

Nurses' Responses to Telenursing Robots

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Abstract

In this work, we wanted to assess nurses' perceptions of robotics, as well as what impacted their perceptions. We were specifically interested in the impacts of prior experiences, a robot's gender, and being shown a video of a specific telenursing robot, TRINA. To accomplish our goals, we interviewed registered nurses in a semi-structured format, and coded the data using ATLAS.ti. We found that nurses supported the use of robots for physical tasks. They did not support uses involving patient assessment or education. Nurses' knowledge of technology informed their concerns about robotics, but it also served as a reference point. Nurses thought the gendering of a telenursing robot would not affect their views of it, but could affect a patient's, particularly in gender-based stereotypes. Their preferred pronoun of "he", "she", "they", or "it", was "it". They were not impacted by viewing a video of a telenursing robot. From our research, we developed a set of recommendations for implementation and design of nursing robots.

Introduction

From improvements in EKGs to medical records moving from paper to electronic, technology is integral to the field of nursing. As part of that trend, robotic technologies are entering healthcare. For the purposes of this research, healthcare robots are those that include but are not limited to the robots for surgery, rehabilitation, and assistance of daily living. One subfield of healthcare robots is nursing robots. These nursing robots help with or supplement nursing tasks. In hospitals, nurses work with nursing assistants, who perform basic care tasks, give medication, or do some instructed medical tasks (Müller et al., 2021). As such, nursing assistant robots are those that perform routine nursing assistance tasks frequently performed by nurses or nursing assistants. These robots may do tasks like organize medicine (Cousein et al., 2014), or assist in moving patients (Guo et al., 2017). Some argue that the expansion of technology, especially robotics, within healthcare, can provide better care; for example, one study found that utilizing a medicine organization robot resulted in 53% less medication errors (Cousein et al., 2014). However, technology, especially robotic technologies, have limitations, in addition to social implications (Maibaum et al., 2022). Moreover, the introduction of these assistive devices can change the nursing field and future work in these areas. Technologies in this space should be informed by those performing the work as they may have different insights into the technologies. More specifically, nursing has its own history, as well as relationships to other parts of the hospital. These must be considered when implementing healthcare robots (Maibaum et al., 2022).

The current work aims to better understand the state of technology and robotic devices in the nursing industry. To do this, we interviewed nurses about their experiences with technology in healthcare, their experiences with robots, ideas for where robotics could help them, and areas where robotics should not be considered in the nursing industry. We wanted to ask about these topics to investigate the future of telenursing robots, and as a part of current research on and development of a specific telenursing robot, TRINA. TRINA stands for Tele-Robotic Intelligent Nursing Assistant. TRINA is a

research robot, originally developed in 2017 to work in quarantine spaces with highly contagious patients (Li, et al., 2017). TRINA has been used for studying handing objects from a human giver to a robot receiver (Nemlekar et al., 2019) and interfaces for telenursing robots (White et al., 2020) (Lin et al., 2020). In conjunction with the goals listed above, and in collaboration with the work being done on TRINA, our study also aims to gather information about nurses' specific perceptions of TRINA in a user-aided design process, so that this feedback can be used to improve TRINA.

Nursing Tech Ecosystem

In understanding nurses' perspectives on robots, it is also helpful to know what technology they are already familiar with. Nurses are expected to learn and use many kinds of technology, including the Electronic Health Record (E.H.R.). Although the terminology is not standardized, EHRs are generally understood as the evolution of paper medical records. Instead of being on paper, patient medical information is entered digitally and stored electronically. In 2008, less than 10% of hospitals were using an EHR, but by 2015, approximately 80.5% of U.S. hospitals were using EHRs (Adler-Milstein et al., 2017). The implementation and integration of EHRs can also provide information on how nurses might react to the implementation and integration of nursing robots. It took at least seven years for the majority of hospitals to use EHRs. In addition, the research investigating the implementation of EHRs found several barriers that limited their widespread integration. This research found that the most stated barriers for EHRs were "resource constraints, poor/insufficient training and a lack of technical/educational support for users, as well as poor literacy and a lack of skills in technology" (Tsai et al., 2020, p. 17). In attempting to implement robotics, the barriers may be similar. However, Tsai et al. (2020, p. 17) also found that there were a number of suggested benefits to the use of EHRs, including efficiency, "better communication, improved accessibility and enhanced quality of care." Robotics may also encounter similar benefits. The wide use of EHRs also demonstrates the capability of nurses, with training and assistance, to adapt and use new technologies.

Nursing Work

In addition to understanding the environment of technology around nurses, it is also helpful to understand what tasks nurses perform. While the assumption might be that nurses largely perform medically related tasks, like medication administration or caring for patients, research suggests nurses spend more of their time on communication and documentation. For instance, one study found nurses spent less than a third of their time with patients (Michel et al., 2021). The same research showed that nurses spend much of their time performing communication tasks, such as team conferences (Michel et al., 2021). The same emphasis on communication can be seen in another study that was conducted on a medical-surgical unit in the U.S. The researchers found that in a four-hour period, nurses spent about 12.5% of their time communicating with patients, and about 11% communicating with other nurses (Yen et al., 2018). When communications with others, like nursing assistants or family, are included, nurses spent roughly 35% of their time communicating. They spent another 25% of their time on documentation, and roughly 24% performing tasks like administering medication, doing hand-off, and performing patient assessment. While documenting, they spent significantly more time on Electronic Health Record charting and review than on paper charting (Yen et al., 2018). Overall, many of the tasks that nurses performed were focused on communication, or required assessment of information.

Current Robotics

To assist with nursing tasks, robots are currently being used and developed, both in hospital settings and home settings. The robots can be defined in two broad categories, assistive and social assistive. Assistive robots perform tasks like providing help moving from one place to another, feeding, monitoring, bathing, and exercising. Social assistive robots help take care of patient's mental well-being, from emotional support to giving patients mental activities (Maalouf et al., 2018).

