Understanding the Behavior, Challenges, and Privacy Risks in Digital Technology Use by Nursing Professionals

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With the growing adoption of digital technology in healthcare organizations, it is important to understand nursing professionals' behavior and challenges, and the corresponding privacy implications around digital technology use. To this end, we conducted semi-structured interviews with 21 participants (16 nursing professionals, and five nursing faculties) in the USA. In our study with nursing professionals, we explored how they used digital technology and protected sensitive health data at their workplace. We investigated their understanding of privacy breaches and possible consequences, the challenges they encountered to maintaining privacy, and their workarounds to deal with such issues. We looked into the support that professional nurses receive in the form of organizational training, and how they collaborate with the IT department at their institution to address technical issues. In addition, we shed light on the gap between their academic preparation and professional needs in the context of digital technology use and privacy protection, where we also interviewed five nursing faculties to get more in-depth understanding of this issue from the point of view of academia. Overall, our findings provide valuable insights for the CSCW community to better understand the challenges and privacy risks in digital technology use by nursing professionals, and lead to our recommendations to address these issues.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)**; **User studies**; • **Security and privacy** → **Human and societal aspects of security and privacy**.

Additional Key Words and Phrases: Digital technology, privacy, nursing professionals, workplace.

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1 INTRODUCTION

The COVID-19 global pandemic has heightened the visibility of healthcare professionals, where the role of nurses in taking care of individuals, families, and communities cannot be overstated.

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They play a crucial role in helping the patients not only to recover from sickness, but also to attain and maintain a good health. Nursing professionals are intricately connected to providing medical services, whose duty is not limited to patient care only; they play a critical role in a wide range of tasks, including collecting, storing, retrieving, and updating patients' health information. Here, patients' health records serve a wide range of purposes in addition to diagnosis and treatment provision, such as improving efficacy within the healthcare system, driving public policy development, and conducting medical research [33].

In recent years, we have observed a rapid rise in the electronic storage of patients' healthcare data, where the USA could potentially save $81B annually by moving to a universal Electronic Health Record system [32]. The patient's medical record accumulates significant personal information including: identification, genetic information, psychological profile, history of medical diagnosis and treatments, sexual preferences, employment history, and income [32, 45]. Thus, patients' medical records are considered highly sensitive, protected by the Health Information Portability and Accountability Act (HIPAA) in the United States [42, 48]. The leakage of healthcare information that nurses handle on a daily basis at their workplace (location of work or place of employment, e.g., the hospitals) could lead to severe consequences.

Most medical institutions have switched to electronic (i.e., digital) platforms from paper-based systems. The recent studies [25, 34, 36] present the benefit of using digital systems in a healthcare organization, which include strengthening their network and process of information management, and reducing the mistakes made by medical staffs. The review of 25 years of CSCW research in healthcare [25] emphasized on investigating, and incorporating the voice of nurses in technology design for medical institutions. However, a little study has focused on understanding the issues that nursing professionals face with using digital systems at their workplace. We addressed this gap in our first research question (**RQ1**): *What challenges do nurses encounter in using digital systems at workplace, and how do that affect their professional duties?*

The lack of privacy is a concern in healthcare, where the prior work studied the perceptions of nurses and patients on privacy for sexual relationships [51], patients' unawareness of privacy rights [49], and the role privacy and dignity workshops in healthcare organizations [19]. The studies of Zhou et. al. [61, 62] shed light on the disagreement between nurses, and underlying politics in protecting patients' psycho-social data. In a separate study [10], Aylott identified the risks of leaking a patient's identity if the medical staffs are not mindful in using online social media. Overall, the concerns about protecting patients' data from adversaries and prying eyes are on the rise [12, 54]. To this end, there is a dearth in existing literature to understand the end users' (e.g., nurses') behavior that could pose privacy risks and make patients' data vulnerable to leakage. We investigated these issues in our second research question (**RQ2**): *How could nursing professionals' practices and behavior in using digital systems lead to the risks of privacy leakage in a healthcare organization?*

To address these research questions, we conducted semi-structured interviews with 21 participants (16 nursing professionals, and five nursing faculties) in the USA. The findings from our study with nursing professionals present the perceived complexities of, and inadequacies in digital systems that disrupt the natural workflow in medical institutions. Our analysis unfolds how the infrastructural and technological barriers, lack of inclusion in system design, and the tension between accessibility, service, and privacy make sensitive health data vulnerable to misplacement, loss, and leakage. We identified the issues, including increased workload and cognitive burden, reduced throughput, after-hours working, and human errors – arising from the downtime of internet and digital systems in medical organizations, and unpacked the privacy risks of switching back-and-forth between digital and paper charting in these situations.

Our results show that the lack of understanding about a digital system affects the collaboration between nurses, and adds to the difficulty in their conversation about technological issues. Our analysis points towards the gaps between academic preparation at nursing schools and professional needs in healthcare organizations in using digital systems and taking privacy-preserving measures. To get more insights into this issue from the perspective of nursing schools, we conducted semi-structured interview with five nursing faculties that inform us about the factors contributing to these gaps, and the strategies to bridge them.

Taken together, our findings provide valuable insights for the CSCW community to understand the expectations, needs, and privacy risks around the use of digital systems by nursing professionals. Based on our results, we offer recommendations in the contexts of re-calibration of technology and procedure in medical institutions, inclusive design for nurses, improving training and support by healthcare organizations, and the role of nursing schools in taking collaboration initiatives to reduce the gaps between academic preparation and professional needs of nurses in using digital systems and protecting sensitive health data.

2 RELATED WORK

The recent HCI and privacy research focused on understanding the situated needs in technology use and privacy protection in the landscape of different professions, especially the ones that involve protecting clients', customers', or sources' identity and sensitive information. The examples include journalists – who need to protect sources' identity and the information provided by them [40, 43, 44], lawyers [40], bank employees [1, 21], financial accountants [22], and the employees in non-profit organizations (e.g, NGO) [38]. Another branch of recent literature examines how the human factors and organizational culture in software development process affect the security guarantee and privacy protection offered by their products [8, 9, 24, 26, 56].

The use of digital technology has been steadily rising in healthcare organizations. While the studies on people needing the care is more frequent [36], a little research focused on how nurses interact with digital systems in the process of offering medical services to patients, and the privacy vulnerabilities related to how they use digital systems at workplace. In this section, we briefly discuss the insights from prior research on digital technology use and corresponding privacy issues in nursing, where we highlight the gaps in existing literature that motivated our work.

