the circle of care [51,52]. In addition, developing a structured clinical workflow around TM-enabled triage will ensure that all team members, including patients, have clearly defined responsibilities within this novel integrated care model.

Our findings, along with previous research, suggest that TM could be successfully embedded in a novel integrated model of care, specifically for patients with CCN. We offer the following perspectives for clinicians, administrators, and policy makers to consider in developing integrated care models for patients with CCN:

1. A new model of integrated care is required to manage patients with CCN.
2. NPs are in a unique position to lead an integrated, ambulatory model of care for patients with CCN. NPs can facilitate frequent monitoring and coordination between the interdisciplinary team and across care sectors.
3. TM would be instrumental to support patients with CCN in integrated models of care.
4. TM can be managed by an RN, triaging and delegating when clinically indicated.
5. Key features of TM include routine monitoring metrics that patients with CCN already routinely measure (blood pressure, weight, and blood sugar) as well as direct text messaging, face-to-face video communication, and comment fields.

Using the subthemes identified, an initial care model map was drafted of an NP-led integrated care model with an embedded TM system (Figure 1). Future research will explore the feasibility of implementation of TM within this type of integrated care model. Finally, a larger evaluation is necessary to determine if TM in this model can alter patient, process, or

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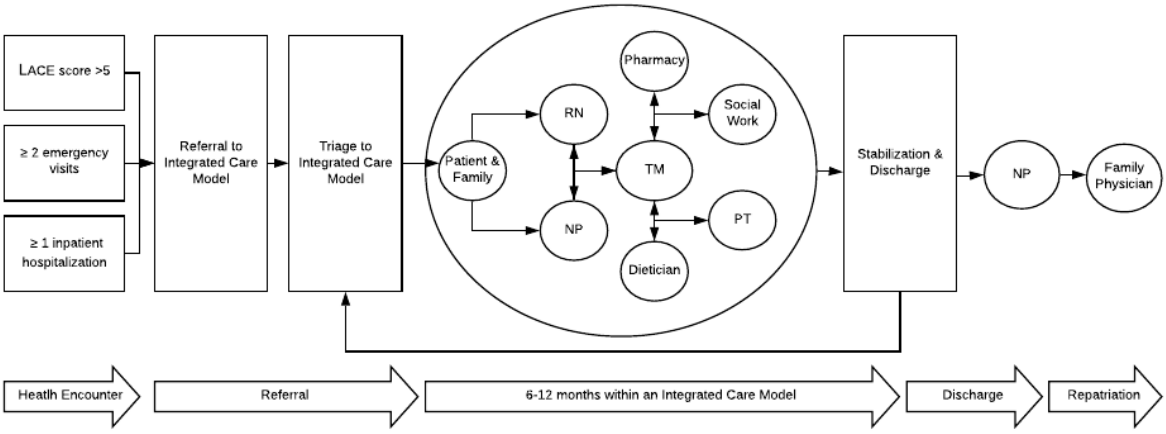
organizational outcomes, such as mitigating acute exacerbations in chronic conditions.

Figure 1. A care model map of a nurse practitioner–led integrated care model with an embedded telemonitoring system. LACE: Length of stay, Acuity of admission, Comorbidities, Emergency department visits; NP: nurse practitioner; PT: patient, RN: registered nurse; TM: telemonitoring.



Strengths and Limitations

An inductive qualitative description approach enabled researchers to obtain rich perspectives from a diverse group of participants. The interview guide was intentionally broad to capture an array of needs from multiple perspectives including on TM. However, due to time and resources, family members and caregivers were not specifically interviewed in this study, which may have limited the identification of complex care needs. In addition, this study was conducted at a single organization within a single health network, which could have limited the generalizability of the findings. However, this exploration of the needs of patients with CCN may provide valuable insights to other health care organizations across Canada looking to innovate and integrate health service delivery in ambulatory care. A mixed method study is now well underway to pilot the feasibility of embedding a mHealth-based TM system into this unique integrated model of care for patients with CCN. Future work will evaluate the components of integrated care in conjunction with the TM features necessary to meet the needs of patients with CCN.

Conclusions

Although developing innovative models of care creates clear challenges within the currently entrenched health care service delivery models, the demand for change is only growing. NPs are in a unique position to lead integrated, colocated, and multidisciplinary teams with comprehensive and holistic approaches to person-centered chronic disease management. Patients are confident in NP-led teams managing complex chronic care and suggest they are in a position to address their needs from a central point of contact. Because of inadequate health care delivery, patients are seeking opportunities outside of traditional care delivery models to seek better experiences within the health care system. These participants are open to new technology, such as TM, to address the current gaps in care, such as lack of access, challenges related to their complexity, and/or multimorbidity and communication discontinuity. TM within NP-led integrated care models is an opportunity to facilitate frequent and actionable monitoring of patients with more than one condition. Finally, developing a structured clinical workflow around TM-enabled triage will ensure that all team members, including patients, have clearly defined responsibilities within this colocated, integrated model of care for patients with CCN.

Authors' Contributions

KG led the overall design, data collection, data analysis, and write-up of this study. CG, KD, JD, and ES each contributed to the design. PW contributed to the analysis and interpretation of the qualitative data. All authors reviewed and edited the manuscript. All authors read and approved the final version of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Semistructured interview guide.
[DOCX File , 20 KB - nursing_v3i1e15691_app1.docx]

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Abbreviations

CCN: complex chronic needs
COPD: chronic obstructive pulmonary disease
CTM: care team members
HF: heart failure
LACE: Length of stay, Acuity of admission, Comorbidities, Emergency department visits
mHealth: mobile health
NP: nurse practitioner
PT: patient
RN: registered nurse
TM: telemonitoring

Edited by E Borycki; submitted 01.08.19; peer-reviewed by S Chokshi, T Rashid Soron, R Pankomera, K Nicholson; comments to author 09.10.19; revised version received 31.10.19; accepted 23.01.20; published 06.03.20.

Please cite as:
Gordon K, Steele Gray C, Dainty KN, DeLacy J, Ware P, Seto E
Exploring an Innovative Care Model and Telemonitoring for the Management of Patients With Complex Chronic Needs: Qualitative Description Study
JMIR Nursing 2020;3(1):e15691
URL: https://nursing.jmir.org/2020/1/e15691/
doi:10.2196/15691
PMID:

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Review

Mobile Health Apps That Help With COVID-19 Management: Scoping Review

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Abstract

Background: Mobile health (mHealth) apps have played an important role in mitigating the coronavirus disease (COVID-19) response. However, there is no resource that provides a holistic picture of the available mHealth apps that have been developed to combat this pandemic.

Objective: Our aim is to scope the evidence base on apps that were developed in response to COVID-19.

Methods: Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for scoping reviews, literature searches were conducted on Google Search, Google Scholar, and PubMed using the country's name as keywords and "coronavirus," "COVID-19," "nCOV19," "contact tracing," "information providing apps," "symptom tracking," "mobile apps," "mobile applications," "smartphone," "mobile phone," and "mHealth." Countries most affected by COVID-19 and those that first rolled out COVID-19–related apps were included.

Results: A total of 46 articles were reviewed from 19 countries, resulting in a total of 29 apps. Among them, 15 (52%) apps were on contact tracing, 7 (24%) apps on quarantine, 7 (24%) on symptom monitoring, and 1 (3%) on information provision. More than half (n=20, 69%) were from governmental sources, only 3 (10%) were from private organizations, and 3 (10%) from universities. There were 6 (21%) apps available on either Android or iOS, and 10 (34%) were available on both platforms. Bluetooth was used in 10 (34%) apps for collecting data, 12 (41%) apps used GPS, and 12 (41%) used other forms of data collection.

Conclusions: This review identifies that the majority of COVID-19 apps were for contact tracing and symptom monitoring. However, these apps are effective only if taken up by the community. The sharing of good practices across different countries can enable governments to learn from each other and develop effective strategies to combat and manage this pandemic.

(JMIR Nursing 2020;3(1):e20596) doi:10.2196/20596

KEYWORDS

COVID-19; mobile apps; mHealth; contact tracing; symptom monitoring; information provision; mobile health

Introduction

The novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1], manifests the coronavirus disease (COVID-19) and was first identified in Wuhan, China in December 2019 [2]. It first presented as severe cases of pneumonia of unknown origin and was identified as a coronavirus in January 2020 [3]. SARS-CoV-2 affects individuals of all ages and spreads through droplets when the infected individuals cough or sneeze [3]. The droplets can still be infectious even after deposition onto surfaces. Infection occurs when these droplets are inhaled or when the contaminated surfaces are touched followed by the touching of one's eyes, nose, or mouth. Transmission of infection is possible during its

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incubation phase (2-14 days), and common symptoms include fever, cough, sore throat, headache, myalgia, fatigue, and breathlessness [3]. The symptoms and manifestations vary greatly among individuals; some have serious consequences like acute respiratory distress syndrome and organ failure, while others can be asymptomatic [3]. Older adults and individuals with comorbidities like diabetes, hypertension, and cardiovascular problems are more susceptible and can manifest more severe symptoms when infected [4].

Since the public announcement of the first few cases, SARS-CoV-2 has spread worldwide and was declared as a pandemic on March 11, 2020, by the World Health Organization (WHO) [5]. As of August 1, 2020, there were over 17.9 million cases recorded and over 680,000 deaths due to COVID-19 [6]. As COVID-19 spread worldwide into countries with different health systems and responses, the number of infected cases constantly changed. To control its spread, several prevention strategies were adopted by various countries. These strategies included self-isolation and quarantine for individuals who were suspected cases of infection or showed mild symptoms [3], wearing of face masks, and adherence to hygienic practices [3]. Public gatherings were also avoided to limit the number of close contacts among individuals [3]. During the first wave of COVID-19, various mobile health (mHealth) apps were rapidly developed in response to tackle the virus.

The first COVID-19 apps that were developed and widely publicized were contact tracing apps, which were created to notify its users if they had crossed paths with another person infected with the coronavirus [7]. The first national app was developed in Singapore, which used Bluetooth technology for contact tracing [8]. If someone was in close proximity with an infected individual, the app would send a push notification to alert them of possible COVID-19 infection and further suggest that they undergo testing [9]. The technology was made open source and shared internationally for other countries to build similar apps for their own populations [10-12]. Since then, there have been various other types of contact tracing apps available, each using different methods of data collection to track the movements of its users.

Symptom monitoring apps have also emerged in response to COVID-19. These apps commonly collect information about the user's health by posing a list of questions related to symptom identification, from which a differential diagnosis is made [13]. However, other innovative methods have also been used, such as automatic collection and recording of the user's health-related data (eg, temperature and pulse rates) from wearables like wristbands [14,15]. In the case of a suspected COVID-19 infection, the user is alerted and advised to go for a checkup at a nearby clinic.

The importance of credible information that can be provided in a timely manner to the public has in part been addressed by some of the information providing apps developed for COVID-19. Information providing apps give details about the coronavirus, disease, good hygiene practices, and guidelines to follow, like social distancing and the importance of wearing face masks [16-19]. However, during the initial stages of the pandemic, the mHealth markets saw the emergence of developers who were trying to take advantage of the situation by creating fake apps [20], as well as ransomware apps that mandated users to transfer money and threatened deletion of the phone's storage if money was not transferred [21]. There were also large amounts of misinformation on the internet [22]. In response, the WHO worked with Google as well as popular social media sites like Facebook, Twitter, Tencent, and TikTok to combat this misinformation [23]. Furthermore, steps were taken by social media apps like Facebook, YouTube, Twitter, Instagram, and Snapchat to limit the rapid spread of misinformation to their massive audience reach [24]. In addition, Apple and Google made efforts to regulate COVID-19–related apps released in their app stores, only allowing apps developed by credible organizations [25]. WhatsApp, a popular communication app, also limited the number of times users could forward messages related to COVID-19 to reduce the spread of misinformation about the coronavirus [26].

Amid the rapidly evolving COVID-19 environment, mHealth apps have been playing an important role in mitigating the COVID-19 response, but to date, there has not been any overview and comparisons of the mHealth apps that have been developed to combat this pandemic. The aim of this review is to scope the evidence base for articles that described apps that were developed in response to the COVID-19 pandemic. This paper categorizes and compares the available apps by providing a description of these apps, their purposes, and the features employed. A recommendation of useful features is also provided for developers and interested stakeholders.

Methods

This review was conducted following the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) extension for scoping reviews [27]. The search period for information was from March 25, 2020, to May 5, 2020, when the outbreak rapidly spread to all parts of the world, including the United States [28]. Google search, Google Scholar, Scopus, and PubMed were used to find apps specific for each country. Considering the rapid pace of articles being published on COVID-19, Google Scholar, Scopus, and PubMed were selected, as these were common databases used by clinicians and would encompass a broad scope of journal articles that would be relevant to clinical and public health practices. The keywords used were: "coronavirus," "COVID-19," "nCOV19," "contact tracing," "information providing apps," "symptom tracking," "mobile apps," "mobile applications," "smartphone," "mobile phone," and "mHealth," and the country names from the top 10 countries that had the greatest number of COVID-19 cases as of April 27, 2020. These countries were China, France, Germany, Iran, Italy, Russia, Spain, Turkey, the United Kingdom, and the United States [6]. Another 9 countries were added to the list, as they were among the first in releasing apps specific for COVID-19 based on articles found during the initial stages of the research from the period of March 25, 2020, to April 1, 2020. These countries included Hong Kong, Iceland, India, Indonesia, Malaysia, Poland, Singapore, South Korea, and Taiwan.