Nurses' perceptions of robotics vary. In one study, the top five tasks that nurses thought could be performed by a robot were "moving patients", "janitorial", "retrieve/move objects", "bathing", and

“feeding” (Chen & Kemp, 2011, p. 623). Many of these tasks are not focused on communication. In agreement with this, one set of perspectives from a study of registered nurses in Taiwan was that robots could help with repetitive tasks and tasks requiring precise movement. Interestingly, they also thought that robots could provide care information to patients (Liang et al., 2019). The incongruence of their responses with respect to communication may be explained in part by the fact that in the study performed by Liang et al., the nurses worked in hospitals using either robotic-assisted surgery robots, or tour guide robots. Both studies line up with the “3 Ds” of robotics, that robotics will be helpful in situations that are dull, dirty, or dangerous (Murphy, 2019). In other words, these studies reveal that nurses are not against robotics in the nursing field as they believe robotics would be helpful for repetitive tasks. However, resistance starts to emerge when robots may start performing tasks that typically require a nurse to provide care or individualized responses. The nurses’ concerns with robotics were that they could not give individual care, and that it would create “privacy concerns” (Liang et al., 2019). Similarly, one study found that nurses did not think that a robot could perform tasks like “administering medicine”, “assessment”, “blood work”, “feeding”, and “touch patient” (Chen & Kemp, 2011, p. 623) because, according to nurses, these tasks require human assessment and human analysis of complex information.

Current Research

In the current study, we wanted to expand on past work that had focused on perceptions of robotics by nurses. Previous research found that nurses spent much of their time communicating (Michel et al., 2021). It also found that nurses generally supported use of robotics for performing simpler tasks, but not those that required assessment (Chen & Kemp, 2011, p. 623). This previous research, however, focused largely on what their perceptions were, not what could be affecting those perceptions. We wanted to focus on the cause. To do this, we looked at three factors: existing environment with respect to technology, an experience with robotics, and the robot’s gender. In

studying these, we interviewed nurses in a semi-structured format, and asked about their experiences and perceptions. We also exposed them to one specific telenursing robot, TRINA. We specifically wanted to answer four questions:

1. How do previous experiences with robots affect how nurses think about them in the nursing field?
2. How do nurses think robots could help them in hospitals?
3. How does how a telenursing robot is gendered affect impressions of it by nurses?
4. How does viewing a video of a telenursing robot affect nurses' impressions of them?

Method

Participants

In total, eight nurses were interviewed. Five of the nurses were currently practicing and three had recently stopped practicing so that they could teach nursing. All were registered nurses. The nurses had an average of 12 years in practice, ranging from 0 to 37 years – one participant was newly a registered nurse and had not begun practicing as a registered nurse. Four of the participants were asked their ages, those asked were between 39 and 58 years. Three of the participants were professors of nursing. Three of the nurses had associate degrees, and five had bachelor's degrees. Of the nurses, four participants were recruited using snowball sampling. They all consented to be interviewed, and to have the interview recorded and transcribed. In addition, they were offered a \$10 gift card for their participation.

Design

In this study, we were interested in how nurses' perception would be influenced by previous experiences, exposure to a telenursing robot, and by the robots' gender. We also wanted to assess their perceptions on tasks that robots could perform. To accomplish this, we used the semi-structured format. In a semi-structured interview, there is not a rigid set of questions that must be asked. The

questions follow broad themes and the interviewer is allowed to follow up when the interviewer would like to continue a line of questioning. Semi-structured interviews have been used for assessing nurses' perceptions of robots before, as by Liang, et al. (2019). For the purposes of this study, we developed a key set of questions, attached in Appendix A. However, the semi-structured format allowed follow-up questions and explorations of different ideas with different participants.

Procedure

Participants were recruited through word of mouth, from peer recommendations, and when possible, through snowballing. Snowballing is when participants are asked if they know anybody who would be willing to participate, and ideally, those people are then included in the study []. Once participants confirmed their interest, they reviewed and signed the informed consent prior to the interview. At the beginning of the Zoom interview, all participants verbally consented to participation as well as provided consent to being audio recorded to allow for transcription of the interview. To get participants comfortable and to allow insights into the nursing profession, the interview started off by asking participants to describe a typical day at work as a nurse. Then, participants were given definitions for healthcare and nursing robots, in addition to several tasks that a nursing robot might do. They were asked about specifically nursing robots, in contrast to the earlier questions about the broader label of healthcare robots. They were asked about their experiences and thoughts with these kinds of robots. The study was conducted in collaboration with a member of the robotics department of WPI, and as part of that, some questions focused on user-aided design about a telenursing robot, TRINA. After being asked about their nursing experience, and their experiences and thoughts about healthcare and nursing robots, they were shown a video of TRINA picking up objects and being controlled by two different methods of control, by nurses, for a prior study. This was to introduce participants to a specific nursing robot. Then participants were asked about their reactions to TRINA, and the people who might use TRINA. Finally, to close out the interview, participants talked about their thoughts on the use of

healthcare robots, in addition to questions specific to working as a nurse during the COVID-19 pandemic. After completing the interviews, participants were thanked and given a \$10 gift card for their time. On average, the interviews lasted about 45 minutes. To see the complete list of questions, see Appendix A. Prior to conducting the interviews for this study, two practice interviews were done to modify and adjust the interview questions.

Materials

Interview Questions

The goal of conducting the interviews was to include the perspective on nurses in assessing the future of robotic technologies in nursing. None of the questions included were pulled from prior studies. The interviews were conducted to answer four research questions:

Research Question 1: How do previous experiences with robots affect how nurses think about them in the nursing field? To answer this question, participants were asked about their experiences and their thoughts on nursing robots. Many of the questions were open ended, however some were yes or no questions, with follow up questions based on their response. For example, they were asked "Have you heard of robots being used in healthcare?" If they answered yes, they were asked about which technologies they had heard of, and if they had used healthcare robots themselves. By asking about their prior experiences, participants were encouraged to reflect on them, and to elaborate on these experiences.