2.1 Digital Technologies in Healthcare

The study of Kai et al. [34] reported the types of digital technologies used in healthcare organizations, where Fitzpatrick and Ellingsen [25] explained the differences between using electronic and paper-based systems to store and maintain patients' health records. Several studies [25, 34, 36] focused on understanding the benefits of using digital systems in medical institutions, and presented empirical evidences of how introducing digital platforms had contributed to strengthen their network and process of information management. Here, Heath et. al. [31] have pointed out the necessity and significance of capturing structured and standard data for the reliability, accountability, and strategic planning in modern healthcare organizations. In a separate study [53], the authors identified the key role of digital technology in protecting patients by eliminating the mistakes that were commonly made by nurses in creating and maintaining paper-based health records. The study of Gurascio-Howard et. al. [27] examined the efficacy and usability of using decentralized technology in designing nursing stations, and reported the benefits of using their proposed scheme in digital communication and day-to-day activities in healthcare organizations.

Multiple studies [14, 15, 20, 46] investigated the impact of digital technology-focused workflow on the in-person communication and collaboration among medical staffs, including nurses. The findings from these studies [14, 15, 20, 46] show that information technology contributed to faster

services in healthcare institutions, however, adversely impacted the collaboration among medical staffs. The studies of Bardram et. al. [11], Hardstone et. al. [29] and Tang et. al. [57] reported that digital technology had shifted the focus of caregivers to using computers for a large part of their work, which in turn, had reduced the scopes of conversation and meetings among medical staffs to have in-depth discussion about the needs and conditions of patients. The studies of Zhou et. al. [61–63] reported the impact of computerization on both formal and informal work practices in healthcare organizations, and shed light on the politics of information that are inherent in complex medical services. In these contexts, the authors emphasized on the collaboration among medical staffs to reach agreement on data collection and sharing in digital platforms [61–63].

The study of Wagner [58] investigated the cultural transformation in nursing with the advent of information technology in healthcare organizations. The findings from this study [58] show that the focus of digital technology on enhancing efficiency often fails to consider the traditional role of medical staffs in patient care, where the transformation to digital systems seems to stretch in healthcare institutions instead of supporting the individuals it involves. This could result in overworking of nursing professionals, and affect the overall quality of medical services [58]. The review of 25 years of CSCW research in healthcare [25] identified the need of investigating, and incorporating the voice of nurses in technology design for medical institutions. However, a little study has focused on understanding the issues that nursing professionals face with using digital systems at their workplace. We addressed this gap in our first research question (see RQ1 in §1).

With the advent of digital systems in healthcare organizations, several studies [18, 35, 59] aimed to understand the impact of using digital medium in academic learning of the future nursing professionals. The study of Webb et. al. [59] identified a positive attitude among nursing students towards electronic learning medium, where the authors believe, the support from administration at nursing schools would be contributing to increase the adoption of digital learning. In a separate study [35], Johnston et. al. examined the e-learning methods and digital game-based education. The findings from this study [35] pointed out a lack of critical engagement in technology-enhanced learning. The study of Burke [18] focused on nursing faculties, and reported on their struggles and stress in preparation and delivery of technology-focused learning materials. However, none of these studies explored the gap between academic preparation and professional needs of the nurses. Our studies with nursing professionals and nursing faculties provide insights into this issue.

2.2 Privacy in Healthcare

The protection of patients' privacy and confidentiality is essential to attain high quality in healthcare services [48]. In the United States, the Health Insurance Portability and Accountability Act (HIPAA) focuses on the privacy protection of health data. Here, Title I ensures insurance portability, and Title II requires the use of national guidelines for electronic health communication [48]. As reported in the study of McCullough and Schell-Chaple [42], HIPAA regulations are not clearly understood by many healthcare practitioners, leading to the confusion, and fear of potential repercussions, including fines and losing jobs.

The study of Quinn and Happell [51] explored the perceptions of nurses and patients on privacy and dignity for sexual relationships in a forensic mental health hospital, where the majority of participants reported the need for a private and dignified place for patient intimacy. In the study of Olsen et. al. [49], both the nurses and patients voiced concern regarding health information disclosure to third-parties. The findings from this study [49] point towards the necessity of educating patients about their privacy rights. The study of Chadwick et. al. [19] focused on the role of privacy and dignity workshops, and reported on a project in the UK NHS Mental Health Trust, where a series of privacy and dignity workshops were delivered to healthcare practitioners.

The studies of Zhou et. al. [61, 62] investigated the disagreement between nurses and underlying politics in protecting patients' psycho-social data, arising from their lack of trust on digital medium in preserving the privacy and confidentiality of patients' health information. In these studies [61, 62], the authors pointed to the lack of cohesive agreement among medical staffs on what information to store in digital medium, leading to the confusion about where to find certain health records. The study of Aylott [10] focused on the increasing use of social media by medical practitioners, and its possible implications on patients' privacy and the reputation of medical organizations. The findings from this study [10] point to the risks of leaking a patient's identity if the medical staffs are not mindful in using online social media, where the accidental posts, or the communication about patients over social media might have serious repercussions. In a separate study [23], Duke et al. reported on the use of social media by nursing students and faculty members, and found that the students were more tech-savvy than the faculties in understanding and using privacy features on social media.

The study of Al-Ameen and Kocabas [5] investigated the perceptions of users about digital medicine, where they unfolded the perceived benefits and concerns of users about using digital pill, situated preferences to share information with other entities, and their preferred modes of learning about the privacy notice before using digital medicine. The authors have pointed out that the skepticism of participants to use digital pill is related to their health and privacy related concerns [5]. The participants voiced specific preferences on how they would like to be informed of the privacy policy of digital medicine before they use this technology, ranging from verbal communication with an expert to using mobile apps [5].

The availability of health information in an electronic format is strategic for industry-wide efforts to improve the quality, and reduce the cost of healthcare services, where protecting patients' data is an issue of growing importance [12, 54]. As reported by Hasan and Yurcik [30], the second highest reported breach in recent years are medical data disclosures, which could leave the patients exposed to economic threats, mental anguish, and possible social stigma [50]. Thus, the drive towards computerization should be proactively pursued through the careful development of privacy-protective measures [54]. Since Anderson's seminal work on the data protection issues in healthcare information systems [7], researchers have developed different technological solutions to protect patients' information at the time of storing, processing, and sharing [2, 37, 60]. However, a little research has been conducted to understand the privacy risks arising from the practices and behavior of nurses while interacting with digital systems at medical institutions. We addressed this gap in our second research question (see RQ2 in §1).

3 METHODOLOGY

We conducted semi-structured interviews with 16 nursing professionals, and five nursing faculties in the USA. We interviewed the nursing professionals between June and September, 2020. In preparing the interview questionnaire for nurses, the authors of this paper conducted several rounds of focus-group discussion. As we prepared the draft, it was then reviewed and edited by our colleague from the Nursing department with prior experiences as a nursing professional at healthcare organizations. We further refined our questionnaire to improve the structure and clarity through multiple rounds of reviews and edits. The findings from this study encouraged us to conduct the next study with nursing faculties. We interviewed the participants over Zoom – an online video communication medium. The studies were approved by the Institutional Review Board at our university.

