Robots as Patient Sitters

Acceptability by Nursing Students

M. Cynthia Logsdon, PhD, WHNP-BC, FAAN, Shamsudeen Abubakar, PhD, Sumit Kumar Das, PhD, Heather Mitchell, PhD, RN, Bhumika Vivek Gowda, Emmaline Wuensch, Dan O. Popa, PhD

Science continues to evolve related to the safe and effective use of robots in healthcare.[1–8] Researchers have demonstrated that robots can support the role of nurses through accomplishment of tasks and improvement of effective communications[6,8–11] and can free professional nurses for more important critical thinking and caring roles.[12,13]

Nursing education events and circumstances in recent years, including the COVID-19 pandemic, have led to successful experimentation in the use of robots and artificial intelligence to support simulation and remote learning.[14–17] Nursing students are an ideal population for which to test new and effective technologies, as they are just beginning to develop their attitudes towards, and comfort with, a variety of procedures and use of technology. Therefore, the purpose of this study was to measure the acceptability of nursing students in the use of robots in a patient sitter scenario.

Study procedures involved a task wherein the robot responded to remote commands issued through a computer tablet by the nursing student (acting as patient) to fetch and retrieve items. If successful, this fetch-and-retrieve robot capability could be used to replace a primary role of patient sitters in fall prevention, to enhance patient safety, and to support the role of the nurse.

In acute care settings, bedside sitters are often used for patients at a high risk for falls, but they are expensive and their effectiveness is unclear.[18] Greeley et al[19] reviewed published evidence about the effect of sitters on patient falls in acute care hospitals. Of 20 studies meeting inclusion criteria, two added sitters to usual care and 18 compared alternatives with sitters. Two studies provided very-low–certainty evidence that adding sitters reduced falls. Eight studies provided moderate-certainty evidence that interventions that included video monitoring reduced sitter use and either did not affect or reduced the number of falls. Very-low–certainty evidence suggested that interventions that included nurse assessment tools (three studies) or a close observation unit (two studies) were effective alternatives to sitters. Thus, exploration of effective substitutes for human sitters is needed. The research question for the study was as follows: Is the use of a service robot in a patient sitter scenario acceptable by nursing students?

KEY POINTS

- This acceptability study was done via repeated experiments conducted with nursing students and using their responses to questionnaires formulated on the Perceived Usefulness and Perceived Ease of Use subscales of the Technology Acceptance Model about their experience.
- The results show a moderate to high acceptance of the Adaptive Robotic Nursing Assistant (ARNA) for the patient sitting task of fetching.
- Overall, the work presents a basis for evaluating the acceptability of the ARNA robot (and similar robots) in a patient sitter task.

METHODS

The study was framed by the Technology Acceptance Model. Originally proposed in 1989,[20] the Technology Acceptance Model presents systemic relationships between several human factors and the usage of a technology. The Technology Acceptance Model instrument includes subscales to measure Perceived Usefulness (PU) and Perceived Ease of Use (PEU)[20] of the technology. Perceived usefulness is the degree to which one thinks that using a specific system facilitates their job. Perceived ease of use is the degree to which one thinks usage of that system is effort-free.

Items to measure PU included the following questions: (1) "How quickly does the robot arrive at its destination using the tablet interface?" (slow [1]/fast [5]); (2) "How safe do you think the robot is while you are controlling it with the tablet interface?" (unsafe [1]/safe [5]); (3) "What would you say the speed of the robot is when moving around the room?" (slow [1]/fast [5]); (4) "How stably did the robot gripper grasp the item?" (stable [1]/unstable [5]); (5) "How safe do you think the robot arm is when it hands over the fetched?" (unsafe [1]/safe [50]).

Author Affiliations: School of Nursing, University of Louisville (Drs Logsdon and Mitchell, and Ms Wuensch); and Louisville Automation & Robotics Research Institute, J.B. Speed School of Engineering, University of Louisville (Drs Abubakar, Kumar, and Popa, and Ms Gowda), KY.

The authors have disclosed that they have no significant relationships with, or financial interest in, any commercial companies pertaining to this article.

Corresponding author: M. Cynthia Logsdon, PhD, WHNP-BC, FAAN, School of Nursing, University of Louisville, 555 S Floyd St K Wing, Louisville, KY 40202 (mclogs01@louisville.edu; mimia.logsdon@louisville.edu).