Research Question 2: How do nurses think robots could help them in hospitals? In answering, participants were initially given a definition of a healthcare robot but were not given examples of tasks that the robot might perform. Then, they were asked a broad question, "Are there any tasks in healthcare where you think robotic technologies could be helpful?" The question being broad, and the lack of examples of what a healthcare robot might do, allowed creativity in their responses. In contrast, in a separate question, they were first given a definition for "nursing robot", as well as tasks a nursing

robot might do. Then, they were asked “Are there any tasks that you think a nursing robot might be able to help you at work? What specifically?” Giving the participants examples for nursing robots before asking about them meant that they could elaborate about the benefits of the examples listed and endorse research that is already happening. The definitions and examples given are available in Appendix A.

Research Question 3: How does how a telenursing robot is gendered affect impressions of it by nurses? For this question, the nurses were asked first, “Would you describe TRINA as “she”, “he”, “they”, or “it”?” to establish what their initial impressions of TRINA’s gender were. Before this point, the interviewer had exclusively referred to TRINA by TRINA, without using pronouns in description. Then, they were asked “If TRINA were to be described as “he” how might that influence your perceptions of TRINA? What if TRINA were described as “she”?”. Asking this question attempted to directly establish how the nurses felt their perceptions could be influenced by the gendering of TRINA.

Research Question 4: How does viewing a video of a telenursing robot affect nurses' impressions of them? To answer this question, the interview was divided into two parts, one before the video was shown, and one after. Before the video was shown, they were asked questions about their perception like, “Do you think you’d feel confident operating the robots by yourself?” After the video, they were asked similar questions but aimed at TRINA specifically, for example, “What are your reactions to TRINA’s interface? Do you think you could use/operate TRINA?”

Transcription

Transcription of the interviews performed by utilizing the transcription software Descript. The researcher then reviewed the Descript transcriptions while listening back to the recordings to fix any errors. The interviews were conducted primarily by one of two interviewers; however, for two of the interviews, there were two interviewers were present where one interviewer asked the questions and the other listened, took notes, and asked clarifying questions if needed.

Interview Coding and Analysis

The codes were created through an iterative memo writing process (Saldaña, 2016). In iterative memo writing, notes and rationales are taken throughout the process of developing a coding schema. Three of the interviews were first coded on paper. Finally, all of the interviews were coded using ATLAS.ti, according to the final coding schema, attached in Appendix B. The schema was divided into several main themes: Previous Knowledge, Concerns, Tasks, Gender and Robotics, and Reactions to TRINA. Each main theme had a number of subthemes.

Results**Previous Knowledge**

The theme Previous Knowledge captured nurses' previous exposures to technology. We found that nurses were using their previous experiences while thinking about robotics, and we wanted to understand the connection. While none of the nurses had specifically used a telenursing robot before the study, they did use technology, including other kinds of healthcare robots, to think about robotics. Specifically, we were trying to answer our first research question, "How do previous experiences with robots affect how nurses think about them in the nursing field?" To answer the question, we categorized what we saw into four major kinds of exposure, which became our subordinate themes: Interfaces, Nursing Tech Ecosystem, Robots in Hospital, and Robots in News. The Interfaces subordinate theme covered experiences interfacing with technology, particularly video games. The Nursing Tech Ecosystem subordinate theme described what non-robotic technologies nurses were already using in hospitals. The Robots in Hospital subordinate theme showed nurses' experiences with robots in the hospitals they were working at. The Robots in News subordinate theme described the robots they had heard about on the news.

Interfaces

Participants' reference point for interfaces or methods of controlling technology was largely video games. When discussing TRINA's interface, five of the eight nurses mentioned video games, either to indicate that they could use robotics,

I think if my seven-year-old can play a Nintendo Switch confidently that I can definitely, uh, be trained to operate TRINA. (Participant B)

or alternatively that they could not.

it's like a video game and I can't do a video game, so, yeah. (Participant C)

Nursing Tech Ecosystem

Nurses mentioned many different kinds of technology that they used in hospitals. The technology helped them perform their tasks. It included systems to monitor patients.

it's at least a camera that's helping monitor patients. But behind that camera is, you know, a as a human and that, you know, that person can use those cameras in each specific patient room to kind of be an additional resource to nurses and say, you know, a patient is trying to get out of bed, maybe is a little impulsive (Participant H)

It also included technology to facilitate communication.

we use these things called, um, interpreter phone on a pole, IPOP, or video phone on a pole, VPOP, you'll hear those interchanged. And it's, you know, it's like a telephone with a screen and you dial in to say, I need a Spanish interpreter, and then either somebody from the hospital pops up on the screen or somebody who's in Morocco, you know, on the phone. (Participant A)

Additionally, it helped serve as a backup for nurses.

in the electronic medical record, how a lot of the technology has been utilized to recognize patterns or potential problems that human beings missed. For example, allergies or medication interactions, that's a huge thing that's come from a safety perspective out of electronic medical records. (Participant B)

Robots in Hospital

Robots were not widely used in the nursing field in the hospitals the nurses worked at. Only one out of the eight nurses had experience directly using a robot in the hospital they worked at.

we call it a Hoyer lift. It's like a, a sling you put under the patient that can't block, and then they just kind of press a button and, and moves like on the ceiling and then goes to the other side, you know, to get them in the chair without any physical. (Participant C)

More broadly, however, three out of the eight had heard of robots in other parts of the hospital, for instance robots being used for surgery.

in the, OR, you know, that we've, there's, there's robotics that are used in any sort of like laparoscopic or, um, open cases that can be kind of helped, used to be used in a more, um, precise setting, I guess. (Participant H)

Interestingly, none of the nurses mentioned social-assistive robots being used in any part of the hospital.

Robots in News

Nurses had heard about robots being used in many different applications in the news and other media.