PID	Gender	Age Range	Race	Education
PN1	NA	NA	NA	NA
PN2	Female	30-34 years old	White	Four-year College Degree
PN3	Female	18-24 years old	White	Four-year College Degree
PN4	Female	25-29 years old	Armenian	Four-year College Degree
PN5	Female	35-39 years old	White	Four-year College Degree
PN6	Female	18-24 years old	Asian	Four-year College Degree
PN7	Male	25-29 years old	White	Two-year College Degree
PN8	Female	18-24 years old	White	Four-year College Degree
PN9	Female	25-29 years old	White	Master's of Nursing in Progress
PN10	Female	18-24 years old	Asian	Four-year College Degree
PN11	Female	18-24 years old	Hispanic or Latino	Two-year College Degree
PN12	Female	25-29 years old	Hispanic or Latino	Two-year College Degree
PN13	Female	35-39 years old	Cambodian	Four-year College Degree
PN14	Female	40-44 years old	White	Graduate Degree
PN15	Male	40-44 years old	White	Graduate Degree
PN16	Female	30-34 years old	White	Four-year College Degree

Table 1. Demographic Information of Nursing Professionals [NA: Not Available]

3.1 Participant Recruitment

In our study with nursing professionals, we recruited participants through sharing the study information via email, online social media, and through snowball sampling. To take part in this study, a participant had to be at least 18 years old and working as a full-time professional nurse, as specified in our recruitment material. The findings from our study with nursing professionals point towards the gap between their academic preparation and professional needs in understanding and using digital systems. To get more insights into this issue from the perspective of nursing schools, we conducted semi-structured interviews with five nursing faculties. To recruit participants, we sent invitation email to the nursing department at several universities, and used snowball sampling. In the recruitment material, we specified that any faculty member in nursing department who teaches courses on digital systems can take part in our study. During our interviews with the faculties, we came to know that a very limited number of courses on digital systems are offered at nursing schools, which in many cases, are taught by a single faculty member in the department.

3.2 Procedure

When a participant showed interest to take part in our study, we emailed them the informed consent document (ICD). As they agreed to ICD, we scheduled a time for an online interview over Zoom. Interviews were audio recorded.

In our study with nursing professionals, we asked participants about their primary role, and professional duties they perform in their current organization. We then asked about the use of digital technology as a part of their day-to-day activities at the workplace, digital information flow within their organization, and collaboration with other nurses and colleagues as a part of this information network. We asked them a set of questions on their privacy perceptions, and protection behavior around the technology use in their organization, along with their understanding of privacy and security risks, and possible consequences if a breach occurs at their workplace. Participants responded to the questions on organizational support and training in using digital technology and

PID	Gender	Age Range	Race	Education
PF1	Female	55-59 years old	White	Graduate degree
PF2	Female	30-34 years old	White	Graduate degree
PF3	Female	40-44 years old	White	Graduate degree
PF4	Female	60-64 years old	White	Graduate degree
PF5	Male	45-49 years old	White	Graduate degree

Table 2. Demographic Information of Nursing Faculty

protecting privacy, and their collaboration with the IT department at their institution to address technical issues. We also asked them about their academic preparation in technology use and privacy protection. Each interview session took between 30 and 60 minutes. In the study with nursing faculties, we asked participants about their understanding of the gaps between academic preparation and professional needs of nurses, factors contributing to these gaps, and how we could bridge these gaps.

In both studies, participants were asked to complete an online survey on demographics at the end of the interview. They were compensated with a $25 Amazon.com gift card for their participation.

3.3 Analysis

The audio recordings from interviews were transcribed, and we then performed thematic analysis on our transcriptions [13, 16, 17]. Each transcript was coded by two independent researchers, where they read through the transcripts of the first few interviews, developed codes, compared them, and then iterated again with more interviews until we had developed a consistent codebook. Once the codebook was finalized, two researchers independently coded the remaining interviews. After all interviews had been coded, both researchers spot-checked the other's coded transcripts and did not find any inconsistencies. Finally, we organized and taxonomized our codes into higher-level categories.

3.4 Participants

Table 1 presents the demographic information of nursing professionals who took part in our study. We could not record the demographic information of one participant due to technical issues. Among other 15 participants, 13 of them are women, and two are men. The age of our participants varied between 18 and 44. Above three-quarters of our participants had at least a four-year college degree. Table 2 reports the demographic information of the nursing faculties in our study. Four of our five participants are female and one is male. Their age varied between 30 and 64. All of them had earned a graduate degree.

4 RESULTS

In this section, we present the findings from our user study with nursing professionals (see §4.1, §4.2, and §4.3) and nursing faculties (see §4.4). For consistency, we use these terms based on the frequency of comments in participants' responses: a few (0-10%), several (10-25%), some (25-40%), about half (40-60%), most (60-80%), and almost all (80-100%).

4.1 Digital Systems in Nursing: An Overview

Most medical institutions have recently switched to electronic (i.e., digital) platforms from paper-based systems, which could be broadly categorized into three primary aspects: charting, communication, and integration. Most of the nurses reported that digital technologies help them with their work, which include reducing user errors like misinterpretation of handwriting, and reminding to provide medication on time.

4.1.1 Charting. Most of our participants reported satisfaction with the pace of work that they have gained through using interactive forms with predefined options in a digital charting system. One of them said, *"Each department where we used to hand write it (charting data of patients) all, and it would take about an hour, and we got it down to about five minutes." (PN1).* Digital charting provides better accessibility to patients' data, where our participants emphasized on two specific benefits: i) They can easily share with, and access data from other departments within their organization, and ii) When the shift changes, the incoming nurse can access patients' data directly from digital platforms without having to look for the nurses in a prior shift or the paper charts created by them.

4.1.2 Communication. Our participants referred to an internal texting system, which has been introduced to facilitate intra- and inter-departmental communication between nursing professionals and other staffs within an organization. Most participants reported satisfaction with the ease in communication that the system has brought to their workflow, which enables them to conveniently exchange information without having to worry about disturbing other nurses, or being bothered through a phone call while they are taking care of the patient. A few participants described the notable role of Video Conferencing in virtually connecting with, and providing support to their patients. One of them said, *"I mean, it's [telehealth/video conferencing] been huge [help] that we can keep our our medically fragile patients getting the least amount of exposure, community exposure to COVID as possible. And I'd seen moving forward that been really helpful for these patients, you know, just in terms of avoiding all kinds of infectious diseases, so that's been huge and the doctors that I've spoken to have openly embraced it." (PN4).*

4.1.3 Integration. As different departments within a medical organization get digitally connected, nursing professionals set off to experience faster and convenient collaboration in serving the patients. In most cases, sharing patients' information between departments, prescribing medication, approval, and transferring this information to the pharmacy are being administered over digital platforms. As a result, the back-and-forth manual transfers of paper-based documents between doctors, nurses, and the pharmacy are no longer necessary, which otherwise, could lead to delays and errors.