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Due to the rapidly changing nature of the COVID-19 pandemic, the main sources of evidence were mainly from online news articles. Information from government websites and health departments of different countries were also reviewed as they were considered to be credible sources and would have the most up-to-date information available for the country [1,5,13,29,30]. Selected articles were limited to the first 10 pages of the Google search results, after which the articles were found to be irrelevant to COVID-19. All articles included in our review were after December 9, 2019, which was the day when the first infection was reported in China [2].

The inclusion criteria were articles that had a clear description about the features used in the apps. Articles from December 9, 2019, to May 5, 2020, were included. Apps that were not relevant to the disease and those that were in a language other than English were excluded. If the articles had limited information about the app, such as type of feature used, a second Google search was conducted with the specific app-related parameters to source for further information. This ensured that a complete profile of each app was obtained.

Results

Overview

A total of 46 articles that described apps from 19 different countries were reviewed (Figure 1). Most of the articles were from news sites, health care organizations, and government sites. The majority (13/19, 68.4%) of the countries studied either already had contact tracing apps or the apps were under development, followed by symptom monitoring apps (6/19, 31.6%). There was 1 app from Malaysia that had both symptom monitoring and information providing abilities (MySejahtera) [31]. Some countries like Italy, France, Germany, and 1 app from Malaysia were in the process of developing apps for contact tracing [31-34]. There was 1 global app found in the review [35].

Of all the apps evaluated (N=29), there were 14 (48%) apps on contact tracing alone, 1 (3%) app with both contact tracing and quarantine features, and 6 (21%) apps purely for enforcing quarantine (n=15 for contact tracing, n=7 for quarantine). Similarly, there were 5 (17%) apps on symptom monitoring alone, 1 (3%) app having both symptom monitoring and information provision features, 1 (3%) app with symptom monitoring feature and for research purposes, and 1 (3%) app was solely for research purposes (Table 1). There were 20 (69%) apps released from governments, 3 (10%) from private organizations, and 3 (10%) from universities. There were 3 (10%) apps that did not provide information about their source; 4 (14%) were web-based, 6 (21%) were available on only Android or iOS, and 10 (34%) were available on both platforms. There were 12 apps (41%) that did not provide information on their platform availability. In terms of the technology used, 10 (34%) apps used Bluetooth for collecting data, 12 (41%) apps used GPS, and 12 (41%) used other forms of data collection such as manual input of details and questionnaires.

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Figure 1. Flowchart of methodology. COVID-19: coronavirus disease; mHealth: mobile health.

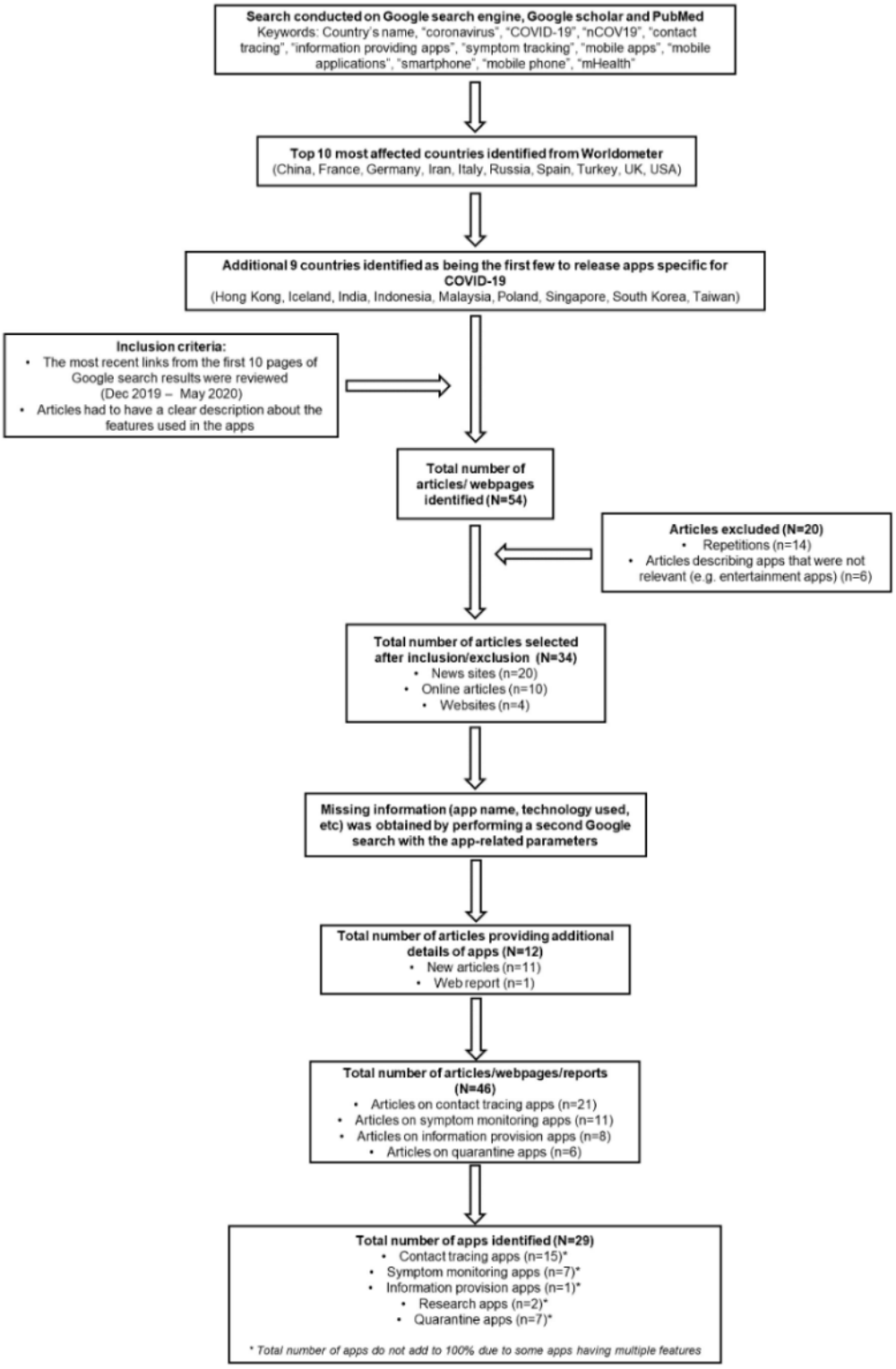

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Table 1. Mobile health apps related to COVID-19[a] (N=29).

Country, App name	Organization/institution	Platforms	Purpose					Technology/method used to collect data		
			Contact tracing (n=15)	Symptom monitoring (n=7)	Information provision (n=1)	Research (n=2)	Quarantine (n=7)	Bluetooth (n=10)	GPS (n=12)	Others (n=12)
China										
Beijing Cares [36,37]	Government[b]	N/A[c]	✓							Input of daily temperature
France										
Under development [33]	Government	N/A	✓					✓		N/A
Germany										
Corona-Datenspende [14,15]	Government	iOS[d] and Android[e]		✓		✓				Smartwatch monitoring
Under development [34]	Government	N/A	✓							N/A
Hong Kong										
StayHome-Safe [29,38]	Government	iOS and Android					✓	✓	✓	Includes a wearable device and uses Wi-Fi and geospatial signals
Iceland										
Rakning C-19 [39,40]	Government	iOS	✓						✓	N/A
India										
Corontine [41,42]	University[f] (Indian Institute of Technology)	Android					✓		✓	N/A
GoCorona-Go [43]	University (Indian Institute of Science)	N/A	✓				✓	✓	✓	N/A
Aarogya Setu [44]	Government	N/A	✓					✓		N/A
COVID-Locator [45]	N/A	N/A	✓						✓	N/A
Indonesia										
PeduliLindungi [46]	Government	N/A	✓					✓		N/A
Iran										
AC19 [47]	Government	Android		✓					✓	Questionnaire
Italy										

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Country, App name	Organization/institution	Platforms	Purpose					Technology/method used to collect data		
			Contact tracing (n=15)	Symptom monitoring (n=7)	Information provision (n=1)	Research (n=2)	Quarantine (n=7)	Bluetooth (n=10)	GPS (n=12)	Others (n=12)
Under development [32]	Government	N/A	✓					✓		N/A
Malaysia										
Under development (MySejahtera) [31]	Government	N/A		✓	✓					Self-input
MyTrace [48]	Government	Android (iOS under development)	✓					✓		N/A
Poland										
Home Quarantine [49,50]	Government	iOS and Android					✓		✓	Capturing a selfie
Russia										
Social Monitoring [51]	Government	iOS and Android					✓		✓	N/A
Singapore										
TraceTogether [7]	Government	iOS and Android	✓					✓		N/A
COVID-19 Symptom Checker [13]	Government	Web[g]		✓						Questionnaire
South Korea										
Corona 100m [30,52-54]	Private organization[h]	iOS and Android	✓						✓	Government surveillance data (ATM[i] transactions and surveillance data)
Self-quarantine Safety Protection [55,56]	Government	iOS and Android					✓		✓	N/A
Spain (Community of Madrid)										
Asistencia-COVID-19 [57,58]	Government	Web, iOS, and Android		✓						Questionnaire
Taiwan										
Not available [59,60]	Government	N/A					✓			Mobile signals
Turkey										
Corowarner [61]	Government	N/A	✓					✓	✓	N/A

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Country, App name	Organization/institution	Platforms	Purpose					Technology/method used to collect data		
			Contact tracing (n=15)	Symptom monitoring (n=7)	Information provision (n=1)	Research (n=2)	Quarantine (n=7)	Bluetooth (n=10)	GPS (n=12)	Others (n=12)
United Kingdom										
C-19 COVID Symptom Tracker [62-64]	Private organization	iOS and Android		✓						Self-reporting
Under development [65]	N/A	N/A	✓							N/A
COVID-19 Sounds [66,67]	N/A	Web and Android				✓				N/A
United States										
Private Kit: Safe Paths [68,69]	University (Massachusetts Institute of Technology)	iOS and Android	✓					✓	✓	N/A
Global										
COVID-19 Screening Tool [35]	Private organization (Apple)	Web and iOS		✓						Questionnaire

[a]COVID-19: coronavirus disease.
[b]n=20.
[c]N/A: not applicable.
[d]n=13.
[e]n=14.
[f]n=3.
[g]n=4.
[h]n=3.
[i]ATM: automated teller machine.

Contact Tracing Apps

There were many varieties of contact tracing apps. China was the first country to develop an app specific for contact tracing by using sophisticated tracking and surveillance methods [36,37]. They involved tracking of infected individuals and their contacts, while others were allowed to carry on with their normal lives [38]. Other countries followed suit after a study conducted by the University of Oxford suggested that the release of contact tracing apps played a major role in decreasing the spread within the community [70]. Malaysia, Singapore, India, Indonesia, and Iceland were fast at developing individual apps for contact tracing [7,39-41,43-46,48]. On the other hand, Italy, Germany, France, and the United Kingdom had apps in the development stage during the period of this review [32-34,65].

Of the 15 contact tracing apps analyzed, 6 (40%) apps had used GPS technology. South Korea's Corona 100m app used data such as the user's last GPS history and a range of information from government information systems, surveillance footage, and credit card transactions [30,52-54]. The most common method for contact tracing apps was Bluetooth (n=9, 60%). These apps anonymously notified healthy individuals if they had been in close contact with an infected individual. This was in contrast to other techniques, such as the one used by China, using strict surveillance methods that raised privacy concerns since the technologies could track the person's location and obtain personal data as well [36,37]. GPS and Bluetooth were used in combination by three contact tracing apps released by the United States, India, and Turkey [43,61,68,69]. All these apps were either supported by the government or from recognized health organizations after restrictions were imposed by the Apple and Google Play Stores.

Quarantine Apps

In addition to contact tracing apps, various countries have also come up with quarantine apps to ensure that quarantine measures are being followed. For example, geofencing apps enforce the quarantine by using mobile phone signals and GPS to track the movements of users. The concept is to create a virtual fence

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around people's houses so that when they disobey the regulations and go outside their houses, the authorities will be notified [43,71]. One of the countries that has adopted this technique is India [41,42,71]. Taiwan also uses the same technology to geofence affected individuals who are required to self-isolate or quarantine at home [59]. The geofencing app works by using base station triangulation, which is not as precise as GPS, but it provides the location with an accuracy of 300 meters. Quarantined individuals are assigned a social worker who calls and checks on them twice a day. If unresponsive, the police are notified and will then visit their house [60]. In addition, Taiwan has also accepted the help of its citizens to develop tools to solve issues like sourcing and distributing face masks to avoid shortage in the affected areas [62].