DOI: 10.1097/CIN.0000000000000936

FIGURE 1. The ARNA.

Perceived ease of use was measured by the following items: (6) "How convenient is it to drive the robot with the tablet interface?" (not convenient [1]/very convenient [5]); (7) "How much attention does it take to drive the robot to the desired place while avoiding obstacles?" (high [1]/low [5]); (8) "How easy is it to drive the robot to the desired place while avoiding obstacles?" (difficult [1]/easy [5]); (9) "How convenient is it to tell the robot where to go using the interface?" (not convenient [1]/very convenient [5]); (10) "How easy is it to grab items with the robot arm using the tablet interface?" (difficult [1]/easy [5]).

The study was approved by the Human Subjects Protection Program of the University of Louisville. The participants (n = 24) were all undergraduate upper division and master's entry accelerated second-degree students in the nursing program at a Research 1 university. Students were recruited by in-class invitations from the research team. The students received credit for clinical/research hours for an undergraduate research course or capstone clinical course as compensation for participating in the experiments. Students signed informed consents upon enrollment.

The Adaptive Robotic Nursing Assistant (ARNA) robot (see Figure 1) is a mobile manipulator that consists of an omnidirectional base with an instrumented handlebar and a 7–degrees of freedom robotic arm. It is a service robot capable of providing both physical assistance and remote teleoperation to a human user and is also capable of autonomous operation. Novel technological contributions in the development of ARNA include its multi-sensor instrumentation board for heteroceptive sensing, a software architecture that facilitates

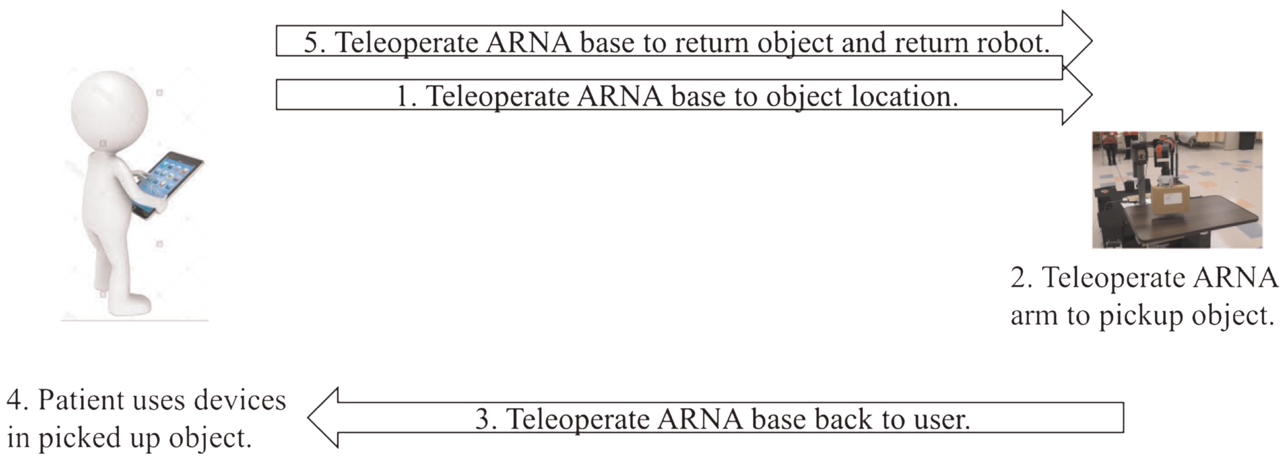

FIGURE 2. Patient sitter experiment conducted.