4.2 System Complexity, Inadequacy, and Lack of Inclusion

4.2.1 Perceived Complexities of Digital Systems. The abundance of features in medical charting with little or no direct connection to nurse's needs can lead to confusion and user errors. Several nurses expressed their frustration on how the complexity of digital charting disrupt patient care and put additional load on their workflow. They reported that many of the options and features in charting software do not contribute to their work, rather having to deal with this complexity demands a significant attention and time which they believe, could be better utilized in serving their patients. One of them said, *"I think actually at the beginning, they actually put two nurses, three people, three nurses in one room with a patient, one person to take care of the patient and two people to chart. That's how hard it was." (PN14).*

Several participants referred to the difficulty in navigation on software interface, which arises from overwhelming options and features. One of our participants described his experience: *"I would*

say when I oriented, it was a little difficult to navigate...given time, I was able to kind of understand, you know, what goes where, but...it's not like, here's this resident or a patient's chart, you can see everything here. It's kind of like you got to find it a different tab. So sometimes it can be a little challenging...it's point-click-care [name of the software the participant is talking about]..." (PN7).

Some participants referred to the integration of multiple systems leading to complexities in regular operations within a healthcare organization, which could even disrupt the workflow of nurses and their ability to deal with an emergency situation. One of our participants expressed her frustration with the connected system: *"I would say that at the beginning the deal [of building an integrated system] was great, but it was like good on paper. But then once they implemented it just really changed everything about how we did everything. So it was really frustrating because there was medications that were locked up, you know, at the beginning or something that we wouldn't be able to get access to a medication in an emergency, unless we scan the patient's band. And all this stuff when maybe the patient didn't have a band became because it was an emergency and they came in and they drop the floor, the bed, the baby right in the bed. And then all of a sudden they're hemorrhaging. So I would need to run to the med room to grab the medication. And it wasn't available to me because I didn't have the patient on that to scan because we didn't have an armband to scan yet because she just she wasn't technically even admitted as a patient yet." (PN14).*

4.2.2 Inadequacies in the Current System. Some of our participants reported that using multiple software, each for a different purpose creates hassles for them and raises difficulty in information transfer between different platforms. While the lack of an integrated software system at their workplace is emphasized by some participants, a few nurses further mentioned that not all departments in their organization are even digitized yet. One of them (PN10) specifically referred to the lack of digitization in the process of administering medicine, where they cannot take advantage of automation and tracking related to the order and delivery of medicine. As a result, they have to remember or manually keep track of the medicine ordered for a patient, whether it is delivered on time, and past records of medication as it comes to placing a new order. Such manual efforts are prone to errors and loss of patients' information, especially when the paper documents are misplaced or lost, and when the nurses have to share information with each other during the change in shifts.

Some of our participants referred to the lack of portability as an inadequacy in the existing system. As they reported, they need to carry heavy computers with them on strollers as several hospital rooms do not have computers; they joked that carrying these computers around is like a workout for them! In another instance, one of the on-call nurses (PN4) who has to visit patients at their home reported that they could not take their desktop computer with them due to the difficulty in carrying and limited accommodation in the patient's home, which in turn, poses additional burden on them to switch back-and-forth between paper-based (at patient's home) and digital systems (at workplace). In both cases, the nurses expressed their need of a light, portable device, like a tablet to take notes and update the patient's records instead of having to carry computers inside their organization or relying on paper-based workflow at the patient's home.

4.2.3 Lack of Inclusion in System Design and Improvement. The introduction of digital systems in healthcare demands unprecedented forethought and consideration, where technological mishaps could lead to the leakage of sensitive information. One of the participants shared an incident with us: *"I feel like sometimes the little slips happen, that I've heard of, but not a situation that impacted the person as much as it did. Even though actually I did hear about HIPAA break with someone using an Apple Watch. And one of the hospitals I was at and the Apple Watch recorded the patient so that was a HIPAA break. Somehow, it ended up on Facebook or something." (PN8).* The understanding of end users' behavior in using a digital system is crucial to make the system inclusive for them, which

in turn, could contribute to better usability, accessibility, and privacy protection. Thus, end users should be included in the process of system design and improvement. Most of our participants voiced concerns in this context of inclusiveness.

Most of the nurses in our study were vocal on their expectations to be included in the development and improvement of the system. They believe that their inputs and suggestions could help improve the system considerably. One of the nurses (PN15) has said that if feedback were taken from them at the design phase of a system, the usability and privacy issues that have now arisen, could be easily avoided. Below, we present two scenarios repeatedly mentioned by our participants, which reflect on the importance of including nurses' needs and behavior into technology design for their workplace.

4.2.3.1 Forgetting to Log Out. Most of the nurses mentioned about forgetting to log out of their computer when they need to get out of their workstation to attend a patient's need, or collaborate with other nurses and colleagues. When asked about how an unauthorized person could gain access to healthcare data, one participant said, *"I probably have to say if someone like you know, chose to not log out or didn't lock their computer, then someone can obviously see it." (PN3).* Thus, as a nurse forgets to log out of the system, the unauthorized patients, visitors, and staffs in a hospital could get access to patients' sensitive information, leading to privacy breaches. One of the nurses (PN1) talked about a case in the eating disorder unit where a computer was left unattended without logging out, and a patient got access to several patients' private data and shared that with the patients in that unit. As a result, the patients who were obese learned about their weight, leading them to severe depression and anxiety. Such unexpected incidents could be avoided through using a simple timeout to enforce an automatic logout. Integrating and encouraging such privacy-protective behavior call for a careful observation of how the nurses use a digital system in their workplace, and leverage that insights in the system design, and staff training process.

4.2.3.2 Casual Communication. Our participants reported using a private communication application, providing access to authorized employees only within their organization. This application has been integrated into the organization's digital system to ease and speed up the communication between nurses and their colleagues in providing better medical care to patients, and protect internal communication from being exposed to outside entities. Each time a message is sent over this application, an alert notification appears at others' devices. Our participants mentioned using this application for casual conversation and planning, where one of them pointed out how the overuse of this application disrupts their attention and causes stress in work: *"I think sometimes people overuse the text application a little bit as they create a group chat of everybody that is working that day. And like sometimes your phone is just completely ding ding all the time with like, all these things that don't really matter. Like somebody else from another unit is going on a break or somebody leaves the chat or like or we have cupcakes in the break room or something. And it can be really stressful if it is a really busy day..." (PN16).*

The insights from our findings indicate the need of a communication system that would help the nurses balance between their professional duties and social interaction at workplace. One possible way to attain that could be providing multiple channels integrated into a single communication system, where nurses would have the provision to customize alert notification for each channel.