In Hong Kong, quarantine is enforced by providing a wearable device (wristband) and a mobile app to people who arrive from other countries. The wristband is scanned and integrated to the app upon installation, and it works by using GPS, Bluetooth, Wi-Fi, and geospatial signals in the neighborhood to determine position. If there is a difference in these signals, the app notifies its user and a quarantine officer [29,38]. When it was released, the public had doubts as to whether the wristband technology could work effectively, since it was paper-like and did not look robust. However, the majority adhered to wearing the wristbands because they believed that it would help them prevent the spread of the virus [72].

Other countries that have enforced quarantine apps include South Korea, Russia, and Poland. For example, the Self-Quarantine Safety Protection app by South Korea uses GPS to track quarantined individuals. Individuals who opt out of using the app are monitored by calls twice a day from an assigned quarantine officer [55,56]. On the other hand, Moscow has also made it mandatory for individuals who tested positive for the coronavirus to download and install the Social Monitoring quarantine app, which uses GPS to monitor movement [51]. Individuals who do not own smartphones will be provided with one that already has the app downloaded so that they can be tracked. In contrast, in addition to GPS tracking, Poland's Home Quarantine app also requires the quarantined individual to take a selfie when randomly prompted to ensure that the individual is at their residence. Upon release of the app in Poland, people had the option to either use this app or agree to be visited by a police officer every day, but it was later made mandatory for everyone under quarantine [49,50]. According to a user of the app, she felt angry and stressed because she missed the alerts several times early in the morning and the police checked up on her at her home. In the second week, the number of alerts "doubled" and drained her phone battery. Furthermore, she became more stressed as she felt that she had to be on standby, even during a shower [73].

Symptom Monitoring Apps

One of the global apps for symptom monitoring is the iPhone and web-based COVID-19 Screening Tool app developed by Apple [35]. This is available for all iPhone users, irrespective of their location. Furthermore, countries such as Spain, the United Kingdom, Germany, Singapore, and Malaysia have also developed symptom monitoring apps [13-15,31,57,66,67]. These apps identify if the user is experiencing symptoms related to COVID-19. If the user's responses indicate that the user may have COVID-19, they are provided with simple management advice to follow. Generally, these apps pose a series of diagnostic questions that include symptoms like fever, type of cough, body aches, contact with any infected individual, and recent travel, among others, which help identify via a back end algorithm whether the user is suspected to have COVID-19. If the user is suspected to be infected, these apps will generally provide information on what to do in that scenario (eg, wearing a face mask to reduce the spread and providing information about nearby hospitals). For example, the United Kingdom's symptom monitoring app, called C-19 COVID Symptom Tracker was made by a private developer [62-64]. It was highly welcomed by the public with 2,979,018 contributors as of May 6, 2020 [62]. The app was also helpful in identifying that 1 in 10 people in the United Kingdom had coronavirus symptoms [74]. In addition, Spain's app could also alert officials on whether quarantine measures were being followed by the public in an area [58].

An advanced variation of symptom monitoring apps is Germany's Corona-Datenspende app, which uses smartwatches or smart bands to collect data on the user's biometrics such as temperature and pulse that are then assessed for possible COVID-19 infections [14]. Similarly, the COVID-19 Sounds App is a web-based app developed in the United Kingdom that is able to record a user's cough sounds and detect whether the user is infected with the coronavirus based on machine learning of their cough sounds [66].

Among all the symptom monitoring apps reviewed in this study, besides the apps from Germany and the United Kingdom that were able to automatically monitor and record the patient's health parameters, all of the other apps involved manual recording of symptoms or answering questionnaires provided by the app. Another app, called AC19, was released by the Iranian government in the Android app store for symptom monitoring but was later found to be using GPS technology to track suspected infected individuals. This app was found to be linked to a suspicious app developer company that had a history of developing other apps that collected and provided data to Iranian intelligence agencies. The app was later banned from the Google Play store but is still available through the developer's website and other third-party app stores [47].

Information Providing Apps

Various governmental organizations and health agencies have used social media platforms like Facebook, WhatsApp, Instagram, and Twitter to provide specific information about COVID-19 to the public. Although these platforms have app functionalities, Facebook, Instagram, and Twitter can also be used on a browser, and thus, information provision is not just limited to mobile app users. WhatsApp has been widely popular and is one of the main methods of providing information on COVID-19 in many countries. For example, government agencies from Australia, India, Singapore, and the United Kingdom harnessed the WhatsApp platform by developing their own chatbots to disseminate information to their citizens on the country's COVID-19 situation and local measures taken during

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this pandemic [17-19,75,76]. However, in response to the infodemic that has surrounded COVID-19, it was necessary to regulate the information that was spread by users through WhatsApp [75]. WhatsApp also collaborated with the WHO and developed an information providing tool, which works by users messaging a designated number to request for information about COVID-19, such as infection numbers, hygiene practices, and locations of medical centers, among others [16,77]. The GovTech Agency in Singapore also developed its own artificial intelligence (AI) tool on WhatsApp to translate official news from English to other languages such as Chinese, Malay and Tamil to disseminate relevant information to its citizens [76]. It works similar to the WHO bot that provides a set of programmed responses that are updated with the information that has been requested by users. Malaysia has also proposed its own MySejahtera app, which is still under development and will include information provision features such as a hotline number and a Virtual Health Advisory along with symptom monitoring features [31].

Discussion

Principal Findings

From our review, contact tracing, symptom monitoring, and information providing apps were the key types of apps that had been developed for the management of COVID-19, with the majority being developed by health organizations and governments. To combat misinformation surrounding COVID-19, many organizations, including the two major mobile app players in the market—Apple and Google—made efforts to curate the COVID-19–related apps available in the app stores. Apps that provided misleading information were banned from their respective app stores, resulting in apps that were more credible and developed by established health care organizations and governments [25].

Not surprisingly, most of the apps identified from our review were for contact tracing. These apps were developed to alleviate the time and resources required for the manual contact tracing process, which could be channeled to other resources instead. However, a key issue for developers was to support information collection without compromising user privacy. The advantage of using GPS surveillance methods was the accuracy of the user's identification. China's method of data collection was deemed to be intrusive, as it invaded the privacy of individuals. However, this method was effective in identifying individuals who had breached the quarantine laws. Hence, it was welcomed by the general public in China, and they supported the government on its efforts to reduce the transmission of infection. Although this method could work in China, it could not be replicated in other countries due to the differences in their political and cultural stances on privacy [78]. Therefore, other countries explored and employed other data collection methods that were more mindful of privacy issues. Bluetooth-enabled contact tracing was the most popular method, since only when users had crossed paths would they have been detected, and data was not transferred and stored to any online server. A well-designed Bluetooth-enabled contact tracing app was first developed by Singapore, which was later shared to the rest of the world by making its development code open source [10]. This helped other countries roll out similar apps at a faster rate. Germany used an interesting and different approach of wearable devices for the automatic monitoring of vitals. The public acceptance of this technology is yet to be studied.

Although the responses to contact tracing apps were welcomed by most countries, it is still early to determine whether they are really effective in limiting the spread of the coronavirus [79]. It has been suggested that ~80% of the population needs to install such apps for it to be effective [80]. This is a concern because highly susceptible populations for COVID-19, such as older adults, are not adept with technology [81]. Furthermore, the majority of the contact tracing apps only register nearby users every 5 minutes and, hence, may have the possibility of missing out individuals. The range of Bluetooth is also farther than the recommended 1.5 meters advised by the WHO, thus giving rise to the possibility of over reporting the number of cases, especially in multistory buildings where the Bluetooth signal can pass through the walls [81]. Lastly, a Bluetooth-based contact tracing app will stop working altogether when the user opens a game app such as "Candy Crush." Despite these problems, authorities are still advocating these apps even though the uptake of such apps are low, as it can play a role in benefiting the population to some extent [79,82].

Instead of having contact tracing apps specific to each country, a joint effort to develop a universal app for contact tracing may be more beneficial, since useful trends on the COVID-19 spread among the different countries can be identified and compared by international organizations such as the WHO. Hypothetically, the codes for developing such a universal app can be made open sourced and modified to suit each individual country's needs and privacy laws. In fact, Apple and Google are collaborating to develop a universal app in the near future for contact tracing [83]. Their proposed method is to use Bluetooth to develop the app, similar to the way that Singapore had created their contact tracing app. However, the intended app will not use GPS data and will not store information online so that it can address the privacy concerns of many individuals. The Bluetooth app uses the "decentralized" approach since there is no recording of information into a back end database; thus, it is safer in terms of privacy because there is less risk of hackers accessing sensitive information. However, the disadvantage is that it may be difficult to enforce downloads and use of such apps [84]. On the other hand, the United Kingdom had opted for a "centralized" approach, where information would be stored and analyzed online, and notifications sent out based on interactions [84]. Although the centralized approach would pose a privacy risk, officials justified that this data would be helpful to identify trends of the disease spread [84]. However, there was concern regarding privacy by the general public, and the app did not function properly on iPhone devices during testing. Therefore, the United Kingdom government has subsequently decided to use the Apple and Google Bluetooth app to aid in its development, resulting in the app being decentralized as well [85].

Symptom monitoring apps were also useful in identifying disease trends and possible infection zones. Although most countries developed symptom monitoring apps based on manual

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input of symptoms and questionnaires, the symptom monitoring app developed in Germany could automatically collect the user's vitals such as temperature and pulse, thus identifying patients who are symptomatic and possible infection zones through an interactive map [15]. This pandemic has also rapidly enhanced the uptake of telehealth systems in many countries. When combined with the use of wearable devices, it may be possible to conduct home screening and remote monitoring of COVID-19 symptoms through other integrated features such as mobile doctors or telehealth systems.

Our review managed to identify certain apps that had integrated information providing features with the other contact tracing and symptom monitoring features. Another popular method to disseminate COVID-19–related information was through social media platforms such as WhatsApp. Given the high rates of social media use, using social media channels to provide factual COVID-19 information would likely ensure the rapid and widespread access to relevant health information [86]. Combined with the fact that these apps are harnessed by various governments to provide reliable information about COVID-19, information such as advice to follow and precautions to take to prevent or avoid the spread of COVID-19 can be disseminated to the public in "chunks" as an educational resource, as well as to clarify their doubts. By combining with other features, a multipurpose app that provides all information and services about COVID-19 will potentially be attractive to users and the public.

Future of Pandemic Management

To effectively tackle a pandemic such as COVID-19, a multipronged approach should be used. A proper contact tracing app that is implemented at the starting stages of the outbreak is important. Furthermore, authorities should make it a priority to advocate the uptake of contact tracing apps by the public by educating about the benefits of using such apps, perhaps through social media and public health campaigns. The Bluetooth-enabled contact tracing method is by far the most popular in terms of effectiveness and maintenance of privacy. The universal app that is currently being developed by Apple and Google can help limit the spread on a larger scale, as the reach of such an app will be greater and can provide an opportunity to prepare for similar future outbreaks internationally. Figure 2 suggests some features that should be available in mobile apps for COVID-19. Other important functionalities that can be integrated into these contact tracing apps include features for automatic symptom monitoring and information provision. The addition of these features will provide a more holistic public health approach in response to the situation. As technology advances, the symptom monitoring algorithm can be enhanced and tailored to the pandemic to improve its accuracy in diagnosis. Wearable devices such as smartwatches and smart bands will become more common and integrated with daily lives; thus, these can potentially aid in the vital monitoring of health statuses of vulnerable populations. Through machine learning and AI methods, automatic and rapid identification of suspected infections will become more accurate in the future. Lastly, consolidated information that is provided by credible organizations such as the WHO can avoid any unnecessary confusion as to which advice to follow in a pandemic situation. Governments can then adapt and tailor the information to suit their populations. With advancement in telehealth and mHealth systems, mobile doctors will be the way to go in situations like this where self-isolation is needed. However, with the advancements in technology, "digital humans" may potentially be the solution to reduce the burden of health care professionals in future pandemics [87].

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Figure 2. Ideal features of mobile apps for COVID-19. COVID-19: coronavirus disease.

Limitations and Future Work

Since COVID-19 is a new outbreak and the situation is rapidly evolving, the articles in this review were mainly from news articles and online webpages. There were few peer-reviewed journal articles about mobile apps related to COVID-19. Furthermore, we could not conduct a thorough search of the Google and Apple apps stores as most of the apps were country-specific; thus, they could not be downloaded and evaluated. Hence, we could only obtain information from the news articles and webpages that were found, but the details on the various apps were also not comprehensive in these articles. In addition, the databases searched (Google Search Engine, Google Scholar, Scopus, and PubMed) might not have been able to provide information on certain apps due to country restrictions, for example, apps from China. Another limitation was that sources in languages other than English were also not included in this review. From these sources, we could only

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collate apps that were either already available to the general public or still under development during the period of review. We advocate that a more comprehensive review should be done in the near future when the situation is stabilized, possibly post–COVID-19. Future work on how effective these apps were in decreasing the coronavirus spread should also be undertaken. This will help identify apps and features that are beneficial in future pandemics.