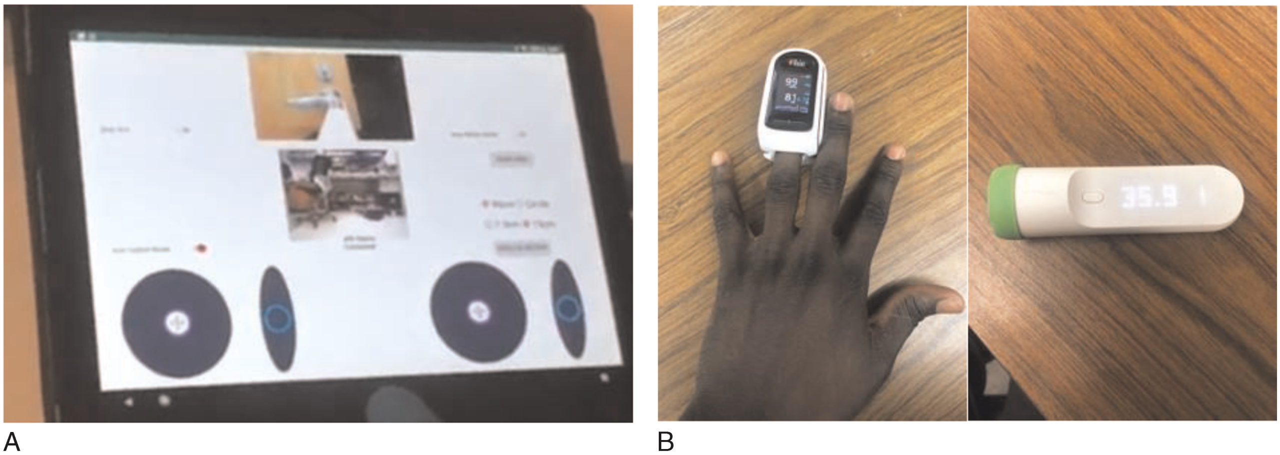

FIGURE 3. A, Tablet interface to control ARNA in patient sitter mode. B, Pulse oximeter and digital infrared thermometer that were contained in object picked in the patient sitter experiment.

rapid transition between different autonomy levels to carry out different tasks, and a neuroadaptive controller that enables the incorporation of task and user preferences to allow the robot to be used with users of varying abilities in similar and different tasks.[11,21] To complete the tasks in this study, the ARNA robot was designed to perform the following functions: (1) autonomous navigation in unstructured environments, (2) pick and place certain classes of objects in the environment, (3) heteroceptive sensing of environments and human health, and (4) interface with a human user via physical and teleoperative means.

The experiments were conducted at a simulation suite located at the School of Nursing at the university. The simulation suite houses two hospital-like rooms, an observation/control room used for simulated scenarios, many patient simulator manikins, and other high-fidelity simulation equipment. For the sake of this experiment, the task was performed by teleoperation of the robot base and arm through a tablet interface in the simulated hospital room.

As shown in Figure 2, the task to be performed in the experiments consisted of five (5) parts: (1) Using the tablet interface, a user teleoperates the ARNA robot to the location of

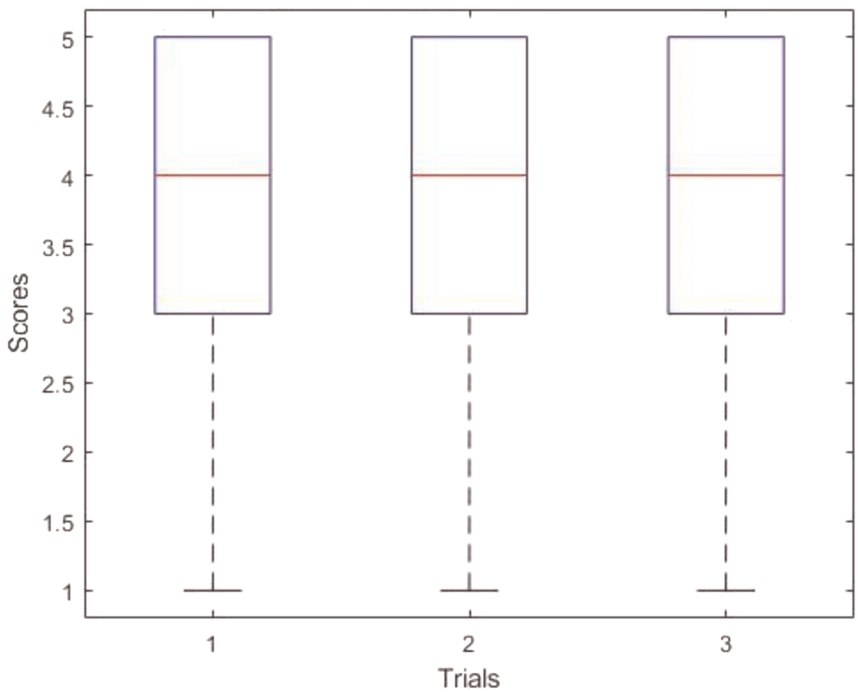

FIGURE 4. Average score of usefulness across trials.