4.3 Infrastructural and Technological Barriers

Infrastructural and technological barriers at healthcare organizations could lead to the risks of privacy breaches, loss of sensitive data, and loss of time.

4.3.1 Loss of Internet and System Failure. Most of our participants mentioned loss of internet as one of the challenges in their workplace. They reported that losing internet causes the medical organizations to revert to the old system of charting and making notes on paper, where nurses often forget to secure paper documents due to the lack of habituation in using paper charting and cognitive burden imposed by the change in workflow and procedure at the unavailability of internet. As the internet is back, nurses have to input all the information from paper documents to the digital system, which is a time-consuming process and leads them to work overtime, as noted by our participants. This process becomes more complicated and error-prone when the paper documents are misplaced, or when a nurse could not retrieve information from the notes on paper that was recorded by a nurse in an earlier shift. One of our participants said, *"There were multiple times where I would work all day without internet and was not able to chart the things that they had done...and then had to go back and try to figure out what we hadn't entered. Then, there would be missing information which became a problem a few times. And if you don't update it as you go, you forget and you lose your notes. So that happened quite a few times. And pertinent information that would have helped them with getting coverage with our insurance wasn't documented because the internet wasn't up."(PN1).*

Nurses are forced to revert to charting and taking notes on paper when a system failure occurs at their organization, causing similar issues as discussed above. One participant further added, *"I've had to paper chart a few times when the system was down and it probably takes me double the time." (PN8).* The system failure results in chaos at a healthcare organization, creates confusion among nurses and doctors due to temporarily losing access to patients' information which becomes a critical issue when a patient is scheduled for treatment. One of the participants (PN2) shared an incident with us where a patient was misidentified as another, leading to embarrassment and sharing sensitive medical information with one patient about the other one.

The nurses reported concern about poorly coordinated organization-wide system maintenance and update, where they are not notified prior to these events. As a result, it created confusion at the workplace and took a while for them to realize that it was not a sudden system failure rather the system was down to facilitate a pre-planned maintenance. Losing access to digital systems is more frequent due to maintenance events than unprecedented technological issues, as noted by our participants; they believe, a well-coordinated system maintenance with informing them prior to these events would help them to better prepare in switching to paper charting, and retrieving (e.g., printing out on paper) the information of patients who are scheduled during the maintenance period.

4.3.2 Insufficient IT Support. Most of the nursing professionals in our study referred to the insufficiency in IT support at their organization, which make them revert to paper-based workflow and incur delays in medical procedure – the impact of such delays could be severe when the urgent care is needed for a patient. Our participants specified three primary issues with IT support that demand attention from the upper management. First, the lack of manpower in IT support considering the number of departments and medical staffs in their organization. Second, the unavailability of IT personnel at the time of need, where one nurse said, *"Have one or two people for during their nighttime to help, or weekends to help out are readily available. So that like as a new nurse, I didn't have access to, to patient charting until two or three weeks later after I'm on the floor with my preceptor and the whole time, I basically more or less lost time to be able to feel confident and know my navigation around the system. So, it's, you know, makes me feel like I'm behind and that should not be the case." (PN12).* Third, IT personnel is often slow to respond and resolve issues; one of our participants said, *"That (IT support) probably could have used a little bit more speed...the phone call was not very fast or effective. It just seemed like it took so long to get anything done." (PN14).*

4.3.3 Tension between Accessibility, Service, and Privacy. Some nursing professionals reported concern about privacy breaches that could occur as a result of the effort in making their service more accessible and satisfactory to patients. They mentioned that they keep the nursing stations and their rooms open so that the patients could easily get access to them. However, there were cases, where the patients who were admitted in the hospital entered the room of a nurse without knocking or prior notice. In such situations, patients might get access to sensitive health information of other patients, where the nurses might forget to secure their paper documents (also see §4.3.1) or log out of their computer (also see §4.2.3.1).

A few nurses mentioned that their organization needs them to allow patients – who are admitted in the hospital – to access their banking accounts and emails during their stay. In this context, the nurses have to allow patients to access internet from their workstation, where they reported concern that allowing such access has inherent privacy risks due to the sensitive healthcare data accessible through their computer.

4.4 Gaps and Challenges in Nursing Education and Training

In this section, we present our findings on the gaps and challenges in nursing education and training in using digital systems and taking privacy-protective measures.

4.4.1 Through the Lens of Nursing Professionals. Almost all of our participants referred to the gap between their academic preparation and professional needs in technology use and privacy protection on digital platforms. Overall, we found a relation between emphasizing on this gap and the year of graduation of our participants, where the nurses who had graduated earlier used to report higher difficulty in coping with digital systems at workplace. Some of the nurses specifically mentioned that they were taught about paper charting during academic preparation, and thus, it was difficult for them to cope with digital charting at workplace; this challenge was further aggregated due to their lack of expertise in using a computer.

Such gaps in understanding current systems affect the collaboration between nurses; some of our participants mentioned that it is challenging for them to communicate with nurses who are not at the same level as they are in understanding digital systems, where they have to carefully choose verbose and metaphors to make sense of their communication about technology. One of our participants said, *"Yeah, so a lot of the other nurses that I work with are um, a generation older than me and are not as comfortable with technology as I am. And so, we're really careful when sharing information with each other." (PN4).*

The organizational training could help to minimize the gap between academic preparation and professional needs. However, most of our participants expressed their dissatisfaction with the training they had received from the medical institution in understanding and using digital systems, as discussed below.

4.4.1.1 Inadequate Professional Training. The nurses mentioned that the training is based on presentation, lacking hands-on learning experience, where the contents are generic and not contextualized to the department-specific workflow. One of the nursing professionals reflected on her experience from working in multiple medical institutions, *"So every organization I've worked for has like a day of training. But then what is hard is that this covers the entire hospital. But then every unit is specific of how they use that certain technology, and all organizations do not necessarily have unit specific technology training." (PN5).*

Some nurses further mentioned that a one-time training was provided hastily when they had joined the job, however, they often face difficulties in using the system, even in addressing trivial issues since their organizations do not offer any refresher training nor provide access to the training materials outside of that training session. Some of our participants referred to the lack of training

when the digital system is updated at their workplace or a new software is integrated into the system. In this context, a few participants mentioned that the nurses get occasional training from a nurse in their floor, who has relatively higher expertise with digital systems and thus, bears the responsibility of training other nurses. They reported concern about receiving training from a nurse instead of an IT expert that they could only be as good as the nurse training them.

