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Integrating Collaborative Robots into a Complex Hospital Setting:

A Qualitative Descriptive Study

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Abstract

Objective: To describe the use, activities, and human interactions of cobots as a delivery system for medications, supplies, and equipment within a complex and multi-level 900-bed hospital setting. Integrating collaborative robots (cobots) into existing hospital workflows as a secure delivery transportation system is an early innovation and emerging area to explore. **Methods:** Guided by the Diffusion of Innovations theory, a qualitative descriptive design was used to build the foundational knowledge required to better understand and describe cobot implementation in the acute care hospital setting. The cobots were observed on all shifts, on different days of the week as they interacted with staff members, clinicians, and visitors while they traveled throughout the hospital completing deliveries. Data were analyzed among the study team members using an inductive coding approach followed by a qualitative content analysis level of interpretation. **Results:** For seven weeks from November 2022 – December 2022, 33 hours were collected from 23 individual cobot observation sessions. These observations included 89 end-to-end cobot deliveries. After analysis, four major themes emerged: 1) humanization of robots, 2) usability of robots, 3) cobots' autonomy, and 4) cobots' functionality within a dynamic hospital environment. **Conclusions:** Implementing cobots as a semi-autonomous delivery transporter is still in the early innovation phase. The cobots used in this study required human support to function adequately in a complicated and unpredictable environment. To sustainably augment current and future workflows exclusively performed by human, the cobots will need to transition toward greater model of autonomy and less human assistance.

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Introduction and Background

Robotic technology has become increasingly integrated into the healthcare landscape. Robots represent a potentially important, even transformative role that started in 1985 through surgical assistance.[1] Over the last 40 years, robots have been used in a variety of supportive roles in healthcare such as rehabilitation, surgery, telepresence (i.e. virtual consults), pharmacy, social assistance (i.e. companionship), interventional medicine, radiology imaging assistance, disinfection, radiotherapy, and delivery/transport support.[2,3] Robots in healthcare were valued at $4.06 billion in 2022 and are projected to double in value by 2032.[4] With the rising demands in

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healthcare, a limited workforce, and increasing sophistication of robotic technology, robots are projected to further augment clinical practice that was exclusively human led.[5]

To meet this evolving need, human-robot collaboration (HRC) has become a critical design principle to ensure robots can safely assist humans in a shared and collaborative workspace.[6] A cobot (collaborative robot) incorporates HRC into its functional design[6,7] and HRC is important to consider in the inpatient healthcare setting where the environment is complex and unpredictable, and requires rigorous safety measures.[5]

Cobots are being introduced into the dynamic acute care hospital settings to assist with non-clinical tasks such as completing secure deliveries,[2] which in turn may have implications for the healthcare workforce and their work environment. For example, a two-wave study design explored whether offloading the delivery of instruments and medical supplies to a robot within an operating room could improve nurses' job satisfaction and perceived health improvement (i.e., the physical burden of carrying heavy supplies and equipment).[8] Their findings supported that amplifying nurses' focus on their professional tasks increased their overall job satisfaction ($p<0.05$) and shifting non-professional tasks to a robot improved their perceived health ($p<0.05$).

Previous research and literature reviews focused on transferring tasks to cobots[9–11] and its implications for clinical practice. Freeman, et al. conducted a proof-of-concept experiment in a simulated intensive care room using a cobot to manually push buttons on an intravenous pump and a call bell, adjust knobs on a ventilator, silence alarms, and turn the dial to increase oxygen delivery.[7] Utilizing a cobot to perform these tasks tested whether nurses could enter COVID-19 patients' rooms less frequently. Findings from this study supported that the use of cobots could reduce the need for clinicians, especially nurses to enter patients' room to reduce exposure and protective equipment use.[7] In another study, Lee et al. surveyed inpatient healthcare professionals to identify needs that could be transferred to cobots. Participants responded they would like cobots to monitor patients and predict safety events such as falls or pressure injuries.[11] Kangasniemi et al.'s integrative review identified how robots and automated devices were currently being used in clinical practice.[12] Findings revealed robots have mostly been used to deliver medications and monitor patients; outcomes identified included safety, workload, changes in workflow, usability, and satisfaction.