I have heard about the robots that will go get supplies for you (Participant E)

The majority of the exposure was through robots for surgery; three of out of the eight nurses mentioned this application.

I mean, I know the ones in surgery, um, but I haven't seen anything that's done with them at the bedside. (Participant D)

Concerns

In answering the question, “How do previous experiences with robots affect how nurses think about them in the nursing field?” we found their prior knowledge of similar kinds of technologies largely influenced their concerns about robotics. Thus, our Concerns subordinate theme captured the concerns that nurses had about robotics. It consisted of six subordinate themes, Breaking, Importance of Human Presence, Privacy, Space, Training, and Trust in Technology. The Breaking subordinate theme consisted of participants’ worries about a nursing robot breaking. The Importance of Human Presence subordinate theme described the participants’ stress on a human completing certain types of tasks over a robot. The Privacy subordinate theme showed nurses’ worries about patient privacy when robotics was involved. The Space subordinate theme consisted of participants’ thoughts about how robots would fit into the physical space of the hospital. The Training subordinate theme described the nurses’ thoughts on the importance of training. The subordinate theme Trust in Technology exhibited nurses’ descriptions of the factors that played into their trust of robots.

Breaking

Technology breaking was a worry for three of the eight nurses.

Not that I have a problem with robots, but I mean, that seems like really expensive and a lot of like potential breakdown. Whereas I think there may sometimes be simpler solutions.
(Participant B)

When talking about breaking, each nurse also brought up dependence on technology as a worry – that not only would the technology break, but that nurses would be so dependent on it that they wouldn’t be able to perform without it.

then you became dependent on something and you have to wait for it to be repaired (Participant D)

One nurse also spoke about when their hospital had been hacked, causing breaking within the system that caused exactly the kind of dependence the other nurses were worried about.

when that happened, it was like pure chaos. Like people didn't paper chart and then like, it was like starting from scratch. Like you, it was like as if you just like woke up in like 1950 and you had to like figure out how things worked. (Participant E)

Importance of Human Presence

Seven of the eight nurses mentioned human presence or connection as being important, and expressed concern that a robot would further disrupt the connection between nurse and patient. The nurses also mentioned existing worries over the prevalence of technology in nursing currently making connection more difficult.

I think there's already concern about the amount of, um, technology that comes between nurses and patients, I think the biggest example I can think of is electronic charting right now where all of a sudden, there's this computer in the room that's distracting the nurse from that essential person to person interaction, which is so important because our, our patients, aren't gonna go and follow their discharge instructions just because we hit a button and print it out and give it to them. (Participant B)

They talked about robots potentially being unable to perform the communication needed for some tasks.

we're having to like help our patients turn over and like be able to reach different areas to do those assessments and like ask questions about how they're feeling, what's going on with them,

and then be able to continue narrowing those questions down based on answers that we get.

And you have to be able to do that in a personable way that actually brings the patient like out to you, like gets them to want to answer you better. Cause you have to have rapport.

(Participant G)

They also mentioned worries about even robots who were not directly interacting with the patient preventing connection.

I actually use like the time that that robot was like doing all those tasks, like, you know, packing things into a box or cleaning things up or opening drawers or whatever. I use that time to talk to my patients and kind of get a little bit more information about them and also offer them more of my space. (Participant G)

Two of the nurses specifically mentioned being worried about direct patient interaction through a robot or by a robot, and expressed more interest in a robot being used for tasks that would not involve that.

I think if it, if the robot was used primarily more to carry out tasks that were not, um, specific to direct patient care, then I would kind of be probably more interested in learning more about that (Participant H)

One of the nurses also mentioned worry over losing their relationship to their nursing assistant.

I just got this robot doing like little tasky things. I mean, I really feel like the patient would, would really miss out on a lot of, uh, personal touch and conversation. You know, I, it would be hard for me to be like the only one. I like having a PCA [nursing assistant] that my patient has a relationship with too. You know, like personality matters (Participant C)

Conversely, they also mentioned potential benefits of robotics, and that possibly robotics would free up nurses for connection by taking over tasks that don't require it.

You just don't even have time to like comfort a crying patient or talk to family, and that might be something that robots can help free up nurses to actually do that nursing that they used to do.

(Participant F)

Space

The physical space of the hospital was a concern when implementing robotics for four of eight of the nurses. They felt that the robot had a possibility of getting in the way, both in hallways and in patient rooms.

there's all these things in a room, and I, I find it hard to believe that a robot could adequately navigate that room and be able to carry out its tasks sufficiently without getting in the way.

(Participant H)

They also mentioned worries about an already crowded and overwhelming environment becoming more so with the addition of a robot to the space.

I think it adds some stress, um, people for, you know, it's already hard enough to take care of the human being in front of you, and then you have all this stuff around you. (Participant A)

Privacy

Patient privacy was also cited as a concern for three of eight of the nurses. One nurse stressed the importance of privacy for undocumented people.

some people might be concerned about having that kind of technology, like taking care of them.

... Maybe they're undocumented and don't want to be recorded by like a robot. (Participant G)

Another nurse mentioned that nurses sometimes attempt to protect patient information by not entering it into the Electronic Health Record.

Or this patient has like a complex family situation going on, or like, you know, problems with communication or like a family dynamic, that's a challenge that you wouldn't be writing that down someplace. (Participant E)

Training

When discussing using robots, six of the eight nurses specifically mentioned training as being important.

I mean, obviously we would have to be given training, like there would be training for it, um, and the hope behind any training is that you would be made comfortable. (Participant G)

One nurse also mentioned that training is provided for using the Electronic Health Record system.

So I had to do two shifts with their electronic medical record, like, training, eight hours each day, and generally, if you onboard to a hospital, your, a part of your orientation is learning the electronic management system. (Participant A)

Trust in Technology

While thinking about using a robot, five of the nurses felt that they would need to work with or see a robot working to trust it.