One of our participants (PN12), who is a recent graduate, mentioned that they had to take courses online in the last semester at nursing school due to COVID-19 pandemic, where they missed the opportunity of hands-on learning, however, expected to fill up this gap from professional training. Now, this participant is worried that she has been pushed to professional duties without proper training from her employer to work on digital platforms, where the adequacy in training is now crucial more than anytime before to deal with the increased workload and patient's emergency during a global pandemic.

4.4.2 Through the Lens of Nursing Faculties. In this section, we present the findings from our interviews with five nursing faculties, who teach digital technology related courses at the undergraduate level. Our participants provided insights into the challenges and opportunities in bridging the gap between nurses' academic preparation and professional needs in using digital systems and protecting sensitive health data. In particular, they emphasized on two issues: lack of opportunity for students to get hands-on experience with using real-world systems, and lack of collaboration between nursing schools and medical institutions. In relation to the first issue, they also referred to the limited budget of nursing schools.

4.4.2.1 Lack of Hands-on Experiences. The nursing faculties referred to the differences between theoretical learning or using prototypes by the students in a nursing school and the real-world digital systems that they have to deal with upon stepping in their professional career. One faculty member said, *"One of the biggest gaps we are seeing is with realism component [real-world systems]...after they [students] have graduated and gone into practice [job], that's the area they wished to be better in how to document, use electronic health record that our practice [prototype] systems [in academia] just can't keep up with." (PF2).* Another faculty referred to the budget constraints of nursing schools in affording the latest technology to help their students gain hands-on experience in using the real-world tools. She said, *"The tech changes and we strive to keep up with it in academia but its expensive to update and get all the new things. We try but it's slow and it's not as fast as we like it to be due to dollars." (PF1).*

4.4.2.2 Lack of Collaboration. In educating nursing students about digital systems, the faculty members emphasized on the collaboration between nursing schools and medical institutions. They pointed out multiple ways to achieve the goal. First, the nursing schools should invite professional nurses as the guest speaker in their classes, so that the students could get up-to-date information on digital systems that are currently in place at medical institutions; one of our participants said, *"So, by bringing in guest speakers who are currently working nurses and helping them in teaching our nurses [students] who aren't yet nurses about the importance of understanding it [digital system] and how it's a huge part of their job as a nurse to understand it, the students will be able to see that it's not just an instructor's opinion but actual real-life nurses who use it on a daily basis" (PF3).* Second, the nursing schools should maintain strong ties with medical institutions in offering course credits to the students based on their clinical hours at the hospital; one of our participants also talked about the challenges that need to be addressed in creating and maintaining such collaboration, *"One of the major issues we've seen across the country is that hospitals are becoming increasingly hesitant to allow nursing students to perform in the clinical context due to liability concerns. They're also concerned*

about lawsuits. So, they've made it increasingly difficult for students to obtain clinical experience." (PF4).

The faculty members believe that addressing the above issues would substantially improve their students' academic preparation in using digital systems and understanding corresponding privacy issues. They believe in the new-generation nursing students that they would successfully adapt to new technologies through the training and support from academic institutions and medical organizations. One faculty member commented, *"Well, I think that most nursing students are already computer savvy, because that is our culture, especially among our younger...they all like their devices, pads, mp3 and gadgets...they're all in." (PF4).*

4.5 Risks of Privacy Violation

Our participants referred to several privacy-invasive scenarios and incidents, as presented below, which they believe could be avoided through appropriate training from their organizations, and better infrastructural and technology design.

Several participants reported that they had observed nursing professionals sending more information than needed in their electronic communication with other nurses and medical staffs, where that extra piece of information was not supposed to be disclosed to others for protecting the patient's privacy. They also mentioned that sending files over fax should be preceded by a message to the intended recipient so that it would not fall into wrong hands, where participants had noticed the received documents unattended over fax machine at their workplace. A few participants referred to the risks of privacy leakage when the nursing professionals communicate patients' information with their colleagues through text messages over personal device (e.g., mobile phone), where one of them said, *"...it's [personal text messaging] not HIPAA compliant. So it is a risk factor of having their information leaked out." (PN6).*

The leakage of patients' information to other entities could occur during in-person communication between medical staffs, including nurses. A few of our participants mentioned the open-space architecture of their workplace, where the risk of HIPAA violation is high, because the patients being attended at one workstation can hear the communication of nurses with their colleagues, and patients at nearby stations. One of our participants (PN14) further mentioned that in case of a patient's emergency, nurses hurriedly come to call other nurses and share the patient's information loudly due to the urgency of situation, although there lies the risks of privacy violation.

The nurses who are assigned for a patient, are authorized to access and know about that patient's health information. That means, the attempt to access a patient's data without authorization could lead to HIPAA violation. A few participants shared the incidents with us where nurses had become curious to learn about other patients' health information although they were not authorized to. One of them mentioned a celebrity patient who was admitted in their hospital, where the nurses, although not authorized, tried to access that patient's information out of curiosity. He said, *"There are also people who are just interested in a patient they shouldn't be interested in...someone who was famous in a hospital and other people went to, you know, learn more about them, and they got caught looking at a chart they didn't need to and then, you know, lost their job." (PN15).*

Our participants did not report any concern about outside entities (e.g., hackers) in protecting sensitive health data on digital platforms. Overall, our findings indicate that their understanding of privacy risks is based on their observation of surroundings.

5 DISCUSSION

The use of digital technology has a significant role in modern healthcare systems [34, 41, 52]. In our study, we identified the inadequacies and complexities in existing systems, along with the infrastructural and technological barriers. Our findings point towards the scopes of improvement through

inclusion, training, and reducing the gap between nurse's academic preparation and professional needs. In this section, we discuss the implications of our findings and provide recommendations to make digital systems more inclusive, usable, and privacy-preserving for nursing professionals (Figure 1 and 2 provide a highlight of the implications of our findings).

5.1 Re-calibration of Technology and Procedure

Our findings show how the complexity and inadequacy in digital systems and software could disrupt the natural workflow in medical institutions. The overwhelming options and features in charting software put cognitive burden on nurses, leading to human errors. The more usable software interface can be designed by involving the end users through contextual inquiry-based studies, in order to identify which features in the software are used on a regular basis by nurses; through making those features more discoverable and accessible on the platform, the designers could attain the balance between offering a complete set of features and nurses' comfort with using that software.

Our findings shed light on the issues (e.g., increased workload and cognitive burden, reduced throughput, after-hours working, human errors, and confusion and chaos in workplace) that arise from the downtime of internet and digital systems in medical organizations, and reveal the privacy risks of switching back-and-forth between digital and paper charting. The downtime of systems as a result of maintenance events can be mitigated by providing phased roll out of updates so that only some of the devices get out of commission at a time; the coordination between different departments in a hospital is crucial in this regard, where the nurses and other medical staffs should be informed prior to a maintenance event. Losing internet at a critical time could lead to serious repercussion in a medical organization, and thus, fail-safe and backup plans are necessary. For example, a secondary line of internet could help to deal with the failure of primary internet facility. Further, having a set of spare computers will provide an immediate alternative for the computers that are in repair.