While there is growing literature on cobots in hospitals, research on their use as delivery transporters in acute care is scarce. In one of Delaware's acute care setting, using robots to innovate hospital workflows offers a new perspective on task management. This study aims to describe the usage, activities, and human interactions of cobots as a secure delivery system in a complex hospital environment.

Methods

Theoretical Framework

The theory of Diffusion of Innovations (DOI)[13] guided this study to describe the innovation stage of integrating this robotic technology into hospital operations and clinical workflows. DOI is a social process that occurs when new technological advancements spread from introduction to adoption.[13] The DOI theory consists of four constructs: communication, time, social systems, and innovation.[13] Innovation, defined as a practice or object considered to be new,[13] was the construct of interest in this study. According to the DOI theory, five factors influence innovation adoption: relative advantage, compatibility, complexity, trialability, and observability.[13] Relative advantage is the degree to which an innovation is perceived as being better than what is currently in place and trialability, is the degree to which an innovation is perceived as relatively difficult to understand and use.[13] Compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters and complexity refers to the extent to which the environment is ready for a technological innovation.[13] Observability is the degree to which the results of the innovation are visible to others.[13]

Design and Sample

This study received Institutional Review Board (IRB) approval to conduct a qualitative descriptive study[14] to observe and take field notes of cobots' activities, functionality, and human interactions within a dynamic 900-bed inpatient hospital environment. Because of the early innovation of implementing cobots into this complex setting with limited prior knowledge, a qualitative descriptive design was ideal and appropriate to build the foundational knowledge that will provide the basis for and will inform future in-depth studies.

Using a maximum variation sampling technique,[15] the study population included hospital staff members, visitors, and patients who interacted with the cobots on all three clinical shifts (7am-3pm, 3pm-11pm, and 11pm-7am). This sampling technique was employed to capture the extensive range of interactions and variation that occurred on each shift among staff, visitors, and the cobots. Prior to cobot deployment, staff members received and were encouraged to watch a brief webinar training via email to learn how to use the cobots. In-person, hands-on training was provided by the Clinical Robot Associates (CRA) when needed at the point of interaction with the hospital staff and cobot. The CRA was a dedicated cobot human operator to support the cobots and/or staff members as needed during the delivery process.

Qualitative data were collected for seven weeks during November 2022 - December 2022, approximately six months after the cobots were operational and making deliveries around the hospital. The cobots were first deployed and operational at the end of April 2022.

Hospital Setting

The acute care hospital setting located in suburban Delaware expands 1.3 million square feet with nine floors that includes 31 inpatient units that comprises 900 beds, over 2,000 doors, and 43 elevator bays (Figure 1). This hospital also includes three pharmacies located on the basement, first, and second floor levels. The expansive emergency department has approximately 100 beds.

Figure 1. Physical Hospital Structure

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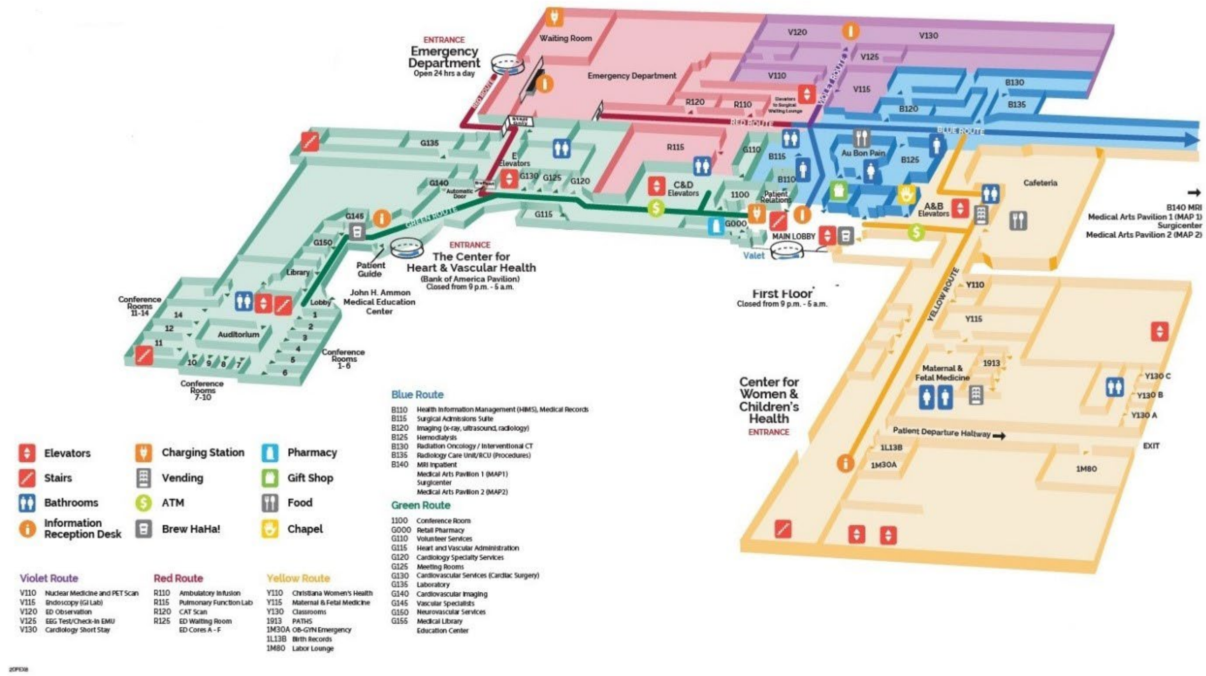