Conclusion

This review has identified a variety of apps that may be potentially useful to curb the spread of COVID-19. The majority of the apps were for the purposes of contact tracing and symptom monitoring. However, these apps, especially those for contact tracing, can only be effective if they are advocated by the government and taken up by the community. Contact tracing at an early stage, along with proper hygiene and social distancing practices, remain the ideal way to deal with COVID-19. Governments can also benefit by encouraging their citizens to participate in their efforts to combat the pandemic, as in the case of Taiwan. In addition, the sharing of good practices across different countries, such as the case of Singapore, can enable governments to learn from each other so that effective strategies to combat and manage this pandemic can be developed to control the spread of the coronavirus.

Authors' Contributions

KY and DC conceived and designed the study. HS conducted and analyzed the results. HS, KY, and DC wrote and revised the manuscript. All authors agreed to the publication of the manuscript.

Conflicts of Interest

None declared.

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Abbreviations

AI: artificial intelligence
COVID-19: coronavirus disease
mHealth: mobile health
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SARS-CoV-2: severe acute respiratory syndrome coronavirus 2
WHO: World Health Organization

Edited by T Risling, G Eysenbach; submitted 22.05.20; peer-reviewed by YT Cheung, G Darville; comments to author 13.06.20; revised version received 24.06.20; accepted 24.07.20; published 06.08.20.

Please cite as:
John Leon Singh H, Couch D, Yap K
Mobile Health Apps That Help With COVID-19 Management: Scoping Review
JMIR Nursing 2020;3(1):e20596
URL: https://nursing.jmir.org/2020/1/e20596/
doi:10.2196/20596
PMID:32897271

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Original Paper

Using the Self-Management Assessment Scale for Screening Support Needs in Type 2 Diabetes: Qualitative Study

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Abstract

Background: Globally, most countries face a common challenge by moving toward a population-based structure with an increasing number of older people living with chronic conditions such as type 2 diabetes. This creates a considerable burden on health care services. The use of digital tools to tackle health care challenges established views on traditional nursing, based on face-to-face meetings. Self-management is considered a key component of chronic care and can be defined as management of the day-to-day impact of a condition, something that is often a lifelong task. The use of a screening instrument, such as the Self-Management Assessment Scale (SMASc), offers the potential to guide primary health care nurses into person-centered self-management support, which in turn can help people strengthen their empowerment and self-management capabilities. However, research on self-management screening instruments is sparse, and no research on nurses' experiences using a digitalized scale for measuring patients' needs for self-management support in primary health care settings has been found.

Objective: This paper describes diabetes specialist nurses' (DSNs) experiences of a pilot implementation of the SMASc instrument as the basis for person-centered digital self-management support.

Methods: This qualitative study is based on observations and interviews analyzed using qualitative content analysis.

Results: From the perspectives of DSNs, the SMASc instrument offers insights that contribute to strengthened self-management support for people with type 2 diabetes by providing a new way of thinking and acting on the patient's term. Furthermore, the SMASc was seen as a screening instrument with good potential that embraces more than medical issues; it contributed to strengthening person-centered self-management support, and the instrument was considered to lead both parts, that is, DSNs and patients, to develop together through collaboration.

Conclusions: Person-centered care is advocated as a model for good clinical practice; however, this is not always complied with. Screening instruments, such as the SMASc, may empower both nurses and patients with type 2 diabetes with more personalized care. Using a screening instrument in a patient meeting may also contribute to a role change in the work and practice of DSNs.

(JMIR Nursing 2020;3(1):e16318) doi:10.2196/16318

KEYWORDS

eHealth; internet; type 2 diabetes; self-management; primary health care; qualitative research; nursing

Introduction

A need for structural changes in health care systems has emerged due to demographic changes and an increasing number of older people with chronic diseases such as type 2 diabetes (T2D), hypertension, chronic obstructive pulmonary disease, and asthma [1-3]. T2D is increasing in prevalence and constitutes a major cause of morbidity and mortality globally. In addition to contributing to a significant decline in health status in many patients, this condition creates considerable burden on health

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care services [2,4]. Self-management is considered a key component of chronic care and can be defined as the management of the day-to-day impact of a condition, which is often a lifelong task [5]. Self-management support and evaluation of patients' self-management efforts are most often based on glycated hemoglobin (HbA_{1c}) values and other measurements such as blood pressure and blood lipids. However, diabetes services are often unable to meet patients' needs, such as emotional adjustment [6]. The struggle for people with T2D to manage self-care is therefore seldom evaluated [7]. However, most instruments focus on medical issues while instruments assessing patients' perspectives and special needs for self-management support are lacking.

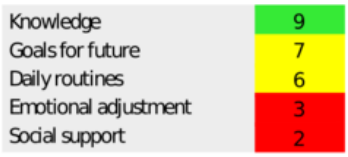
The development of digital tools for self-monitoring is rapidly increasing and becoming more common in chronic diseases. When implementing digital self-management support programs, there is a challenge to change from a traditional biomedical care approach based on monitoring and advice toward person-centered care based on empowerment [8]. Recent studies show that there are split opinions about using digital tools for self-management support among diabetes specialist nurses (DSNs) [9] and people with T2D [10]. Using digital tools challenges established views on traditional nursing based on face-to-face meetings and the importance of the care relationship in itself. In addition, patients seem to be quite positive about using eHealth for self-management support, while DSNs perceive that they lack an overview and are working in a digital chaos [9,10]. This study attempts to bridge this divide by applying the concept of person-centered self-management guidance using a screening instrument—the Self-Management Assessment Scale (*SMASc*) [11].

A broad definition of self-management implies both activities and support of chronic conditions, which may vary [12,13]. Self-management is defined as daily tasks that individuals must undertake to live comfortably with a chronic illness by gaining confidence in dealing with medical management, role management, and emotional management [10,12,14-16]. Self-management support, on the other hand, is defined as the provision of education and supportive interventions by health care professionals to increase patients' skills and confidence in managing their health problems. This includes regular assessments of problems, goal setting, progress, and problem-solving support [16,17]. Emotional support for coping with the existential and emotional impact of having chronic conditions is seldom included in an annual visit to diabetes clinics [7].

The demands of governments and policy makers on the development of digital care are increasing. Digital care is suggested to decrease pressure on health services, but changes in responsibilities for patients and health professionals are not sufficiently evaluated or reported [18-21]. In Sweden and many other Western countries, DSNs—specialist nurses with education in diabetes care and working within primary health care—are the professional groups that most often meet and provide self-management support to people with T2D [22-24]. This study focuses on DSNs and their experiences of participating in a pilot implementation of person-centered self-management support for people with T2D, where digital tools are combined with the goals of person-centered care. This combination has the potential to enable tailored solutions and individual approaches that strengthen self-management capabilities, self-efficacy, and patient empowerment [9,25,26].

Within a pilot implementation, a self-assessed screening instrument (*SMASc*) was introduced that could assess the needs for self-management support. The *SMASc* is a short, validated screening instrument developed within our research group [11]. The instrument screens for strengths and possible barriers for self-management to be used in conversations between the person with T2D and the DSN. The *SMASc* instrument assesses 5 areas important for effective self-management over time: knowledge, goals for the future, daily routines, emotional adjustment, and social support, all generated from the literature on patient perspectives on chronic illness, including T2D and related self-management challenges [11], and it visualizes the results as an automatically generated profile (Figure 1). Each area of the *SMASc* has cutoffs between low value (red; acute need for self-management support), median value (yellow; no acute need for self-management support), and high value (green; no need for self-management support), directing the conversation regarding self-management support between the nurse and the patient [11].

Figure 1. An example of one measurement and interpretation of the Self-Management Assessment Scale.



The DSNs, when using the *SMASc* in the diabetes clinic, involved their patients in reflective conversations about the patients' needs for self-management support in the various areas. They could also suggest other digital resources such as apps and websites for patients to improve self-management in problem areas. The *SMASc*, therefore, offers the potential to guide nurses into person-centered self-management support, which in the next step could increase people's responsibility for their health and strengthen their empowerment and self-management capabilities [10].

Research on experiences using self-management screening instruments is sparse, as no published research on nurses' experiences using digital scales for measuring patients' needs for self-management support in primary health care settings has been found. To address this knowledge gap, it is important to gain more insight into and highlight this topic. Therefore, this study aims to describe DSNs' experiences of a pilot

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implementation of the *SMASc* instrument as a basis for person-centered digital self-management support.

Methods

Design

This study is a part of a larger randomized intervention project (ClinicalTrials.gov [NCT03165084]) that aims to design and implement person-centered interactive self-management support in primary health care in the north of Sweden. More information about the project's design, setting, and intervention is documented in a study protocol [27]. This study uses a qualitative descriptive approach based on participatory observations and individual interviews.

Setting and Participants

This study was performed in 3 primary health care centers in Sweden, with 5 DSNs managing the diabetes clinics. DSNs are fundamental to this study because they introduce the *SMASc* instrument and, when needed, provide self-management support for people with T2D. The characteristics of the participating DSNs are given in Table 1.

Table 1. Demographics and clinical characteristics.

Characteristics	Participants (n=5), n (%)
Gender	
Female	4 (80)
Male	1 (20)
Education level	
Primary health care nurse	5 (100)
Age (years)	
<50	2 (40)
≥50	3 (60)
Years working in the current job	
≤5	2 (40)
6-10	1 (20)
≥11	2 (40)

Preparation and Accomplishment of the Pilot Implementation

The participating DSNs were provided with a 1-day group training session, which included role-playing. In addition, they received a two-hour introductory session with the first author (UÖ). The training involved learning how to use the *SMASc* instrument to score and discuss the needs for self-management support and to develop person-centered plans for self-management support together with patients. The participating DSNs invited patients at their annual visit to their diabetes clinic and asked them to score their self-management support needs by using the *SMASc*. Thereafter, they were expected to discuss the 5 areas of the *SMASc*, with a particular focus on low-scoring areas. The profile of the *SMASc* results was expected to make the discussion more person-centered, and patients were also, when needed, recommended digital self-management support through the webpage [27] or the app, MySugr [28-33]. There was a handout manual containing instructions for DSNs about the *SMASc* and how to interpret the scoring and how to cope with possible barriers. The first author (UÖ) visited the intervention practice sessions on the first day of the intervention to provide additional support and to ensure that the DSN had understood the information and was able to work with the screening instrument in their consultations with the patients with T2D.

Data Collection

Participatory observations of clinical visits (n=14) and following individual face-to-face interviews with each of the DSNs were conducted between September 2018 and February 2019. Participatory observations focused on the interaction between the DSN and the patient during consultations. The observer adopted an *observer as participant* approach, interacting only with participants if it was necessary to make a participant feel more at ease with the observation process [34,35]. Field notes were used while taking observations and were analyzed by identification and categorization of the types of interaction and further if there were any special occurrences observed during the visit. To ensure credibility and dependability, one author (ÅH) experienced in qualitative analysis confirmed the data and categorization. The observations were not audiotaped [35,36]. According to Silverman and Marvasti [37], the context of the observation is fundamental for the quality, further one has to be aware of facial expressions, gestures, and movements—all key data while making an observation. These types of observations were then used to interpret various situations and were used in the following interviews [37]. The interviews included open-ended questions, were audiotaped, and lasted for 60 to 90 min. On the basis of the observational data, a general semistructured interview guide was complemented with the questions. The opening question was, "Have you ever used any digital screening tool to measure the patient's need for self-management?" Examples of other questions included the

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following: "How is it to use the *SMASc* instrument in the patient meeting compared to before?" "Can the *SMASc* instrument highlight the needs of support that the patient is most in necessity of? "Would you be able to tell in what way?" The interview guide provided a flexible frame for questioning and domains (areas) covering topics about DSNs' knowledge and perception in using the *SMASc* instrument for person-centered guidance and self-management support in their meeting with patients.

Data Analysis

Qualitative content analysis, as described by Graneheim and Lundman [38,39], was used to analyze the interviews [40]. This is an appropriate method to highlight people's thoughts about their experiences and their actions [38] and focuses on describing variations and identifying similarities and differences in the text by analyzing the manifest as well as the latent content. Themes at various levels were identified in this study. Subthemes are expressed closer to the interview texts, whereas the themes are expressed more on a latent level, that is, with a higher degree of interpretation [38,39].

The data material was transcribed verbatim by the first author (UÖ). The analysis was conducted in several steps. First, all transcribed text materials (also field notes from observations) were read thoroughly to assess the situation. Next, the text was divided into meaning units, answering the aim of this study. Each meaning unit was condensed and coded. During this process, the first author with help from coauthors continuously returned to the original text to ensure that the core meaning of the meaning units was maintained. This continuous cross-referencing process was maintained throughout the analysis. Similar codes were grouped into subthemes, which were later sorted and abstracted into themes. Finally, the latent meanings of the themes were interpreted and described as a main theme with a higher level of interpretation and abstraction [38,39]. During this procedure, to reach reliability, all authors discussed and reflected on the interpretation, sorting, and labeling of codes, subthemes, themes, and the main theme until consensus was reached.