Even just any like coworker if, you know, if there's a new aide or whatever, you know, until you really understand how they work and see their care, sometimes you might not feel as comfortable and you might wanna be in the room with them. (Participant F)

Additionally, two of the nurses talked about training as being important in their trust.

assuming I had been given training on working with the robots and assuming I knew that they could safely deliver certain levels of care, um, I would probably be comfortable after time and exposure working with robots in general. (Participant G)

Two of the eight nurses mentioned evidence of patient safety as a factor in assessing whether they would trust a robot.

I guess I would wanna just, you know, see enough, uh, research and evidence that, you know, what kind of errors do they make? (Participant F)

Tasks

The Tasks theme was made up of tasks that nurses mentioned either in support or in disagreement of robotics performing. It was largely our answer to the question, “How do nurses think robots could help them in hospitals?” However, through the course of our research, we also thought it was important to talk about tasks that nurses mentioned in the context of robotics but did not think a robot could perform. It consisted of four subordinate themes: Assessment, Education, Physical Tasks, and Supplemental Care. The Assessment subordinate theme described nurses’ focus on the importance of assessment in nursing. The Education subordinate theme showed nurses’ stress on the importance of educating their patients. The Physical Tasks subordinate theme consisted of nurses’ descriptions of physical tasks that a robot might perform. The Supplemental Care subordinate theme consisted of participants’ views on a robot being a supplement for nurses, rather than a replacement. When discussing Supplemental Care, six out of the eight nurses also mentioned a lack of staff, leading to Supplemental Care having its own subordinate theme, Lack of Staff. The Lack of Staff subordinate theme consisted of nurses’ experiences working in hospital without adequate staffing.

Assessment

Assessment was mentioned by seven out of the eight nurses.

You, you know, any med you don't know, you gotta look it up. It's, it's on the computer. ... Um, so, and you know, you can't just give a blood pressure med without knowing the blood pressure. So I make sure I, I see all of my vital signs on my patients before, because the PCAs typically do the vital signs. (Participant C)

Five of the eight doubted the ability of robotics to perform the assessment necessary.

there's something about you develop an instinct after a while. You could walk in a room and know like something's not right, and, um, and so, you know, to keep an eye on that patient, like pay a little bit more attention. I don't think that's something that could be done by a robot.

(Participant F)

Nurses also mentioned worries about a robot's ability to perform patient-specific or individual care at the level of a nurse. Two of the eight nurses cited it as a worry when using robotics.

The patients are, they're not all structured. Everybody's different. Everybody has different needs. Like, not everybody can sit up in bed. Not everybody's trays are cleared off to, to have their breakfast. (Participant C)

Education

Education was mentioned by three of the eight nurses.

it's the responsibility of the bedside nurse who's orienting that nurse to, you know, kind of address any issues or go over any specific conditions that that patient might be presenting with and kind of helping review any, um, you know, procedures, terms, you know, interventions, you name it, and you know, kind of going over that and being in the room with them, helping them practice those skills, and then also following 'em up with them afterwards and, you know, under- basically reaffirming that they, you know, understand or. Maybe going over something if there was any sort of confusion or you know, if maybe they need a little bit more practice or intervention. (Participant H)

One nurse mentioned that robots would not be able to educate at the level of a nurse.

I think any tasks that don't require critical thinking or assessment skills or education, certainly robots could help it. (Participant B)

Physical Tasks

Nurses generally were in support of robots being used for physical tasks. They mentioned tasks like in uses for infectious diseases, moving items, and cleaning rooms. All of the nurses mentioned moving items, talking about the amount of time they spent on the task.

Like those tasks, those are wasteful time for me. So if a robot could do those things, looking for supplies, looking for equipment, um, that's the stuff that wastes a lot of time. (Participant C)

They also included tasks that would bring them in contact with patients, like moving patients and patient hygiene. Seven of the eight talked about the possibility of a robot moving patients, citing concerns about the danger to nurses.

repetitive motion tasks, like lifting and repositioning patients that really have a high cost to healthcare because they lead to so many injuries (Participant B)

Two of the eight nurses discussed hygiene tasks.

Hygiene's a very personal kind of thing. So like I could see some patients doing well with, um, with some assistance that way with hygiene, like maybe like, you know, dental and, um, other, you know, hygiene bits, like getting helped into the shower (Participant G)

However, some nurses also pushed back against the idea of a robot being used for hygiene applications.

when the nurse was doing the bed bath, they were assessing the client's skin. They were maybe providing some education to the client, and those are things that can't be done by an aide, and certainly couldn't be done by a robot, or maybe they could be, maybe I just don't know enough, but I think that that's, you know, a piece of nursing that is hard to replace. (Participant B)

Nurses were also interested in potential use with infectious diseases. Three of the eight talked positively about the idea of an infectious disease robot.

somebody had talked about Ebola and, you know, infectious diseases and using robots in the room when it's, you know, you can't like, again, this is kind of weird cause it's high stakes, but it's high stakes to get sick. Um, so I think that that's kind of, um, an application in nursing that's um, yeah, you know, potential on other potential. (Participant A)

Supplemental Care

Nurses were in support of using robots to supplement nursing care. Every nurse mentioned the possibility of robots providing more help to nurses, rather than replacing them.

Um, you know, I think that those sorts of things, if you're still, you know, if they're meant to augment a person rather than completely replace, um, I think everyone wins there. (Participant B)

Two of the nurses were in support of robots being used to check nurses' work or be a backup for nurses.

I think, um, or maybe just like, even as a backup, you know, for, for the nurse, because nurses and nurses aides are human and we make mistakes, and that doesn't mean that a robot's perfect either, but the more sort of safeguards that are in place to help our patients the better, like, I think about in the electronic medical record, how a lot of the technology has been utilized to recognize patterns or potential problems that human beings missed. (Participant B)

When discussing supplemental care, they also pulled from the subordinate theme for Supplemental Care, Lack of Staff. They talked about the need for more help in healthcare, and how they thought the addition of robots could provide it.