Cobot Features and Functionality

The two cobots used in this study were approximately 4 feet, 11 inches in height, had a rounded head with digital, blinking eyes that can turn into a heart shape to acknowledge individuals nearby. Other characteristics included a torso, a chest touch screen, and a single robotic right arm that could wave and press door plates to open automatic doors. Their robotic arm was not designed to retrieve items. In addition, the cobots had three different sized drawers (small, medium, large) aligned with the torso to carry supplies. To communicate, the cobots could 'meep' and notify clinicians about deliveries through chimes. They could also communicate in a soft, calm feminine voice by saying, "please call me an elevator" when prompted by the CRA at the elevator bays.

To request a cobot-facilitated delivery of medications, supplies, and/or equipment, clinicians and staff could use free-standing iPad kiosks located throughout the hospital in areas such as inpatient care units, equipment rooms, pharmacies, and the front desk. When the cobots received the request, they would navigate to the pick-up location using lidar, cameras, and occasionally the aid of the CRA. The CRA often stayed near the cobots to monitor and observe their functions to ensure successful deliveries especially when elevators and manual doors were involved. The CRAs were required to assist the cobots with elevator ingress and egress, and correct floor location.

Staff would securely load items in one of the cobot's three identity (ID) badge-accessible drawers. The cobots would then travel to their delivery destination with either supplies, medication, and/or equipment to be unloaded by staff. The cobots had to navigate an environment of complex and unpredictable elements such as people, closed doors, equipment, and elevators. Because of these contextual circumstances, they sometimes relied on CRA support to make successful end-to-end deliveries.

Data Collection Procedures

Data collection consisted of four study team members who shadowed and observed the cobots from a distance, typically with the CRA, throughout the inpatient hospital settings and on each shift (i.e., day, evening, and night) and on various days of the week, including the weekends. Collecting data on different days and different shifts ensured the research team captured the fluctuations in the dynamic hospital environment that could affect the cobots. For example, dayshift during the week (7am-3pm, M-F) historically is busier and could be more challenging for the cobots to navigate because of the increased number of people and equipment moving around the hallways related to patient care, visitation, and diagnostic procedures. Evening (3pm-11pm) and nightshifts (11pm-7am), and weekends tended to be quieter related to limited patient care procedural activity and visitation.

The study team members did not interact with the cobots and/or any staff, visitors, and patients during observations. Field notes and observations were collected in real time on secure iPads through a Microsoft Teams site to provide a rich, thick description of patients, visitors, and staff's interactions with and utilization of the cobots. Field notes included reflexive memos[15] as the researchers were part of the hospital setting shadowing the cobots.