Ethical Considerations

The Regional Ethical Review Board at the Umeå University approved the study (Dnr 2014-179-31M), which was conducted according to the ethical principles described in the Helsinki Declaration [41]. All participants, including patients who participated in the observations, were informed about the study both in writing and verbally before giving their written informed consent. Transcripts were anonymized, and the participants were ensured confidentiality and were free to withdraw at any time. They were also informed that in case of any concerns, they could get their concerns clarified and any data collected could be excluded from the analysis, but none of the participants made such demands.

Results

Participants' experiences of the pilot implementation of the *SMASc* instrument in primary health care were mostly positive. DSNs expressed various feelings, and from their narratives, 4 identified themes describing their experiences of using the *SMASc* instrument were identified and labeled: *A screening instrument with good potential*, *Embraces more than medical issues*, *Strengthen person-centered self-management support*, and *Both parts develop through collaboration*. The main theme that tied the 4 themes together was formulated—*A new way of thinking and acting on patients' terms*. To increase the transparency of the interpretation, themes and subthemes are illustrated with quotations. An overview of the results is shown in Textbox 1.

Textbox 1. The main theme, themes, and subthemes emerging from the analysis.

Main theme: A new way of thinking and acting on patients' terms

Themes and subthemes:

1. A screening instrument with good potential
   - An educational, easy-to-use tool
   - Builds on honest answering
2. Embraces more than medical issues
   - The patient becomes more than the disease
   - A door opener to address difficult topics
3. Strengthen person-centered self-management support
   - Conditions for tailored counselling satisfying
   - Patients become more empowered
4. Both parts develop through collaboration
   - Incentives for self-management and support
   - An opportunity for reflections and reframing

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A New Way of Thinking and Acting on the Patient's Term

The use of the self-reported *SMASc* instrument to screen and estimate the patient's needs or levels of self-management support in the daily work in the diabetic clinics involved various feelings among the participants. The DSNs emphasized that they found that using the *SMASc* in their meeting with the patient with T2D involved having a more in-depth conversation between them. They expressed that using the instrument, which embraced more than medical issues, led to more person-centered support and further that it was built on mutual trust developed through collaboration. This was interpreted as *A new way of thinking and acting on patient's terms*—the DSNs received a new tool that altered their way of approaching the patients.

A Screening Instrument With Good Potential

The participants described the *SMASc* as an easy-to-use tool to use for in-depth communication with their patients, but a prerequisite was that the patients should respond honestly when scoring using the *SMASc*. Therefore, the *SMASc* was interpreted to be a potentially good instrument for use in DSNs' daily work with patients with T2D.

An Educational, Easy-to-Use Tool

The DSNs described that they had experienced the *SMASc* to have streamlined the meeting with the patient. The DSNs also expressed that no extra time was needed to fit the *SMASc* into their regular workflow. The tool was also perceived as easy to fill in and educational for both the patient and the nurse. It took approximately 1 to 2 min to fill in on an iPad, and they received the scoring directly. Furthermore, it was also easy to interpret the results, with scoring points and the demonstrative colors—red, yellow, and green. By interpreting the scoring and demonstrating it for the patient *on the table*, the DSNs expressed that it was a helpful way to address important topics that could be meaningful for the patient:

> *...the questionnaire was easy for them to fill in...it became easy to discuss the results [of SMASc]...with all the colors...like the traffic lights...Together [DSN and patient] then we decided what topic we should concentrate on...*

Builds on Honest Answering

The prerequisites of using a tool such as the *SMASc* are that the patients' answers must be based on truth and honesty; otherwise, it fills no function. The DSNs verbalized that they had experienced that *for some reason, a few of the patients probably did not answer honestly on theSMASc*. For example, if a patient had their partner present during the visit and the patient scored high on *social support* but the DSN simultaneously knew that the last time the patient visited, he or she had complained about his or her spouse's lack of understanding:

> *...for example, if a patient brings his partner to the visit to the diabetic clinic...then it may become difficult for them to fill in SMASc truthfully about having poor social support...then it will be incorrect...and it can then be difficult for me to talk to the patient about it...it can be sensitive...*

Embraces More Than Medical Issues

The DSNs described that they usually checked the patients' laboratory values and body weight to judge how the patients *behaved*. They had tried to educate the patients, foremost in pathophysiological and medical topics if the values deviated from the normal. Psychosocial topics were also important, but these had been difficult to address before. The participants also expressed that from their point of view, effective self-management is often dependent on the collaboration between the patient and the DSNs. Although the patient was viewed as a person and thereby more than only a disease, the focus during visits was often on measurements, but by using the *SMASc* and the conversation around it, the DSNs gained a better understanding of the patient's overall life situation, thereby increasing his or her empathetic understanding. The *SMASc*, which embraces more than medical issues, could highlight topics that have seldom been discussed earlier.

The Patient Becomes More Than the Disease

The *SMASc* conversation focused on the following topics: patients' knowledge, goals for the future, daily routines, emotional adjustment, and social support. During the annual visits, the nurses had to follow up the standardized annual medical measurements at the same time. The DSNs stated that patients' daily decisions had a huge impact on their health, and they must therefore be active and informed about their medical issues. They advocated that measurements such as HbA_{1c} and other curves are important but could feel bad when such values were normal, and they did not listen to the patients' other struggles. The *SMASc* helped them to understand and make visible which area the patient was struggling with. The DSNs expressed how they were discussing problem areas chosen by the patient. By focusing on the patients' everyday life priorities, communication was strengthened, and they got a better understanding of the patient's overall situation:

> *I think it [results of SMASc] contributes to being able to meet the patient where he or she is...and I think I listen more, actually...it is easier to understand the patient's needs because the questionnaire covers wide areas...*

A Door Opener to Address Difficult Topics

The DSNs described it as a door opener in communication when the patient obtained the results from the *SMASc* and it became clear what topics should be raised in the conversation.

The DSNs also felt that it enabled them to provide better care. The use of *SMASc* was described as a new way of thinking and working. Areas that received low points were those that the DSN concentrated on in the conversation with the patient. On the basis of the answers in the *SMASc*, the DSN could better assess where to start and what to focus on in the discussion. This provided a foundation for new directions in their self-management support and answers on what both patients and DSNs should continue with. If patients scored highly on *knowledge*, the DSNs would realize that they need not repeat information about things that the patients understood:

> *...by using the questionnaire involves a new way of thinking and working...it guides both me and the*

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patient on what to concentrate on in our conversation...

Strengthening Person-Centered Self-Management Support

The DSNs expressed that by using the *SMASc*, it became clear and visible for them if a patient scored low in any area. This allowed the DSN to approach the patient in the conversation through an in-depth dialogue to better address the patient's personal needs. In this way, the DSNs gained insight into what to focus on, and together with the patient, they could set up an individual care plan and support them accordingly. Thus, these individual strategies led to tailored and person-centered self-management support.

Conditions for Tailored Counseling Satisfying

The DSNs described that the *SMASc* gave them the opportunity to address personal issues about what motivates patients in their self-management. On the basis of patients' scores and the following discussion, a range of topics that have been discussed previously, such as personal risk factors, readiness for change, patients' self-management needs, preferences, and health behaviors, were also highlighted. The DSNs experienced that it became easier to develop an individualized self-management plan together with the patient after the *SMASc* scoring. The DSNs described that although they had only used the *SMASc* for a short time, they considered that the instrument provided them and the patient with the prerequisites for more person-centered care and tailored coaching. Subsequently, they believed that it strengthened *the patients' ability to carry out self-management activities. The DSN reported that it sometimes took time for them to build a trustworthy relationship with patients with T2D, but by using theSMASc*, it became easier for them to come closer to patients and to discuss sensitive topics. They stated that conversations were considered to improve compared with earlier conversations:

> *...some things that are addressed in the questionnaire may be,...like different type of goals or needs for support for future plans...that may not always come up at the usual visits to the diabetic clinic..., now it will be easier to approach such topics as well...you want to be able to reflect on what has been done and what effects that it has resulted in...*

Patients Become More Empowered

The DSNs reported that their discussions with patients about the low-scoring areas in the *SMASc* motivated the patients to more effectively improve self-management. By making this color scoring visible and sharing between them, the patients seemed to cope better and gain restored strength to perform new activities or better adapt to situations. However, the DSNs all agreed that this required an involved patient and that not all patients could easily be reached. Within the project, DSNs were instructed to refer patients to digital sources for self-help. Some patients seemed to have a positive reaction to this, and the option to monitor themselves without the nurse's involvement was viewed as positive and surprising for the nurses. Using a digital tool, such as the *SMASc*, was perceived as a new solution for some of their patients, and the DSNs saw that they would have a new task as coaches in digital self-management support instead of educators:

> *...one might also think that it [results of SMASc] also can motivate the patient to take responsibility for their own health care...the insights and transparency are not only for me but also for the patient...time for self-reflection...*

Both Parts Develop Through Collaboration

Using the results of patients' *SMASc* scores helped both DSNs and patients to understand more about themselves and one another. This provided an opportunity for reflection and evaluation from earlier discussions. This was suggested by the DSNs to help the patients strive toward more effective self-management and help the DSNs to understand what type of support they could provide to the patient. Therefore, the *SMASc* was useful for both parts and guided them toward better collaboration and understanding as well as development for self-management and support.

Incentives for Self-Management and Support

DSNs highlighted that the *SMASc* gave them incentives for better and more person-centered support and that topics became visible to patients they had not thought of before, such as future goals. The DSNs described that it was this collaborative approach that helped the patients to acquire skills and confidence to manage their condition. Participants also highlighted the need for new self-management strategies and allowed nurses and patients to make a personalized assessment of problems. The DSN expressed that patients with T2D could receive a new kind of support such as emotional support or guidance on illness integration, including issues that are most important to them at this point of departure:

> *...what is important is that the patient has good illness integration...that everyday life should be the most important, living with the disease [T2D] is challenging...but, it should not take over your whole life..., it should not feel like a mountain that one can't climb...*

Opportunities for Reflections and Reframing

The DSNs described that they thought that the *SMASc* could be a useful tool in their conversations with patients as it provided an opportunity for reflection, evaluation, or feedback on the previous efforts for both patients and DSNs. It provided answers to what is less good in health care and what changes had to be made in the patient's own treatment plan. One DSN explained it as having a new mirror image, which included things that had already been done and even reflected on how the self-management support had been perceived. This gave both patients and DSNs an opportunity for reframing and changing the direction forward. The DSNs expressed that the annual assessment with the *SMASc* to obtain a receipt on how the patient managed his or her life with diabetes must be implemented in full scale:

> *...what I think about this SMASc...it can be of help...new way to work...no question about that...if you [the patient] fill it in...then I, as a diabetes nurse*

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get the feedback from the patient...in the results of SMASc...about previous efforts, about my efforts on the patient's efforts...

Discussion

This paper aims to describe DSNs' experiences of a pilot implementation of the *SMASc* instrument as a basis for person-centered digital self-management support. To understand the experience of using such an instrument and what it means for a day-to-day practice in the setting of a diabetes clinic, the use of such digital resources such as the *SMASc* needs to be studied. The central focus in such an observation is the interaction between patients and nurses. Combined with interviews where the DSNs could directly describe and explain their experiences, this study captures a reflexive account of using the *SMASc*. The main theme concluded that *the use of SMASc* involved *a new way of thinking and acting on patients' terms*.

The DSNs highlighted that the *SMASc* instrument was perceived as *a screening instrument with good potential* to facilitate discussions of self-management strategies and thoughts around new ways of thinking and acting on patients' terms in the health care situation. The analysis also indicates that the use of *SMASc* as a digital screening tool offers the possibility of another kind of patient meeting where *both parties are developed through collaboration.* As is seen with other examples of using digital resources, applications are altered and reformed through utilization in everyday practices [42-44].

In this study, the DSNs expressed that using the *SMASc* helped them to restructure the consultation method. They realized that the *SMASc* had the potential to help them focus on matters of relevance for the patient, thereby enabling them to learn more about the patients' needs. It was expressed as positive that the *SMASc embraces more than medical issues* and *strengthens person-centered self-management support*.

The *SMASc* offered an overview that helped the DSNs to change focus and highlight issues of importance for the patients, aspects that might otherwise not have been mentioned if they had used their former daily routines.