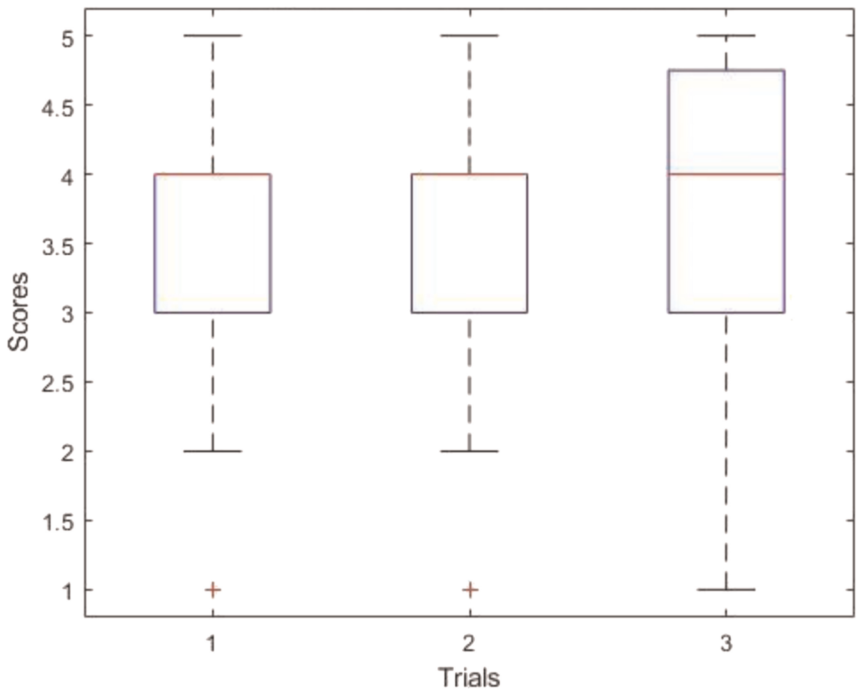

FIGURE 5. Average score of ease of use across trials.

object to be fetched. In the experiments in this work, the object to be picked up is a box containing an infrared thermometer and a pulse oximeter (Figure 3). (2) With the robot at the location of the object, the tablet interface is used to teleoperate the arm to fetch the object. (3) The user teleoperates the ARNA robot base to within arm's reach of the user. Then, the user collects the item from the gripper of ARNA's arm, uses it, and returns the object to the gripper. (4) The user teleoperates the ARNA robot base to the location where the item was originally picked and then teleoperates the arm to place the object properly. (5) The user teleoperates the ARNA robot back to the experiment start location. There were three trials to enable evaluation of any improvement in their use of the robot that might come with repeating an operation. At the end of each trial, each student completed a questionnaire of Likert-scaled questions about their experience interacting with the robot in patient sitter mode.

Time to perform each experiment was also recorded. This time was broken into base travel time, which is the time to drive to and from the patient and the object to be picked up, and arm teleoperation time, which is the time taken to move the robotic arm to pick up the box.

RESULTS

Data indicate that students rated the technology's usefulness at 3.77/5.00 with an SD of 1.10 and the ease of use at 3.49/5.00 with an SD of 1.12. As illustrated in Figures 4 and 5, this indicates a moderate to high acceptance of use of the ARNA robot in a sitter scenario. In terms of the relationship between PU and perceived ease of use, PU had a 27.2% dependence on perceived ease of use (ie, $R^2 = 0.272$) with a P value of .05.

Table 1 shows the average measured time for each of the trials performed by the participants in the experiments. The average total time taken to execute the entire patient scenario across all 24 users over all three trials was 209.52 seconds. This is time saving for a nurse in which they would otherwise come to the patient's room to fetch an item for a patient, assist them in its use, and return the object. Completion of the task also replaces one role of the patient sitter.