Data Analysis

Qualitative data were manually analyzed in a stepwise approach after all field notes and observations were collected and organized. Memoing and initial coding was performed line by line for each observation and field note data entry.[16] Data were reviewed several times and analyzed separately by four trained individuals (S.B., P.M., A.S., W.B) on a weekly basis using a content analysis level of interpretation.[14] Then the four co-investigators came together to compare and discuss initial codes, code definitions, and segmented texts. Frequently occurring codes were identified, defined, and compared across code books. The emerging themes and sub-themes were discussed, labeled, defined, and further refined by merging, adding, and removing redundant themes. This iterative process led to the development of major themes and sub-themes.[16] Data saturation occurred when no new codes or themes emerged.

To ensure trustworthiness of the results, codes, code categories, definitions, segmented texts, and themes were reviewed and discussed with consensus reached among the research team (S.B., P.M., A.S., W.B). An audit trail was created and accessible to all study team members in a secure Microsoft Teams site. Study team members discussed their reflexive memos and bracketed any biases that allowed them to refrain from judgement and opinions.[16]

Results

During seven weeks of data collection, we observed the cobots completing 89 which consisted of traveling from one destination to the next in an expansive hospital setting. At any point during the delivery process, the CRA intervened to support the cobot 107 times of which 72 interventions were related to the elevator assistance. Other CRA assistance rendered to the cobots were related to not being unable to open or navigate through doors (n=20), difficulty navigating around an obstacle (n=4), staff unsure how to use the cobot (n=7), mislocalization of the destination (n=7), and unable to locate staff to unload the content in the drawers (n=1). People interacted with the cobots totaling 138 times which consisted of 79 positive, 17 negative, and 42 neutral interactions. The cobots were also observed to be ignored or not acknowledged 36 times.

The analytic process yielded 22 initial codes and 12 code categories. From these code categories, four major themes with six subthemes emerged. After collecting and analyzing seven weeks and 33 hours of data, four major themes emerged: 1) humanization of cobots, 2) usability of cobots, 3) cobots' autonomy, and 4) cobots' functionality within a dynamic hospital environment (Table 1).

Table 1. Key themes with Examples from Observations and/or Field Notes

Key Themes	Relevant Observations/Quotes
Human responses to the cobots	Visitor upon seeing the cobot rolling through the hallways began laughing and asked, "Is that your friend?" Nursing students after seeing a cobot excitedly stated, "Did you see that?" to one another. A visitor said to the patient in the unit, "They have one of those (cobots) at another hospital." A patient was sitting in the hallway and with fascination stated, "That's crazy." "She's scary." Three staff members walked by and ignored the cobot.
Cobot usability	One registered nurse opened the cobot immediately without help. Another registered nurse attempts to unload the cobot but appears unsure. The CRA walks over to her to demonstrate the draw opening process to her. No one at the nurses' station addresses the cobot upon arrival for delivery. The cobot just silently stands there.
Perceived cobot autonomy	The cobot did not move through the automatic doors quickly enough and they closed. The CRA had to manually open the automatic doors again for the cobot to go through. The CRA uses his remote control to move the cobot onto and off the elevators. The cobot is silently waiting by the elevator for the CRA to arrive that will facilitate ingress onto the elevator. The cobot automatous travels to the elevators in the basement.
Cobots' functionality in the hospital setting	The cobot rolls through the automatic door on the first attempt, stops in its cobot delivery spot on the unit and chimes once to notify staff of its arrival. The cobot entered the unit where a yellow caution spill sign was on the floor in the middle of the hallway in proximity to a patient chair. The cobot stopped for approximately 30 seconds to assess the situation and it was able to autonomously navigate through the narrow space with success. A bed was partially blocking the hallway. The cobot was able to navigate around the bed with ease and continue down the hallway. A bed is blocking the cobots delivery spot. The cobot is silently spinning in circles while people walk by and watch.

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	When prompted by the CRA, the cobot will ask, “Can you call for an elevator?” The CRA will push the buttons to call for an elevator.

Theme 1: Humanization of Cobots

A prominent theme to emerge in this study was the treatment of the cobots as human beings that included human reactions and emotional responses. Individuals who saw and/or interacted with the cobots typically had an emotional (positive, negative, or neutral) response. Sometimes, individuals had no response upon seeing the cobots. Examples of emotional responses were related to being curious or fearful, such as “Woah, can I take a selfie with the cobot?” or “That’s crazy, she’s scary” after seeing the cobot roll by. Reactions were mostly positive, but occasionally negative. Examples of positive reactions were, “Wow, it’s a robot” and smiled; and “Hey robot baby. I miss you.” An example of negative reactions was, “we are ruining the cobot’s day with our closed door.” Sometimes, people ignored the cobot rolling by or did not interact with it when they were loading or unloading contents into its drawers.