The *SMASc* can make it possible to identify the barriers to self-management, and the DSN is given a resource to assess patients' self-management needs. This is in line with other related studies and initiatives [45-49] aimed to support nurses with analytic tools to better understand patients' situations and to evaluate self-management interventions. One such example is the development of the Self-Management Screening (SeMaS), by Eikelenboom et al [50,51], a SeMaS tool aimed to support the creation of patient profiles that could support nurses in counseling and the evaluation of self-management interventions in primary care. First, an important difference between SeMaS and *SMASc* is the length. SeMaS includes 27 items and the *SMASc* includes 10 items, in favor of *SMASc* in clinical practice. Second, SeMaS is based on psychological theories related to behavior change and internet use, whereas the *SMASc* is developed inductively from *the experiences of patients living with T2D. SeMaS is not translated into Swedish, and we had no knowledge of the instrument when we started to develop the SMASc* [11,50].

The *SMASc* provides a visual response that helps the DSNs to prioritize and provide attention and support to areas of importance. Other topics on the DSN agenda could therefore wait and be managed later or even disregarded. In the context of Swedish primary care, the DSN meets with the patient annually. As consultation traditionally follows a *one-size-fits-all* [52] kind of a character, thereby giving a clear concept about what to expect and what questions should be asked, the *SMASc* provides an opportunity for an alternative person-centered approach. With this background, the DSNs in this study discovered that the *SMASc* gave them an incentive and support to find out more about how patients experienced their situation and options for self-management. It specifically focused on what patients found to be relevant to discuss and what they did not want to bring up, which did not always comply with the topics the DSN routinely chose to pay attention to. Interestingly, although person-centered care has been promoted for several years [53-57], the DSNs expressed that it is difficult to discuss personal topics such as social support, emotional adjustment, and goals for future without a *manual* like the *SMASc*. However, the conversational space through the *SMASc* suddenly became wider, which led to counseling that could go beyond questions about medication and the importance of compliance in routines.

The *SMASc* was experienced as easy to use, and the DSNs highlighted that they appreciated that the *SMASc* also gave them important suggestions, thereby helping and allowing them to address the issues that they would have otherwise forgotten or left out. Technological development in health care has been described as living in a digital chaos [9]. The development of digital resources that includes one's perspective seems to prolong engagement in it. This is supported by other related studies concerning patients' engagement in digital resources. Lupton [58] describes that patients will only use new technologies if they are relevant to their problems and are engaging, easy to use, and effective in achieving change. The DSNs in this study found this tool to be both engaging and easy to use as well as effective in achieving change. The use of *SMASc* provides a structure for personalized counseling. The design of *SMASc* was pragmatic; the aim was to offer a screening tool that is easy to use and easy to interpret. The visual result is documented as a traffic light screenshot—something that can be attached to patients' health records in the future. The digital prototype presented to the DSNs in this study had a low key visual design, as the prime focus was to explore how the result of the instrument was utilized in the meeting by both DSNs and patients. The color scheme—green, yellow, and red—however, follows a traffic light metaphor [59,60], where the latter two colors guide the DSN toward the topics that need attention. This metaphor was perceived to be pedagogic by the DSNs, even if the design can be improved.

Using the *SMASc* was important for the DSNs as it helped them to discover a new way of thinking and acting on patients' terms. The use of screening tools *such as theSMASc* will imply a change of roles in the DSN work models and practices. The emerging challenge here concerns the structure of the meeting with the patient and the strategies by which the DSNs moderate

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the conversations in a person-centered manner. The DSNs experienced the *SMASc* as a resource that functioned as a facilitator and initiator in their interaction with the patients about sensitive topics. It facilitated the conversation between them, and it was felt that it led to shared engagement concerning self-management and support needs.

Strengths and Limitations

A strength of this study is the qualitative design that allows for an understanding of DSN experience based on the actual use of the *SMASc* instrument. Its closeness to daily DSN practice is another strength that emerged, as the pilot implementation was integrated into daily processes as much as possible. This enhances its relevance to decision makers as an application in daily practice that is proven feasible. Furthermore, the sample of participating nurses and the number of observations were considered sufficient. However, some limitations of this study need to be discussed. Some challenges existed in the recruitment phase, where 2 DSNs were recruited later than the others. The DSNs in this study had volunteered to participate and had a specific interest in diabetes care and may have tended to express more positive opinions than average. Therefore, our findings do not necessarily reflect the perceptions of other DSNs.

Conclusions

To our knowledge, this is the first study that has reported DSNs' experiences of using a screening instrument to measure the level of needs of self-management support for patients with T2D. The results indicate that from the perspective of DSNs, the pilot implementation of the *SMASc* instrument offers insights that contribute to strengthened self-management support for people with T2D and serves as a guide to person-centered care in clinical practice. However, to obtain this, the benefits rely on whether nurse-led digital self-management support is prioritized in the organization and whether the DSNs are engaged in person-centered care in practice during the visit.

It is important to understand that the implementation of an instrument such as the *SMASc* may also challenge the traditional roles of DSNs. Even though person-centered care is advocated as a model for good clinical practice, this is not always complied. Instruments such as the *SMASc* may contribute to making such a shift happen. This study shows that DSNs experienced the use of *SMASc* as an enhancement to diabetes nursing and that it has the potential to improve self-management among patients with T2D. This study supports that the *SMASc* is ready to be used but some minor technical refinement and design improvements may need to be done before full-scale implementation.

Acknowledgments

The authors would like to express their gratitude to the DSNs who generously gave input from their day-to-day work at a diabetes clinic. This study was funded by the Swedish Diabetes Association; the Department of Nursing and the Faculty of Medicine, Umeå University; and the Kempe Foundation.

Authors' Contributions

All authors have been involved in the design of the study. UÖ recruited participants and carried out the data collection and transcriptions. UÖ, ÅH, and UI carried out the data analysis with important input from CO and LJ. UÖ drafted the first version of the manuscript, and all authors contributed to editing the final manuscript. All authors have read and approved the manuscript.

Conflicts of Interest

None declared.

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Abbreviations

DSN: diabetes specialist nurse
HbA_{1c}: glycated hemoglobin
SeMaS: Self-Management Screening
SMASc: Self-Management Assessment Scale
T2D: type 2 diabetes

Edited by E Borycki; submitted 18.09.19; peer-reviewed by L Sun, P Lopez Jornet, A Mallidou, D Chrimes; comments to author 25.11.19; revised version received 10.05.20; accepted 10.08.20; published 15.09.20.

Please cite as:
Öberg U, Orre CJ, Hörnsten Å, Jutterström L, Isaksson U
Using the Self-Management Assessment Scale for Screening Support Needs in Type 2 Diabetes: Qualitative Study
JMIR Nursing 2020;3(1):e16318
URL: https://nursing.jmir.org/2020/1/e16318/
doi:10.2196/16318
PMID:

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Original Paper

Effect of a Smartphone-Based App on the Quality of Life of Patients With Heart Failure: Randomized Controlled Trial

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Abstract

Background: Patients with heart failure have low quality of life because of physical impairments and advanced clinical symptoms. One of the main goals of caring for patients with heart failure is to improve their quality of life.

Objective: The aim of this study was to investigate the effect of the use of a smartphone-based app on the quality of life of patients with heart failure.

Methods: This randomized controlled clinical trial with a control group was conducted from June to October 2018 in an urban hospital. In this study, 120 patients with heart failure hospitalized in cardiac care units were randomly allocated to control and intervention groups. Besides routine care, patients in the intervention group received a smartphone-based app and used it every day for 3 months. Both the groups completed the Minnesota Living with Heart Failure Questionnaire before entering the study and at 3 months after entering the study. Data were analyzed using the SPSS software V.16.

Results: The groups showed statistically significant differences in the mean scores of quality of life and its dimensions after the intervention, thereby indicating a better quality of life in the intervention group ($P<.001$). The effect size of the intervention on the quality of life was 1.85 (95% CI 1.41-2.3). Moreover, the groups showed statistically significant differences in the changes in the quality of life scores and its dimensions ($P<.001$).

Conclusions: Use of a smartphone-based app can improve the quality of life in patients with heart failure. The results of our study recommend that digital apps be used for improving the management of patients with heart failure.

Trial Registration: Iranian Registry of Clinical Trials IRCT2017061934647N1; https://www.irct.ir/trial/26434

(JMIR Nursing 2020;3(1):e20747) doi:10.2196/20747

KEYWORDS

heart failure; mobile app; quality of life; mobile phone

Introduction

Heart failure (HF) is a complex and progressive clinical syndrome that causes functional or structural impairments in the heart and results in impaired ventricular emptying or filling [1]. HF was reported in 6.2 million people in the United States of America between 2013 and 2016, which indicates the continuous increase in its prevalence [2]. According to the latest data, the prevalence of HF is expected to increase by more than 46% from 2012 to 2030 [3] owing to increased age and survival rate after a myocardial infarction and increased incidence of risk factors such as diabetes [4].

Patients with HF may experience a wide range of symptoms, including shortness of breath, cough, swelling of extremities,

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and fatigue [1], which can reduce their physical and mental health capabilities and lead to hospitalization. The rate of hospitalization of these patients is high [5]. Several factors play key roles in the readmission of patients with HF because of illness progression or exacerbated symptoms, including inappropriate treatment adherence and suboptimal health care education during and after the hospitalization period, which results in the lack of knowledge [6]. Patients with HF have low quality of life (QoL) due to their physical problems, advanced clinical symptoms, and readmissions [7]. QoL can be considered as an important indicator of health care, and its improvement is the goal of care in patients with HF [8] for their overall survival. QoL is affected by the health status of patients and is a reflection of a person's psychological and physical well-being [9]. Poor QoL can be caused by patients' high rate of hospitalization, morbidity, and mortality. Poor QoL indicates the diverse effects of a health condition and its treatment and caring process on patients' lives. Thus, improving the QoL of patients with chronic illnesses such as HF is vitally imperative [10].

To improve patients' QoL, lifestyle changes should be made. In patients with HF, self-care and treatment adherence are the important parts of disease management [4]. One of the reasons for the deterioration of the signs and symptoms in patients with HF is nonadherence, which is related to the lack of knowledge about the illness and treatment process, forgetfulness, complexity of treatment, and personal and social issues [11], as well as a reduction in their motivation to adhere to the therapeutic regimen [12]. Motivating patients and providing quality care by the health care team can increase patients' adherence to treatment and lead to lifestyle changes [13].

Adequate self-care behavior is shown to result in reduced risk of hospitalizations and mortality among patients with HF [14]. Adherence to self-care behaviors decrease markedly after discharge, which has negative effects on readmission and QoL. Patient education plays a substantial and important role in increasing treatment adherence [15]. Therefore, patients with HF should be educated and supported [14], particularly in the long term after discharge, since they mostly complain of receiving little education and support from health care providers about how to manage their condition, treatment, and self-care [11]. Distance monitoring after discharge from the hospital can help with controlling symptoms, improving self-care [16], and subsequently QoL.

Given the increased prevalence of HF and self-care challenges, the use of simple and accessible technologies to support self-care is important [17]. The long-term nature of the management of chronic diseases and the need for frequent monitoring have motivated researchers to develop advanced therapies and telemonitoring [18]. Recent advances in information technology can provide the potential to remove the barriers to education and clinical monitoring of patients. Since the majority of the worldwide population owns a mobile device, there is inevitable potential for mobile health to provide a platform to access health information and advice [19]. Nowadays, the use of mobile devices has been expanded to provide patients with health care services and purposeful communication between the therapeutic team and patients. The use of telemonitoring by using mobile devices is especially needed to quickly assess the signs and symptoms of the patient and make a decision on the treatment [20].

Use of apps or software on the smartphone can facilitate monitoring of patients' health through educational messages, audio files, and video clips. Smartphone-based apps have the potential to collect real-time data and graphically draw data for further interactions [21]. In general, although some apps have been developed for patient care, only few studies have examined their effectiveness. The effectiveness of smartphone-based apps for the management of some diseases and conditions have already been evaluated, such as in patients with chronic pain [22], for the diagnosis and notification of acute pesticide poisonings [23], and in patients undergoing heart valve replacement [24]. The aim of this study was to validate a smartphone app called "My Smart Heart" [25] and to investigate its effect on the QoL of patients with HF.

Methods

Design of the Trial

This study was a randomized clinical trial (pretest and posttest with a control group design, Multimedia Appendix 1), which was conducted in 2018 in the cardiac care units of Mashhad Medical Center, Iran. After obtaining approval from the ethics committee affiliated with the Iran University of Medical Sciences (code: 1396.9411449003) and registration on the website of clinical trials (code: IRCT2017061934647N1), willing patients signed the letter of consent before the study. This study adhered to the basic ethics principles and the tenets of the Declaration of Helsinki.

Patient Recruitment

In this study, patients with HF who were admitted to the cardiac care unit were selected using the following inclusion criteria: age of 18-65 years, being literate, class II or III of HF according to the New York Heart Association classification, patients admitted to the hospital due to exacerbation of HF, having a smartphone or a tablet with the Android operating system, and ability to use a smartphone and the app. Patients who met the following criteria were excluded from analysis: unwillingness to continue participation in the study, no use of the app for 1 week (each patient used a one-time password to enter the software), and death.