The rigidity of the existing digital system has come out as a concern of our participants, who reported frustration that they could not provide medication to the patients who forgot to bring their band in an emergency situation. Authorizing a supervisor nurse on the floor to override the system would allow them to better serve their patients, especially in case of emergencies. To prevent unintended misuses, we emphasize on the practical and scenario-specific training for nurses before incorporating such override features in the system.

5.2 Inclusive Design

The protection of patients' information is one of the most important necessities in healthcare services, where HIPAA has established the privacy regulations that need to be followed by the medical institutions. Our results indicate how the leakage of patients' information could lead them to severe depression and anxiety. With the introduction of digital systems in medical institutions, nursing professionals now have to be more cautious with protecting patients' data from unauthorized entities [19, 42, 51, 54]. To this end, our findings show how the lack of inclusion in system design, infrastructural and technological barriers, and the tension between accessibility, service, and privacy could make sensitive health data vulnerable to misplacement, loss, and leakage.

We emphasize that the technology design for nursing professionals should be more inclusive, where both accidental technological mishaps (e.g., recording and posting of the patient's information on social media through a smartwatch) and common human errors in medical organizations (e.g., forgetting to log out of computers while leaving the nursing station, losing or misplacement of patients' data while switching between paper and digital charting, etc.) should be carefully considered. In some cases, the design solution could be as simple as implementing auto-timed logout

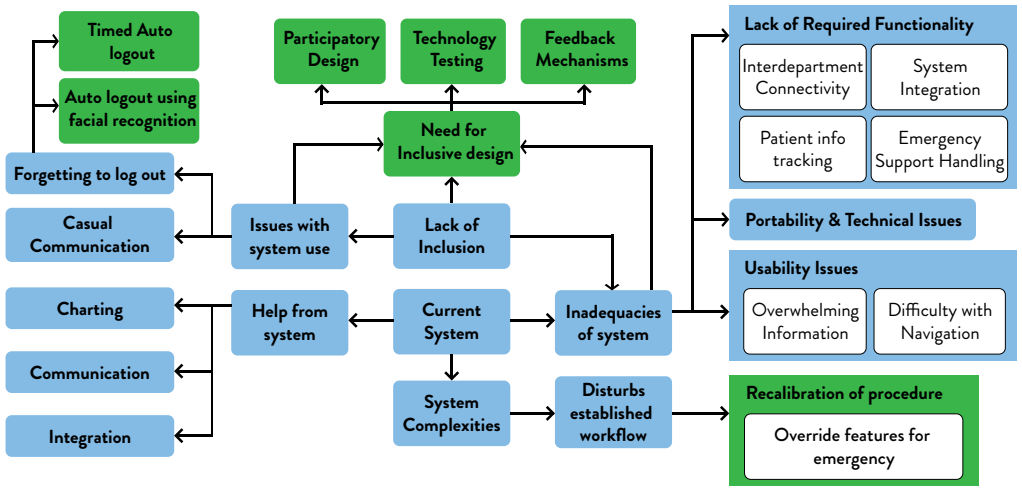

Fig. 1. Inadequacies and Complexities in Current Systems, and Implications on the Future Design. *Note:* The boxes in blue represent the findings from our study with nursing professionals, and boxes in green represent the corresponding implications.

when computers at nursing stations remain inactive, so as to minimize the risks of unauthorized entities sneaking into patients' data. More advanced solution could take advantage of the recent advancement in facial recognition to detect the presence or absence of authorized nurses for auto logout from their computers.

The nurses in our study talked about the risks of privacy violation due to the open-space architecture at their workplace. To address these issues, the medical organizations need a long-term vision in the future design of facilities and workspaces, to make them resilient to privacy violation that could result from overhearing the conversation of nurses with their patients, and colleagues. In addition, nursing stations could be rearranged to be more privacy-preserving, so that the computers do not face towards the entry point of patients, mitigating the risks of confidential information being displayed to unauthorized entities.

Most nurses in our study emphasized that as end-users of the systems, their voice should be heard by the organizations responsible for system design. In addition to contextual inquiry and observation-based studies, the designers could actively involve nurses through participatory design. Also, nursing professionals' feedback would be valuable during the pilot testing of prototypes. Here, considering the busy schedule of practicing nurses, involving recently retired nurses actively in the design process should also be considered.

5.3 Improving Training and Support: Role of Medical Organizations

The training for medical staffs are important to ensure high quality in healthcare services [39, 47]. The organizational training and IT support would help nurses become proficient in using, and addressing technical issues with digital systems. The impact of delays in medical procedure due to the lack of efficiency in providing timely technical support could be severe when the urgent care is needed for a patient. In our study, nurses pointed out the expectations from their organization in providing more efficient IT support, by addressing the existing issues with lack of manpower, unavailability of IT personnel, and slow response from them at the time of critical need. To address