Theme 2: Usability of Cobots

An important theme to emerge was cobot usability that included subthemes of ease of use and confusion. Staff who used the cobots often were observed loading/unloading items from their drawers with ease. A pharmacy tech stated, “I like using the cobot, it’s easy to use and makes my life easier when I can’t send medications.” Several nurses were observed accessing the cobot without any issues or hesitation. Conversely, some nursing staff demonstrated uncertainty about how to use the cobots to retrieve items in its drawers and/or to interpret its pickup/drop off chimes. For example, one of the nurses did not know how to use her ID badge to unload the cobot’s drawers. She requested assistance from the CRA who demonstrated how to access the cobot’s drawers. Another nurse was observed trying to swipe her ID badge all over the cobot to open the drawers without any success. In addition to difficulty accessing the drawers on the cobot, clinical staff were observed to be uncertain about whose job it was to address the cobot when it arrived at the patient care unit. For instance, a nurse at the central nurses’ station was observed staring at the cobot rather than badging in to retrieve its contents when it arrived at its delivery spot on the unit.

Theme 3: Cobots’ Autonomy

Cobot autonomy is defined as a robot being able to sense, plan, and act upon that environment, with the intent of reaching a task-specific goal, without external control,[17] and this was a major theme to emerge. Cobots in this study often required human support to make successful deliveries within a requisite time of usually 30-60 minutes throughout a complex environment of multiple floors and locations. Clinicians and staff were required to load and unload drawer contents, as the cobots’ arm was designed to open automatic doors and press buttons for navigational purposes. For complex maneuvering such as entering and exiting the elevators, navigating small spaces, or circumventing large obstacles that obstructed their paths, the CRAs intervened with their remote controller to override the cobots.

Cobot navigation within the hospital setting was an autonomy subtheme. The cobots demonstrated a consistent degree of autonomy (i.e., no external or CRA support) when navigating through the hospital basement level where there were less stops and obstacles, as well as between single-level inpatient units. For example, one of the cobots entered a unit with a spill on the floor with a yellow caution sign. The cobot recognized the obstacle and autonomously maneuvered around the spill. In another instance, cobots recognized a bed in the hallway was an obstacle, stopped and assessed its surroundings, then navigated around the bed to complete a delivery. However, the cobots occasionally made navigation errors such as taking a wrong turn or taking a circuitous route to make a delivery. When these errors occurred, the CRA would manually control the cobots to ensure they reached their correct destinations in a timely manner.

Theme 4: Cobots' Functionality Within a Dynamic Hospital Setting

The last prominent theme to emerge pertained to how the cobots functioned within an inpatient hospital setting. Subthemes included delivery execution, cobot behaviors, and communication abilities. The cobots are designed to be a secure delivery system, yet errors sometimes occurred during the delivery process. For instance, the cobots used their robotic arm to push the door plate to enter a closed-door area; however, sometimes the doors closed too quickly before the cobot could roll through. The cobots would then re-initiate the entire process: reading the door bar code, moving its robotic arm to push the door plate, placing its robotic arm back into position, and then rolling through the doorway. When a cobot could not repeatedly roll through a doorway quickly enough, the CRA would manually push the door plate and override the cobot system to drive it through the doors before they shut.

Cobots also displayed typical robotic behaviors that may be perceived by humans as both expected and unexpected behaviors. Expected behaviors involved stopping to load navigation maps between units, waiting for CRA support at the elevators to manually enter and exit on appropriate floors, stopping when someone or something was in its path, and waiting for someone to load and unload its drawer contents when it arrived at its designated delivery spots. Unexpected behaviors included spinning around, emitting distressed sounds, and stopping in the hallways for an unusually long time. In one instance, a bed was completely blocking the cobot's designated delivery location, which resulted in the cobot spinning in circles trying to move into that spot. Another time, one of the cobots emitted a 'distressed' sound when it was hit by an automatic closing door that caused it to suddenly stop in the middle of the doorway.