Um, however, like I can see how this technology can be beneficial in a lot of cases, especially since as many people are aware, like hospitals are incredibly understaffed (Participant H)

Lack of Staff

All of the nurses mentioned not having enough staff throughout the nursing field.

I think, um, like I said, with the patients becoming more complicated, the shortages are outta control, people are leaving nursing left and right, I did. you know, clinically at least, um, getting really burnt out much faster than they used to. You know, you almost never see a 30 year nurse anymore. (Participant F)

Gender and Robotics

The theme Gender and Robotics described participants thoughts on the relationship between robotics and gender, specifically focusing on their perceptions of TRINA based on how TRINA was gendered. We were answering the question, “How does viewing a video of a telenursing robot affect nurses' impressions of them?” We found that our theme coalesced into three subordinate themes, Lack of Gender, Lack of Impact, and Negative Connotations with “she”. The subordinate theme Lack of Gender showed nurses’ thoughts on TRINA not being gendered, or having a gender. The subordinate theme Lack of Impact described participants’ ideas about how TRINA would affect their perception. The subordinate theme Negative Connotations with “she” showed how participants felt using “she” to describe TRINA would affect patient perception.

Lack of Gender

TRINA was identified as not having a gender because of being a robot by four of the eight nurses. Correspondingly, six of the eight nurses described TRINA as an “it” when asked which pronoun, of “he”, “she”, “they”, or “it” they would use for TRINA. The remaining two described TRINA as a “she”.

I almost think of it because TRINA is not gendered, you know, because TRINA is a robot. But then again, I think that, you know, especially in our older client population – that might not fly.
(Participant B)

One mentioned that gender identification would be based on visuals, more than stated gender.

I think humans are pretty visual, and so regardless of whether or not the, the robot, which clearly has no gender, tried to introduce themselves with some sort of identification as a gender, I think they would just be misplaced. (Participant H)

Lack of Impact

Four of the nurses specifically pushed back against the idea that the gender of TRINA would affect their perception at all.

I don't really have an opinion. Okay. I don't know why, why that? Well, I know there's a reason you put it in there. Yeah. But I don't, there's nurses that are males, females, all kinds of different, so to me it doesn't make an impact whatsoever. (Participant D)

Negative Connotations with “she”

There was pushback against using “she” to describe TRINA from three of the nurses. Two of the nurses felt that by using “she” to describe TRINA, TRINA could be more open to abuse.

So calling it, she would make it feel more normal, um, but might also open it up to more like abuse by, by patients or even staff (Participant G)

One nurse felt that diversity in nursing was important, and that using “she” could continue a deficit of diversity in nursing.

I think that, um, you know, we still would, most of the population, say she, and so referring to TRINA by the she pronoun might be more acceptable to a population that assumes that most nurses are female or most nurses' aides are female. But then again, is that like just perpetuating this lack of diversity in nursing. (Participant B)

Reactions to TRINA

The Reactions to TRINA theme was made up of nurses' direct responses to TRINA, as we were answering the question, “Do you think you'd feel confident operating the robots by yourself?”. In

analyzing their responses, two subordinate themes emerged: Ability, Infectious Diseases and Precision. The Ability subordinate theme consisted of nurses' worries about TRINA's capabilities. The Infectious Diseases subordinate theme was constructed of nurses' descriptions of TRINA's use in infectious disease scenarios where it would be safer for a nurse outside of a patient's room. The Precision subordinate theme described nurses' doubt about TRINA's precision.

Ability

Four of the nurses cited concerns about TRINA being able to complete their daily tasks as a nurse.

I think based on what I could see in that video and the limitations of TRINA as shown, I think the only application I can think of right now would be those rooms that you don't want to go into
(Participant B)

Infectious Diseases

Five of the nurses mentioned TRINA for use with infectious diseases.

that robot could have went in and brought an extra blanket or something like that if you know, and they exposed to these types of things, you know, like you wouldn't have been exposed and you felt guilty that you were not doing as much for your patients as you should have because you were trying to limit your exposure. (Participant E)

Precision

Similarly, four of the nurses mentioned doubts about TRINA's ability to be precise.

the general motor skills of that robot were kind of impressive and like, could be very useful, the fine motor skills a little less so (Participant G)

Discussion

In this work, we were interested in interviewing nurses on their thoughts about robotics – and what impacted those thoughts. Our findings show that nurses use their prior knowledge of non-robotic

technology in thinking about robotics. This showed in two major ways. First, we found that many of nurses' concerns about robotics stemmed from their previous knowledge of other technologies. For instance, when discussing the importance of human presence, they mentioned worries about how technology was already coming between them and their patients. Similarly, when they talked about robotics breaking, they talked about moments when technology broke. Second, we found that nurses used their knowledge as a reference point for predicting or assessing their capabilities with robotics. One clear example of this was seen when they talked about TRINA's interface. When discussing TRINA, many of the nurses pulled from their experience using video game interfaces to predict whether they would be able to use TRINA, and if they would be comfortable with TRINA.

This work found many different avenues that nurses might be affected by when thinking about nursing robots. Future work should look at diversifying the sources of information that nurses receive, in particular, studying whether an interaction with a nursing robot impacted their perspectives. Looking at the perspectives of others who have a stake in the design of engineering robots, in particular the perspectives of nursing assistants, will also provide more guidance in implementing robots. On the other side of the equation, interviewing robotics engineers may provide a bridge between different perspectives.

We were also interested in tasks that nurses thought a robot could perform, or that they pushed back against a robot performing. Nurses mentioned assessment, education, physical tasks, and supplementing care. Our findings support previous research in nurses' lack of support for tasks requiring assessment of information and education, and support for physical tasks (Chen & Kemp, 2011, p. 623). We also found that nurses supported robots being a supplement for a nurse. Liang et al. (2019) found a similar trend. They were generally not concerned about robots being a threat to their jobs.