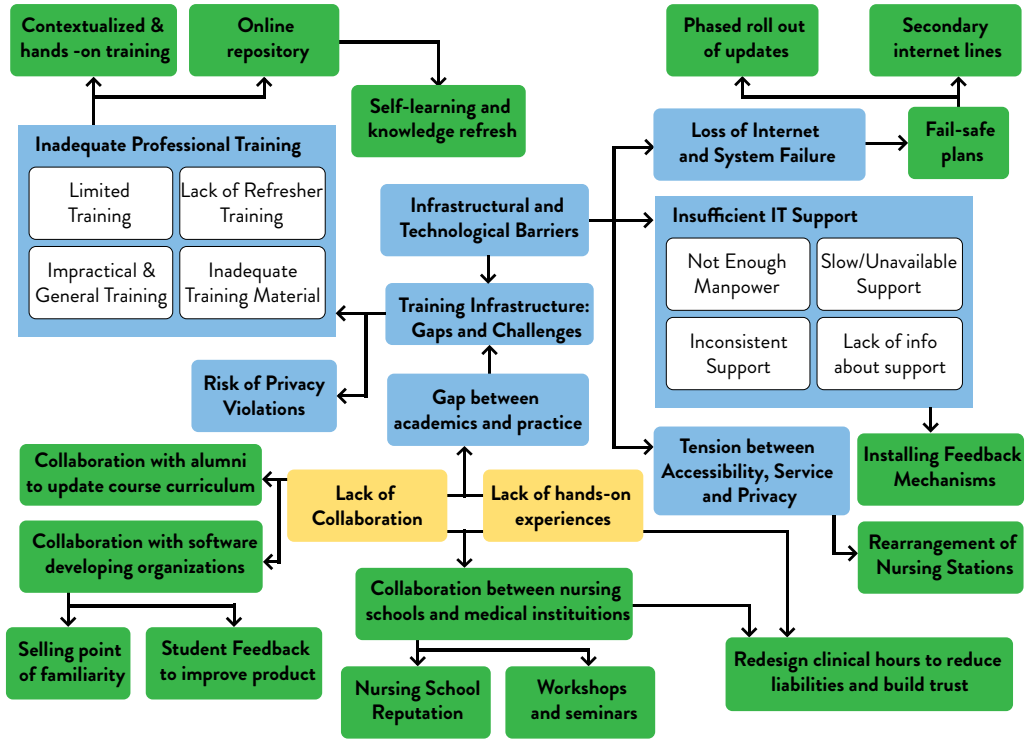

Fig. 2. Infrastructural & Technological Barriers, and Implications on the Design & Collaboration. *Note:* The boxes in blue, and yellow represent the findings from our study with nursing professionals, and nursing faculties, respectively, and boxes in green represent the implications of findings.

these gaps, medical institutions can adopt a feedback mechanism, where a nurse who has asked for IT support will be contacted (e.g., via email, SMS) to provide feedback on the quality of service they have received from IT department. The feedback from nurses should go directly to the upper management, who in turn, would be able to identify the underlying issues that need to be addressed for improving their IT service.

The findings from our study shed light on the scopes of improvement to make the existing training infrastructure more effective and useful for nursing professionals, where contextualizing training materials to the department-specific workflow and modularizing the contents to responsibility-specific use cases would enable nurses to directly apply their learning in everyday work duties. Nurses have expressed the need of hands-on learning experience instead of just presentation-focused training, and want to have the opportunity of refresher training at regular intervals. In addition, keeping the training materials in an online repository providing access to nurses would promote self-learning and reviewing anytime they need. Gathering feedback from nurses at the end of training would enable the medical institutions to further improve their training infrastructure and facilities. In this way, nurses would be better able to take advantage of organizational training, benefiting both the employers and employees through gaining higher efficiency with using digital systems and attaining better privacy protection in medical institutions.

5.4 Collaboration Initiatives: Role of Nursing Schools

Our studies with professional nurses, and nursing faculties point towards the gaps between academic preparation at nursing schools and professional needs in healthcare organizations, in using digital systems and taking privacy-preserving measures. While paper charting is commonly used in an academic setting, the transition to digital charting in the medical institution comes out as a challenge for the nurses. We also found that the lack of understanding about a digital system affects the collaboration between nurses, and adds to the difficulty in their conversation with colleagues about technological issues. Further, to mitigate the risks of health data leakage, it is imperative to educate nursing students about existing vulnerabilities and privacy protection in digital communication, and make them aware of responsible and ethical use of technology.

To address the above challenges, we emphasize on the role of both medical institutions (see §5.3) and nursing schools, where the opportunities of collaboration ought to be explored. Such collaborations would contribute not only to the higher work efficiency and privacy protection in healthcare organizations, but also to the reputation of nursing schools in adapting to the evolving professional needs of future workforce. To this end, nursing schools should take steps in initiating the collaboration with healthcare organizations, starting with the local medical institutions. One such step is to organize workshops and seminars, inviting professional nurses to familiarize students with the current digital systems in medical organizations and offer functional and experience-based knowledge on how to cope with state-of-the-art technologies at workplace.

The faculties in nursing schools could collaborate with their alumni who are currently working as professional nurses through organizing annual or half-yearly panel discussion, and remain updated about the evolve in digital technology use in professional settings. The pool of invited panelists should include both the experienced nurses and recent graduates, where the insights from recent graduates would inform the nursing school about their challenges to bridge the gap between academic preparation and professional needs. The outcome of these collaborations would be contributing to initiate a dialogue on curriculum change, budget allocation, and new faculty recruitment in nursing schools to cope with the advent in technology use in medical institutions.

The nursing schools should consider paying more attention to the scopes and benefits of collaborating with the organizations that develop software for medical institutions, to gain access to their platform for providing nursing students with more practical learning experiences. The collaboration with academia could benefit the software organizations, too. The proficiency of nursing students in using their software could be one of their promotional and selling points, where they could also gather feedback from nursing students on the usability, performance, and understandability of their system to iteratively improve their software design.

The collaboration between nursing schools and medical institutions would facilitate more internship opportunities for the students, where nursing schools could encourage their students through offering course credits based on their clinical hours at the hospital. Also, providing an opportunity for the interns to share their experience and learning with other students (e.g., through workshops, seminars) would contribute to the overall growth of nursing students. As our findings reflect on the liability concerns of medical organizations in allowing nursing students to gain hands-on experience, nursing schools and medical institutions should work together to address these issues, e.g., through designing clinical hours to let the students gradually build trust, and a sustainable relationship with medical organizations.

6 LIMITATIONS AND FUTURE WORK

We interviewed 16 participants in our study with nursing professionals, where we followed the widely-used methods for qualitative research [13, 16, 17], focusing in depth on a small number of

participants and continuing the interviews until no new themes emerged (saturation). We also interviewed five nursing faculties, who teach digital technology related courses at the undergraduate level. We acknowledge the limitations of these studies that a different set of samples might yield varying results. Thus, we do not draw any quantitative, generalizable conclusion from our studies. In our future work, we would conduct large-scale online survey with nursing professionals, and the faculties in nursing schools.

Our study was conducted during COVID-19 pandemic, which might have unprecedented bias on our findings. In addition, self-reported data might have limitations, like recall and observer bias. We did not have a uniform distribution in terms of the participant's gender, where two participants identified as male. It could be due to the fact that most nursing professionals in the USA are female [1]. Further studies are required to understand the relation between gender and privacy behavior in the context of the nursing profession.

Our study was limited to the U.S. participants only. The recent privacy studies [3, 4, 6, 28, 55] highlighted the importance of looking beyond the Western contexts, where the societal and cultural background, literacy rate, public policy, economic condition, and infrastructural support could impact user's privacy perceptions and behavior. We believe future studies should involve nursing professionals from diverse geographic regions, including the developing countries.

In our study, we investigated the privacy practices of nursing professionals. In a healthcare organization, nurses have to interact with different entities. In our future work, we would explore the privacy perceptions and behavior of other entities in a healthcare institution, e.g., physicians, IT personnel, employees in administration, and higher management, which in turn, would allow us to understand the overall privacy practices within medical institutions.

Our findings shed light on the gaps between academic preparation and professional needs of nurses in digital technology use and privacy protection. We believe that more studies are required in the context of nursing schools involving both the faculties and higher management, so as to identify how the educational institutions and healthcare organizations could work together to bridge these gaps.

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