To communicate, the cobots emitted pleasant "meeps" and chimes, and waved its arm. When the cobots arrived at their designated delivery location, they would automatically chime once to alert staff of their presence. While the chimes were automatic, the cobot could meep, wave its robotic arm, or ask for an elevator in a soft feminine voice when prompted by the CRA using a remote handheld control device.

Discussion

Acute care hospitals are dynamic, complex environments where hundreds of people and large volumes of equipment travel daily.[18] Deploying cobots to assist in completing deliveries throughout this unpredictable and unstructured environment, with high standards of quality and safety, is a cutting-edge endeavor with unique challenges. Guided by the innovation construct of the DOI theory, this study highlights and describes the use of cobots as artificially intelligent delivery transporters that are still in the early phase of innovation with unique challenges when operating within a complex hospital setting.

Relative Advantage

When hospital staff and clinicians are introduced and expected to use an early-stage innovation such as delivery cobots, they will take into consideration whether the cobots provide an advantage over the current human delivery infrastructure they are already familiar with.[19] For example, communication is critically important in the hospital environment because clinicians and staff rely on verbal communication to work in teams.[6] We observed the cobots in their current state alerted clinicians and hospital staff of their arrival through emitting a single chime sound yet were not capable of spoken words to explain their purpose or process. This limited communication ability may reduce the perceived advantages of humans providing the same delivery service. Further, the absence of verbal communication meant the cobots were not always quickly addressed after emitting their chime on arrival. This may be related to the important fact that clinicians and staff were working in a busy environment in which they could not hear the single chime without providing additional verbal cues. Clinicians may have grown accustomed to ignoring the cobot too because it could not signify urgency through words like a human could nor does it require respect as a human waiting to receive attention[20,21] When these occurrences happened, the CRA would intervene; however, these communication limitations could result in delayed deliveries when these cobot transition to greater autonomy with less CRA oversight. To enhance the perceived relative advantage over the human-only delivery system, better communication is urgently needed[6] that would start shifting perspectives that cobots could be part of the healthcare team leading to the adoption of cobots in this setting.[18,22]

Compatibility

When robotic technology is deployed that requires human support, people will assess its compatibility with their current needs and existing values.[23] For example, the intent of these delivery cobots was to offload non-clinical tasks permitting clinicians and staff to focus on higher value, critical thinking patient-centered work. Yet, integrating cobots into the hospital workforce is uniquely different, as it completes delivery tasks previously performed exclusively by humans and requires a level of coordination between human and machine.[2] Asking clinicians and staff to embrace these changes may be difficult given the variety of attitudes surrounding technology implementation in healthcare,[24] the potential need for more training and expertise,[5] and whether cobots fit into their existing working paradigm.[23] Shifting tasks from clinicians and staff may also engender uneasiness about job security and possible feelings of competition. Cobots are designed to enhance human abilities, not replace them or their knowledge and experience in healthcare[25,26]; therefore, an appropriate communication strategy is needed to ensure cobots are not viewed as a threat, but accepted into the workforce.

Complexity

Understanding the complexity of a hospital environment is critically important to evaluate whether cobots are ready to participate in this work with clinicians and hospital staff. Most hospitals are older facilities that were built for humans, by humans without a future consideration for robotics. Therefore, hallways may be narrow, elevators may be smaller, and end-to-end delivery locations may be a farther distance apart. For example, the inpatient pharmacy in this study was located in the basement, which presented potential navigational difficulties for the cobots to travel long distances to complete deliveries. When these end-to-end point locations are a great distance apart, unique robotic challenges become more apparent because the cobots in

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this study did not have dynamic awareness of their surroundings similar to what humans possess[6,27] or communication abilities. For instance, CRAs must help the cobots enter and exit elevators, navigate manual doors, and override the navigation system in constrained spaces when needed. These unique autonomy challenges reflect the reality of the acute care hospital environment and the current state of cobot capabilities that require a higher level of human dependence depending on the complexity of the physical setting.[6,27]