Some of the nurses we talked to mentioned that care and connection sometimes came from shared space during physical tasks. Shadowing in hospital may be able to trace these connections from

physical tasks. Similarly, in this study we found a distinction between care tasks and physical tasks. In future work, it might provide another level of understanding to focus on whether this distinction is respected in what nurses actually do. Interestingly, our initial interviews started to illicit responses about both identity and generation. Nurses framed their responses in reference to generation, for example, "I'm just not somebody who's like necessarily afraid of technology. I know that there's a lot of like older nurses who don't like the technology and don't like change, you know, but I'm somebody open to change and open to seeing things progress, you know?" (Participant E). Exploring how identity and generation play into nurses' comfort with a robot performing tasks would provide further insight in how to implement robotics successfully.

We found several trends about how a robot's gender would impact nurse perceptions. Nurses felt strongly that they would not be impacted by the gender of a robot, however they did feel their patients could be impacted. Two of the nurses felt TRINA could be received negatively if referred to as "she". One of the two thought that it would mean the robot would be treated more like a nurse and would therefore open it up for abuse. The other nurse mentioned, "I wouldn't want people thinking of like a she robot. I don't know, like a weird kink kind of way" (Participant E). Interestingly, the majority of the nurses described TRINA as "it".

Exploring why nurses want to think about a robot in a non-gendered fashion might reveal more about how nurses think about robotics, and in turn how to make robots work better in hospitals. Additionally, it could be revealing to ask about a specific robot without giving it a name. The name given to the robot, TRINA, is female-sounding, and perceptions without the influence of a female-sounding name might differ. Comparing patients' perceptions about a robot to what nurses think patients' perceptions would be about the same robot could reveal crucial differences to consider. Nurses may have a skewed view of what their patients think.

We found that viewing a telenursing robot does not appear to affect nurses' impressions of a robot. Nurses gave similar feedback before and after viewing was similar, however, there were some specific comments about TRINA, the robot shown in the video. After seeing the video, and without being given any additional information about TRINA, four of the nurses commented about applications for infectious diseases. This is interesting because one of TRINA's initial reasons for development was use with infectious diseases (Li, et al., 2017). Nurses also mentioned worries about TRINA's ability to complete the daily tasks of a nurse, and TRINA's precision. When implementing robotics in hospitals, simply showing nurses a video of a robot working will not change their initial impressions. To trust a robot, nurses want to work with it.

Limitations

The sample size for the work was small, as only eight nurses were interviewed. Having a smaller sample size means that there were less perspectives included. It also means that the results of this study are more dependent on the locations and specific hospitals of the nurses interviewed. For the same reason, some themes that emerged during the study were not able to be explored. Some of the participants interviewed worked at the same hospital, meaning that the results of the study could be dependent on the policies and limitations of the hospitals.

Recommendations

Our research coalesced into several recommendations about how to implement and design nursing robots. We found that nurses' experience in video games should be considered in the design process when accessibility to nurses is a goal for robotic technologies. Making the interfaces of robotics look and work similarly to video games could help acclimatize nurses to an unfamiliar system, as well as decrease the amount of time it takes to learn. In addition, it could make nurses more confident in their ability to learn the new technology. When implementing robotics, it may be helpful to ask what nurses' current concerns are. By asking about their current concerns, these concerns can be addressed both in

the robot itself, and in how the robot is introduced. Addressing nurses' concerns about the technology in question could make nurses more trusting of it and more confident in using it. For example, if nurses in a particular area have been hacked previously, it may be important to reinforce the robot against cyber-attacks and provide information about the steps being taken to protect the robot against hacking to the nurses using it. Not gendering a robot to nurses will help the robot's acceptance with them specifically. Additionally, the pronoun "she" should be avoided or used carefully, as it may mean the robot will receive different treatment because of gendered stereotypes. Our research also supports the idea that to implement robotics, it could be helpful to provide nurses with time training with the robot and information about how the robot could help them make a safer environment for their patients.

Conclusion

Throughout this work, we have aimed to assess nurses' views on robotics, and what impacts those views. We found that nurses thought robots could perform physical tasks, but leaned away from tasks requiring assessment or education of patients. We also saw that nurses' prior knowledge of technology fed into their concerns, and that they used their knowledge as a reference point for robotics. Additionally, most nurses believed the gendering of a telenursing robot would not impact their opinions, and they preferred to refer to a robot as "it" over "he", "she", or "they". We also found that showing nurses a video of a telenursing robot did not impact their views significantly. These points inform the design and implementation of nursing robots.

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Appendix A: Interview Questions

Key Research Questions to Address in Interview:

- 1) How do previous experiences with robots affect how nurses think about them in the nursing field?
- 2) How do nurses think robots could help them in hospitals?
- 3) How does how a telenursing robot is gendered affect impressions of it by nurses?
- 4) How does viewing a video of a telenursing robot affect nurses' impressions of them?

Interviewer Script:

- 1) Thanks so much for taking the time to talk with me today. Before we get started, I want you to look over this informed consent agreement. Please let me know if you have any questions. If you agree to participate, I just need for you to sign the informed consent. If you decide you do not want to participate, that is completely fine as well!
- 2) Do you agree to participate in today's interview?
- 3) Can I record this interview? I will use the recording to transcribe the interview and once that is complete, I will delete the recording. Is that okay? You are welcome to say no.
- 4) Great, let's go ahead and get started.

Nursing Experience

- 1) I first want to get a sense of your experiences as a nurse.
- 2) Do you hold a degree in nursing? (Y/N)
 - a. IF YES, what degree do you have? Undergraduate? Graduate?
 - b. When did you get this degree?
- 3) Are you a registered nurse? (Y/N)
- 4) How many years have you been practicing nursing?
- 5) Would you mind us asking your age?
- 6) What does a typical day at work as a nurse look like for you?
- 7) Do you work with any nursing assistants? (Y/N)
 - a. What types of tasks do the nursing assistants typically do to support you?
 - b. Do you think you have enough nursing assistant support? (Y/N)
 - i. IF NO, in what areas could you use additional nursing assistant support?
- 8) Do you mentor any other nurses or nursing students at work? (Y/N)
 - a. IF YES, do you use any specific strategies when mentoring others at work?
- 9) Are you a nursing faculty? (Y/N)
 - a. IF YES, what do you teach?