The sequential sampling method was used. The randomized block method with the ratio of 1:1 and no permutation was used to assign the patients to the groups. Different modes of assignments to the groups were written on 4 cards and placed in opaque envelopes. Next, the envelopes were placed in a box. A research collaborator who was unaware of the assignment process took the envelopes from the box and determined each patient's place in the groups. This process was continued until the desired sample size was achieved. It should be noted that due to the nature of the intervention, there was no possibility of blinding the subjects. To estimate the sample size at 95% confidence interval, 80% power, assuming that the effect size of the intervention on the QoL in the intervention group compared to the control group would be at least d=10.5 and

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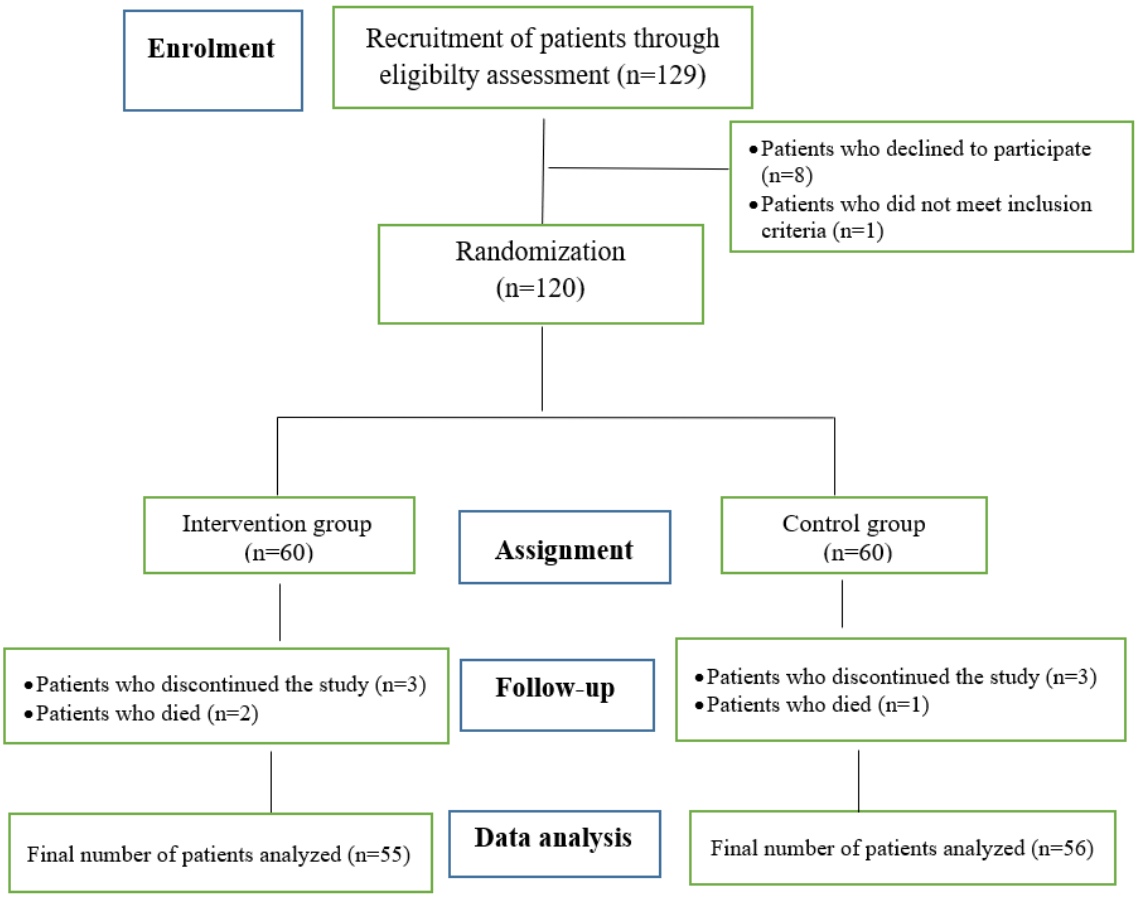
SD=18 [26] and with 25% possibility of sample dropout, the sample size was considered as 60 people in each group (Figure 1).

Figure 1. The process of this study.



Data Collection

Data were collected from the patients' medical records and through interviews using the demographic data form, health information form, and Minnesota Living with Heart Failure Questionnaire (MLHFQ).

Demographic data form: A researcher-made demographic form was prepared on the basis of literature review. It was completed before the intervention by examining a patient's medical file and interviewing him/her. The content validity of this form was assessed and approved by an expert panel.

Health information form: This was a researcher-designed form that was prepared on the basis of literature review. This form was completed before the intervention by examining the patient's medical file and interviewing him/her. The content validity of this form was assessed and approved by an expert panel.

MLHFQ: The MLHFQ is the most common tool for investigating the QoL of patients with HF [27]. The validity and reliability of the Farsi version of this tool have been assessed and approved using the calculation of the Cronbach α coefficient of .95 and reliability score of 0.90 [28]. This questionnaire assesses the patients' perceptions of the effects of dysfunctional illness on their physical, economic, social, and psychological functions. This questionnaire consisted of 21 items on the 6-point Likert scale from 0 (some limitations) to 5 (maximum limitations). The score range was between 0 and 105, with a high score indicating a poor QoL. In this questionnaire, 9 questions were related to physical function, 5 questions covered the psychoemotional aspect, and 7 questions examined the socioeconomic conditions. The questionnaire was designed to be opened and filled out using the Google platform on their smartphones. The patients were asked to fill the questionnaire, and those with a poor and moderate QoL and a score more than 24 entered the study. Further, 3 months after the starting point of the study, the same questionnaire was sent to the patients via the smartphone's virtual social network to be filled out. A follow-up phone call was made to ask the patients to fill the questionnaire. Finally, for reliability, the Cronbach α coefficient was calculated to be .71. The patients were asked to fill the questionnaires, and a researcher who was blinded to the study process gathered these questionnaires at the beginning of this study and at 3 months after the patients entered the study.

Smartphone App Features

An Android-based smartphone app was developed and evaluated [25]. This interactive app (Figure 2) can be used both online and offline. The main characteristics of this app are profiles, reminders, educational content, educational videos, daily messages, pharmacy guides, frequently asked questions, daily recording of physical and psychological symptoms, and vital signs and sending alerts as needed. This app was evaluated by patients, health care providers, nurses, physicians, and programmers, thereby indicating its simple and convenient use

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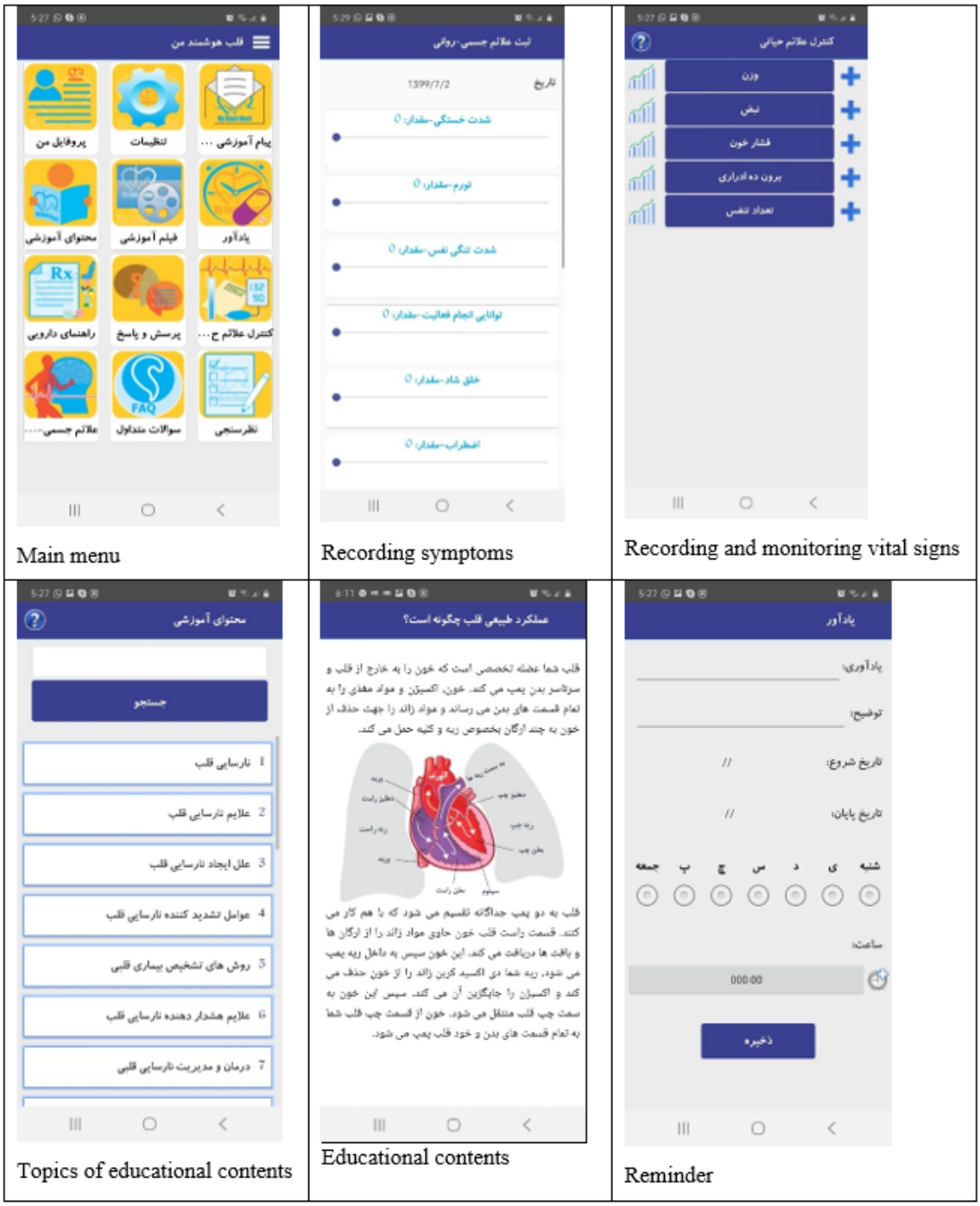
and consistency with the principles of the American Heart Failure Association and the Institute of Health Information Technology [25]. This app has the following features: (1) informing: information about disease, symptoms, symptom management, treatment, and care in various formats (text, photos, and videos); (2) instruction: provision of instructions for the user of the app; (3) recording: ability to record user's information under the subsets of collecting information, sharing information with the researcher, evaluating information, and intervening, as needed; (4) displaying: displaying data regarding symptoms, vital signs, and weights graphically and textually, as well as the ability to extract the PDF and XML formats; (5) guiding: provision of guidance based on the data given by the user and provision of appropriate advice through communication with the researcher; (6) reminder or alert: reminding the user regarding the time of taking medicines, performing tests, and other requirements; and (7) interaction: bilateral interaction between the researcher and patient [25]. This app was provided to patients to use for 3 months.

Figure 2. Features of the interactive Android-based smartphone app.



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Intervention

Patients in the intervention group received the smartphone-based app besides routine care. It was installed on their Android phones, and the patients were taught how to use the program via a 30-minute face-to-face session. The app brochure was also provided to the patients. The method of measuring vital signs, monitoring symptoms, and recording them in the app were taught to patients via the educational content of the app. Every week for 6 consecutive weeks and then every month for about 2 months, notifications were sent to the patients to remind them to use the app. Patients were asked to enter their daily vital signs, symptoms, and weight in the app, which provided the opportunity for health care providers to telemonitor the changes in the data in the text and graph format. In addition, patients could evaluate their daily conditions and its changes by visualizing the recorded data in the shape of a graph. Further, the daily use of the app by the patients was evaluated by the management panel on the internet and encouragements for the use of the app were provided, as needed. Patients and researchers could interact with each other depending on the patients' needs. During the app usage period (3 months), the patients were supported in terms of how to use the program. To provide support, the researcher's telephone number was provided to the patients for contact purposes, if needed. The patients in the control group received routine care, which included the provision of a brochure and the method of taking medicines and referral to the doctor at a clinic 2 weeks later. Moreover, the patients in the control group were provided with the smartphone-based app after data collection.

Data Analysis

Descriptive statistics (frequency, mean, and SD) were used to analyze the qualitative and quantitative data. The Kolmogorov-Smirnov test was used to assess the normal distribution of the quantitative variables. The two-sided *t* test was used to compare the quantitative variables. The chi-square and Fisher exact tests were used for comparing the qualitative variables between the 2 groups. The two-factor analysis of variance was used for determining the effect of the demographic and health information on the QoL in order to investigate the effects of 2 factors (intervention and demographic and health information) on the dependent variable. The repeated measure analysis of variance test was used to determine the effect of the intervention over time. The Cohen effect was used to assess the effect of the intervention. All statistical tests were performed using the SPSS V.22 software (IBM Corp). The significance level was set as $P<.05$.

Results

In this study, data collected from 111 patients were used for the analysis. The groups showed no statistically significant differences before the study regarding demographic characteristics (Table 1).