Trialability

Deploying this type of robotic technology has the potential to affect hospital workflows by complementing the workforce currently required for deliveries supporting hospital operations and patient care.[25] Consistent with previous studies and literature reviews, shifting delivery tasks to cobots could offload these tasks from nurses, clinicians, and staff members, allowing them to work to the top of their training with potential implications for increased job satisfaction and reduced staff turnover.[25,28] However, before achieving this workforce goal, this change necessitates human adoption and acceptance.[25,29] Our observations indicated that frequent use and familiarity with the cobots influenced trialability (i.e. difficulty to use). Pharmacy technicians who used the cobots often could easily navigate its features while nurses or nursing staff who used the cobot less frequently sometimes appeared confused about how to open the locked drawers or its purpose on the unit. When these events occurred, the onsite CRA would show staff how to use the cobots. However, being unsure how to use the cobots could affect their trialability, which may hinder their desire to use in the future.[29] Therefore, these findings suggest that even though clinicians and staff members were sent basic education, they may require more educational touch points to aid in their adoption.[12]

Observability

Observing the cobots' perceived autonomy could influence whether others might embrace this new technology. In our study, people observed the cobots making deliveries with limited to no human interventions. However, when the CRA had to intervene whether for an expected reason, such as for elevator navigation or opening of manual doors, or for an unexpected reason such as obstacle issues or mislocalization of a destination, individuals could witness the cobots requirement of human assistance in certain instances. These observations may influence whether cobots could be adopted with confidence or approached with skepticism.[30,31]

Individuals could also observe how people interacted with or anthropomorphized the human-like cobots. Anthropomorphosis refers to attributing human qualities to inanimate objects.[32] We observed numerous times that when the cobots emitted whimsical beeping sounds, changed their eyes to a heart shape, or waved their robotic hand, many individuals engaged with a smile or an enthusiastic greeting. These human gestures and exchanges were important findings that could foster human-robotic interactions[17,33] required to integrate cobots into the healthcare landscape[11] especially during the early innovation phase when there could be heightened skepticism. This finding was consistent in a previous study in which the anthropomorphic features were viewed as positive attributes and facilitated 'liking' the cobot and viewing it as a 'cute' addition to patient care.[5] The human aspect of cobots is important to facilitate the adoption of new technology into healthcare because it ensures that the cobots are viewed as useful helpers rather than threats, ultimately leading to a more harmonious incorporation into workflows.[25]

Limitations

This study sought to explore the clinical phenomena of incorporating cobots in the hospital environment guided by the DOI innovation construct. Because this study design is meant to describe and provide a broad context about cobots, the outcomes did not measure the cobots' impact on daily workflow, productivity, and/or efficiencies. In addition, this study observed one type of cobot in a 900-bed tertiary care hospital, which may not be representative of all settings and cobots. For example, hospital designs, floors, and number of doors may be different that could affect autonomy, as well as the availability of a delivery tube system to transport medications and supplies among locations. Data collection was limited to a seven-week period of time. A longer data collection period may have encompassed additional diverse observations as the technology improved. Recording field notes has some limitations, such as researcher conscious and/or unconscious biases that may have influenced the notes. To minimize potential biases, the research team engaged in reflexive memoing and bracketing their biases. In addition, the team also regularly participated in open discussions about the assumptions they may have held about the cobots.

Conclusion

Integrating cobots into workflows as a secure delivery transportation system is an exciting addition to Delaware's largest acute inpatient hospital setting, yet there is a pressing need to improve their capabilities if they are they are augment and complement the current hospital workforce. Current state cobots in our setting require human dependency to function adequately in this complicated and unpredictable environment. This initial study was a critical starting point to demonstrate cobots' potential and future value as they become more sophisticated and integrated into health systems. Currently, cobots may be perceived as an expensive delivery system; thus, smaller, less resourced healthcare systems may not be able to justify the costs of integrating, training, and maintenance.[25] However, as the next generation of cobots are created, financial models are expected to evolve toward greater affordability.

This is a promising technology in an early stage of adoption that may offer solutions and possibilities in patient care, not currently realized or imagined.[25] The future of cobots assisting with deliveries will need to transition from in-person human task support to a remote presence, which will be an essential step toward consistency and autonomy.[2] Further, this innovation has the potential to transforms healthcare delivery in the State and inspire the community to approach the healthcare industry with a renewed sense of excitement.

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