Experience with Nursing Robots

- 1) Now I want us to think about robots in healthcare and nursing.
- 2) Healthcare robots include but are not limited to the robots for surgery, rehabilitation, and assistance of daily living.
 - a. Have you heard of robots being used in healthcare? Y/N
 - i. IF YES, what are the healthcare robotic technologies you have heard about?
 - ii. Do you have any experience using any healthcare robots? (Y/N)
 1. IF YES, which ones?
 - iii. Are there any tasks in healthcare where you think robotic technologies could be helpful?
 - iv. Are there any tasks in health care where you think robotic technologies should not be used?
- 3) Let's talk a little bit more about specifically nursing robots now. Nursing robots are a specific subfield of healthcare robots. They are the kind of robots that can perform some routine nursing assistance tasks frequently performed by nurses or nursing assistants. Specifically, a nursing robot can 1) deliver food, medicine and patient room supplies; 2) prepare and clean workspace for nurses; 3) move portable medical devices; 4) assist in patient handling, 5) take measurements of vital signs from patients; 6) clean and disinfect patient rooms; 7) support in tele-communication. These nursing assistant robots work under direct control or supervision of the nurses, or even autonomously or when a nurse is in another room.
- 4) Have you heard of robots being used for nursing assistance? (Y/N)
 - a. IF YES, what kinds of nursing robots have you heard about?
 - b. What types of tasks do these robots perform?
- 5) Are there any tasks that you think a nursing robot might be able to help you at work? What specifically?
 - a. For the safety and quality of patient care, would the robot completing these tasks need to be under your direct control or could it be operating autonomously (on its own)?
- 6) Have you worked with any nursing robots in your job as a nurse? (Y/N)
 - a. If YES, what has your experience been like working with these nursing robots?
 - b. Do you feel comfortable working with these robots?
 - c. Do you feel confident that you can operate these robots yourself? Why or why not?
 - d. If NO, do you think you would be comfortable working with these robots?
 - e. Do you think you'd feel confident operating the robots by yourself?
- 7) Do you have any concerns about working with a nursing robot?
 - a. IF Yes, what are some of these concerns

- 1) Thanks so much for all your thoughts and insights so far. Now, I want to show you a video of a nursing robot named TRINA. TRINA is a teleoperated nursing robot. This means that nurses control TRINA from a room away from the room in which TRINA is in.
- 2) SHOW TRINA VIDEO
- 3) What are some of your initial reactions about TRINA?
- 4) Do you think that TRINA could be helpful in completing any of your daily tasks as a nurse? (Y/N)
 - a. If Yes, how?
 - b. If NO, why not?
- 5) Would you feel comfortable operating TRINA? Y/N
 - a. IF YES, what makes you comfortable?
 - b. IF NO, what makes you uncomfortable?
- 6) What are your reactions to TRINA's interface? Do you think you could use/operate TRINA? (Y/N) Why or Why not?
- 7) Do you think you could learn to use TRINA's interface to control the nursing robot? (Y/N)?
 - a. Why?
- 8) Do any people come to mind who might be able to use TRINA more easily than others? For instance, younger nurses? Older nurses? Male nurses? Female nurses?
- 9) Would you describe TRINA as "she", "he", "they", or "it"?
- 10) If TRINA were to be described as "he" how might that influence your perceptions of TRINA? What if TRINA were described as "she"?

FINAL IMPRESSIONS/THOUGHTS

- 1) Thanks so much for all of your insights, now I want to step back and think about the broader implications of healthcare and nursing robots.
- 2) What are your general thoughts about healthcare and nursing robots after this conversation?
- 3) What are the pros to tele-operated nursing robots?
- 4) What are the cons?
- 5) How do you think nursing robots might influence/impact the nursing field?
- 6) Do you think the use of healthcare/nursing robots will be similar to other technologies or different? In what ways?
- 7) Do you have any concerns about nursing robots taking jobs away from nurses or nursing assistants?
 - a. IF YES, What are these concerns?
 - b. IF NO, Why do you think that?
- 8) Do you think that specialists, separate from nurses, will need to be hired and trained to use nursing robots?

- a. IF YES, who do you think these people will be? Younger? Older? Men? Women?
 - b. IF NO, do you think that nurses will be able to easily navigate this transformation?
- 9) Given the current times with COVID19, we also wanted to ask you a few questions related to the pandemic.
- 10) Have you worked specifically with COVID-19 patients? (Y/N)
- 11) Have you heard of any robots that support COVID-19 patient care?
- a. If Yes, which ones?
- 12) What are your thoughts of using a tele-operated nurse to assist with COVID-19?
- 13) If you were to use a nursing robot to assist with treating COVID-19 patients, would you prefer to be in the room operating the robot or in another room using tele-operation?
- 14) If you would have the chance to participate in the design of nursing robot interfaces, would you like to participate?
- a. If YES, in what ways do you think nurses' participation might help with the design of nursing robot interfaces?

Conclusion

- 1) That is all I have for you today. Do you have anything else you'd like to add or say?
- 2) Do you have any questions?
- 3) Thanks so much for your time and insights. They are super helpful. We've learned a lot today!

Appendix B: Coding Schema

Previous Knowledge

- Interfaces
- Nursing Tech Ecosystem
- Robots in Hospital
- Robots in News

Concerns

- Breaking
- Importance of Human Presence
- Privacy
- Space
- Training
- Trust in Technology

Tasks

- Assessment
- Education
- Physical Tasks
- Supplementing Care
- Lack of Staff

Gender and Robotics

- Lack of Gender
- Lack of Impact
- Negative Connotations with "she"

Reactions to TRINA

- Ability
- Infectious Diseases
- Precision