Table 2 shows that before the study, the mean score of QoL in the intervention and control groups were 42.91 (15.62) and 47.42 (16.38), respectively. The independent two-sided *t* test showed that the groups had no statistically significant differences before the study in any of the dimensions ($P=.14$). At 3 months after the intervention (Table 2), the mean scores of QoL in the intervention and control groups were 26.03 (9.67) and 50.13 (15.54), respectively. The groups had statistically significant differences in the QoL after the intervention, with a better QoL in the intervention group ($P<.001$). According to the results, the effect size of the intervention was high. The mean scores of QoL after the intervention in the intervention group in all domains were less than those in the control group, indicating better QoL in the intervention group compared to that in the control group ($P<.001$). The effect size of the intervention was high. In the intervention group, the reduced scores indicated improved QoL in all the domains compared to that in the control group. In the intervention group, the total and all the domain mean scores of QoL before and after the intervention had a statistically significant difference, indicating an improved QoL after the use of the app ($P<.001$). In the control group, the total mean score of QoL before and after the intervention showed a statistically significant difference ($P=.001$). The mean score of QoL in the control group in all dimensions before and after the intervention showed a statistically significant difference, indicating a reduced QoL in all domains over 3 months.

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Table 1. Demographic and health information of the patients with heart failure before the intervention.

Variables, subgroups	Intervention group, n=55	Control group, n=56	*P* value
Sex, n (%)			.38
Male	34 (62)	30 (54)	
Female	21 (38)	26 (46)	
Age (years)			.24
<40, n (%)	10 (18)	7 (13	
40-49, n (%)	14 (25)	12 (22)	
50-59, n (%)	15 (27)	12 (21)	
>60, n (%)	16 (29)	25 (45)	
Mean (SD)	50.07 (11.77)	52.78 (12.2)	
Education level, n (%)			.18
Elementary to high school	25 (46)	35 (63)	
After high school and before entering university	19 (35)	15 (27)	
University degree	11 (20)	6 (10)	
Marital status, n (%)			.18
Married	51 (93)	46 (82)	
Single	4 (7)	10 (18)	
Employment status, n (%)			.69
Unemployed	4 (7)	7 (13)	
Housewife	20 (36)	24 (43)	
Employed	15 (27)	13 (23)	
Retired	4 (7)	7 (13)	
Income adequacy, n (%)			.31
Adequate	19 (35)	13 (23)	
Somewhat adequate	20 (36)	20 (36)	
Not adequate	16 (29)	23 (41)	
Time since diagnosis (years), mean (SD)	4.52 (4.41)	4.57 (5.01)	.96
Body mass index, mean (SD)	25.96 (3.83)	25.42 (4.59)	.50
Cigarette smoking, n (%)			.97
Yes	8 (15)	8 (14)	
No	47 (85)	48 (86)	
Comorbidities, n (%)			.36
No	17 (31)	13 (23)	
Yes	38 (69)	43 (77)	
Types of comorbidities, n (%)			
Diabetes	19 (50)	26 (61)	.34
Hypertension	28 (74)	33 (77)	.75
Pulmonary disease	5 (13)	5 (13)	.71
Previous hospitalization in the last 3 months because of heart failure, n (%)			
Yes	31 (56)	33 (59)	.12
No	24 (44)	23 (41)	.11
Frequency of previous hospitalization in the last 3 months, n (%)			.08
1 time	18 (55)	10 (42)	

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Variables, subgroups	Intervention group, n=55	Control group, n=56	*P* value
2 times	11 (33)	5 (21)	
3 times or more	4 (12)	9 (38)	
Ejection fraction, mean (SD)	29.41 (9)	29.19 (9)	.90

Table 2. Comparison of the mean scores of the quality of life before and after the intervention between and within the groups.

Parameters, Domain/times	Intervention group, n=55	Control group, n=56	Independent *t(df)* test	*P* value
Physical function				
Before, mean (SD)	18.87 (6.73)	21.75 (8.76)	1.937 (109)	.055
After, mean (SD)	11.96 (5.44)	22.71 (8.05)	8.226 (109)	<.001
Paired *t(df)* test	7.23 (54)	2.274 (55)	N/A[a]	N/A
P value	<.001	.03	N/A	N/A
Changes, mean (SD)	–6.90 (7.08)	0.96 (3.17)	7.53 (74.52)	<.001
Psychological function				
Before, mean (SD)	9.26 (5.41)	10.96 (5.10)	1.703 (109)	.09
After, mean (SD)	4.14 (2.77)	11.71 (4.80)	10.149 (109)	<.001
Paired *t(df)* test	7.26 (54)	2.803 (55)	N/A	N/A
P value	<.001	.007	N/A	N/A
Changes, mean (SD)	–5.11 (5.22)	0.75 (2.00)	7.836 (69.27)	<.001
Social function				
Before, mean (SD)	14.76 (5.77)	14.68 (6.29)	0.072 (109)	.94
After, mean (SD)	9.92 (4.21)	15.7 (5.60)	6.127 (109)	<.001
Paired *t(df)* test	5.59 (54)	2.667 (55)	N/A	N/A
P value	<.001	.01	N/A	N/A
Changes, mean (SD)	–4.83 (6.41)	1.02 (2.86)	6.228 (74.41)	<.001
Total				
Before, mean (SD)	42.91 (15.62)	47.42 (16.38)	1.483 (109)	.14
After, mean (SD)	26.03 (9.67)	50.13 (15.54)	9.787 (109)	<.001
Paired *t(df)* test	7.82 (54)	3.55 (55)	N/A	N/A
P value	<.001	.001	N/A	N/A
Changes, mean (SD)	–16.88 (16.00)	2.71 (5.71)	8.617 (67.34)	<.001

[a]N/A: not applicable.

Table 3 shows that there was significant correlation between the QoL and income adequacy and previous hospitalization in the last 3 months among the patients. Two-factor analysis of variance indicated that these 2 independent variables had no significant effect on the QoL (Table 4).

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Table 3. Correlation of the mean scores of the quality of life with the demographic and health information of patients with heart failure.

Variables, groups	Quality of life	
	Mean (SD)	*P* value
Sex		.51[a]
Male	46.06 (17.56)	
Female	44.00 (13.95)	
Age (years)	N/A[b]	.74[c]
Education level		.76[d]
Elementary to high school	46.20 (15.69)	
After high school and before entering university	43.64 (16.06)	
University degree	44.7 (18.23)	
Marital status		.08[a]
Married	52.35 (12.7)	
Single	44.15 (16.32)	
Employment status		.48[d]
Unemployed	50.81 (16.29)	
Housewife	42.75 (12.9)	
Employed	45.71 (19.09)	
Retired	46.29 (17.42)	
Income adequacy		.02[d]
Adequate	40.29 (14.92)	
Somewhat adequate	43.57 (14.72)	
Not adequate	50.86 (17.02)	
Time since the diagnosis (years)	N/A	.08[c]
Body mass index	N/A	.64[c]
Cigarette smoking		.20[a]
Yes	44.38 (15.83)	
No	49.98 (17.32)	
Comorbidities		.89[a]
No	45.53 (17.23)	
Yes	45.06 (15.77)	
Previous hospitalization in last 3 months because of heart failure		<.001[a]
Yes	38.26 (10.45)	
No	52.50 (17.78)	
Ejection fraction	N/A	.07[c]

[a]Independent *t* test.
[b]N/A: not applicable.
[c]Pearson correlation test.
[d]Analysis of variance test.

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Table 4. Results of the two-factor analysis of variance.

Variables, Domain/times	Intervention group, n=55, mean (SD)	Control group, n=56, mean (SD)	Partial eta squared		
			Group variable	Income	Hospitalization
Physical function					
Before	18.87 (6.73)	21.75 (8.76)	0.066 (0.034)	0.185 (0.034)	0.169 (0.025)
After	11.96 (5.44)	22.71 (8.05)	0.000 (0.357)	0.343 (0.021)	0.396 (0.007)
Psychological function					
Before	9.26 (5.41)	10.96 (5.10)	0.098 (0.027)	0.213 (0.031)	0.105 (0.026)
After	4.14 (2.77)	11.71 (4.80)	0.000 (0.473)	0.088 (0.048)	0.399 (0.007)
Social function					
Before	14.76 (5.77)	14.68 (6.29)	0.999 (0.000)	0.112 (0.043)	0.315 (0.010)
After	9.92 (4.21)	15.7 (5.60)	0.000 (0.235)	0.134 (0.040)	0.614 (0.003)
Total					
Before	42.91 (15.62)	47.42 (16.38)	0.146 (0.021)	0.087 (0.048)	0.111 (0.025)
After	26.03 (9.67)	50.13 (15.54)	0.000 (0.449)	0.107 (0.044)	0.366 (0.008)

Discussion

Principal Findings

In this study, according to the findings, changes in the QoL score and its dimensions in the intervention group were more than those of the control group, and the effect size of the intervention was high. Therefore, use of a smartphone-based app increased the QoL and its dimensions in patients with HF. It is believed that new technologies such as apps can increase patients' satisfaction with medical care and improve their relationships with health care staff and subsequently improve their QoL [29]. Such programs can increase the motivation of the patients to make changes in their lifestyles and increase their QoL. Further, any intervention that reduces the rate of hospitalization and symptoms in patients with HF can improve their QoL. A smartphone app that can record symptoms and provide intelligent responses to the patients' symptoms and related changes in each week and month can help them manage their symptoms effectively. This app can cause a significant improvement in patients' QoL [29]. The app provides the possibility of continuous monitoring of patients even if they are not hospitalized. Moreover, this app and its use are not limited to a specific time and place [30]. In this study, there was a possibility to contact the health care provider via this app, and caregivers could help with reducing the patient's or family's ambiguities with regard to the patient's health condition.

Interventions that improve QoL are integral parts of the management of HF [9]. They can be performed by the therapist as a continuous process of follow-up and monitoring. However, in a review study, wherein the effect of the use of mobile-based apps on the QoL of patients with HF was studied, only a limited number of apps had the required criteria for caring of patients with HF and most programs were commercial rather than functional. Moreover, app use had little impact on the QoL of patients [31]. In the production of the "My Smart Heart" app, efforts were made to reduce the limitations of the existing apps and improve the QoL of patients. The results of our study shows that the effect of this intervention on the QoL of patients with HF was high. In line with the results of this study, a study after 6 months of intervention in patients with myocardial infarction found that the mean score of QoL in the intervention group increased compared to that in the control group [32].

Strengths and Limitations

The smartphone-based app used in our study provides a novel telemonitoring and education method for patients with HF. This study was conducted on those patients who were able to communicate and were literate, with an ejection fraction of less than 45%. For generalizability, similar studies should be conducted in illiterate patients. In this study, the effect of the intervention was studied after 3 months, but the long-term effects of the intervention need to be further researched. In this study, the mediator effects of knowledge and self-care improvement were not evaluated, and therefore, these should be investigated in future studies. Within 3 months of the study process, some medication errors were identified. Therefore, studies should be performed to demonstrate the efficacy of software in improving patient safety and reducing medication errors.

Conclusions

Our study showed that the use of a smartphone-based app increased the QoL of patients with HF. Interventions that improve QoL constitute an integral part of the management of HF, which can be carried out by the health care provider through continuous follow-up of patients using such apps. Nurses as well as patients and their families can use smartphone-based interactive software. Provision of facilities such as counselling centers can provide patients and their families with information about how to use this software to improve their QoL. The results of this research can be considered by nursing managers for patient education. However, it is necessary to study the cost-effectiveness of such interactive software. This method can be used by nurses and other health care providers in HF clinics and heart transplantation centers to improve patients'

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and families' satisfaction with health care, which needs to be further studied in the future.

Acknowledgments

The Iran University of Medical Sciences supported this study. All authors of this paper declare their consent to publish this study in this journal. The Iran University of Medical Sciences financially supported this study.

The data, materials, app, and its codes are available. The datasets generated or analyzed during this study are available from the corresponding author on reasonable request.

Authors' Contributions

Study design: MD, TNG
Data collection: MD, TNG, FVA
Data analysis: MD, TNG, FVA
Manuscript writing: MD, TNG, FVA

Conflicts of Interest

None declared.

Multimedia Appendix 1
CONSORT-eHEALTH checklist (V1.6.1).
[PDF File (Adobe PDF File), 1187 KB - nursing_v3i1e20747_app1.pdf]

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Abbreviations

HF: heart failure
MLHFQ: Minnesota Living with Heart Failure Questionnaire
QoL: quality of life

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Edited by D Dordunoo; submitted 27.05.20; peer-reviewed by P Athilingam, E Opoku-Agyemang; comments to author 18.07.20; revised version received 18.08.20; accepted 02.10.20; published 02.11.20.

Please cite as:
Davoudi M, Najafi Ghezeljeh T, Vakilian Aghouee F
Effect of a Smartphone-Based App on the Quality of Life of Patients With Heart Failure: Randomized Controlled Trial
JMIR Nursing 2020;3(1):e20747
URL: https://nursing.jmir.org/2020/1/e20747
doi:10.2196/20747
PMID:

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