DISCUSSION

As mentioned above, research has been equivocal in the effectiveness of patient sitters to prevent patient falls. An effective alternative to patient sitters is needed that is safe, cost

Table 1. Time Breakdown of Tasks Performed During Patient Sitter Experiment

	Object Pickup Time, s		Object Use Time, s		Total Trial Time, s	
	M	SD	M	SD	M	SD
Trial 1	53.12	11.41	72.47	18.11	211.45	71.89
Trial 2	48.36	12.11	65.32	20.74	192.11	48.02
Trial 3	49.50	11.01	63.18	21.07	190.18	40.52

effective, and acceptable, and service robots are a promising solution. Nursing students are an ideal population for which to test new and effective technologies, such as service robots.

In this work, we present ARNA, a novel service robot capable of use in healthcare, and evaluate the acceptability of its patient sitting functionality. This acceptability study was done via repeated experiments conducted with nursing students and by using their responses to questionnaires formulated on the PU and Perceived Ease of Use subscales of the Technology Acceptance Model about their experience. The results show a moderate to high acceptance of the ARNA robot for the patient sitting task of fetching. Overall, the work presents a basis for continued evaluation of the acceptability of the ARNA robot (and similar robots) in a patient sitter task.

Time saved for nurses is an important concept during an international nursing shortage. Eliminating patient sitters while maintaining safe, effective, and acceptable healthcare is a worthy goal. Any tasks that can be accomplished effectively and safely by technology are important to note. Research that includes economic analyses of the use of robots in healthcare is indicated and would include calculations of nursing time and patient sitter time as compared with costs to purchase and operate service robots.

Although this paper is a notable contribution to studies that would foster the acceptability and widespread usage of robots as patient sitters, future research should include conducting more longitudinal studies that feature other technology acceptance frameworks such as Decomposed Theory of Planned Behavior,[22] which presents a model for understanding behavior of users with a technology based on the relationship between their beliefs, attitudes, and intention. Another suggested framework is the Perceived Characteristics of Innovating theory that shows how major characteristics of a technological innovation—namely, relative advantage, compatibility, complexity, trialability, and observability—can impact its actual usage.[23,24]

Fetching and retrieving items is just one of many possibilities for which robots can be programed. Nurses and engineers must continue to effectively collaborate to design and refine robots that meet the needs of healthcare facilities.[4,21,25] Acceptability data should inform further development. Interestingly, an analysis of recent social media posts indicates public acceptance of the use of robots in healthcare, which will potentially impact the openness of nurses and other healthcare workers to this labor-saving innovation.[10]

References

1. Buchanan C, Howitt ML, Wilson R, Booth RG, Risling T, Bamford M. Predicted influences of artificial intelligence on the domains of nursing: scoping review. *JMIR Nursing*. 2020;3(1): e23939. doi:10.2196/23939.
2. Christoforou EG, Avgousti S, Ramdani N, Novales C, Panayides AS. The upcoming role for nursing and assistive robotics: opportunities and challenges ahead. *Frontiers in Digital Health*. 2020;2: 585656. doi:10.3389/fdgth.2020.585656.
3. Cresswell K, Cunningham-Burley S, Sheikh A. Health care robotics: qualitative exploration of key challenges and future directions. *Journal of Medical Internet Research*. 2018;20(7): e10410. doi:10.219/10410.
4. Frazier RM, Carter-Templeton H, Wyatt TH, Wu L. Current trends in robotics in nursing patents—a glimpse into emerging innovations. *Computers, Informatics, Nursing: CIN*. 2019;37(6): 290–297. doi:10.1097/cin000000000000558.
5. Lee H, Kim J, Kim S, et al. Usability evaluation of user requirement-based teleconsultation robots: a preliminary report from South Korea. *Methods of Information in Medicine*. 2020;59: 86–95. doi:10.1055/s-0040-1715579.
6. Lee H, Piao M, Lee J, Byun A, Kim J. The purpose of bedside robots: exploring the needs of inpatients and healthcare professionals. *Computers, Informatics, Nursing: CIN*. 2020;38(1): 8–17. doi:10.1097/CIN.000000000000558.
7. Maalouf N, Sidaoul A, Elhaju IH, Asmar D. Robotics in nursing: a scoping review. *Journal of Nursing Scholarship*. 2018;50(6): 590–600. doi:10.111/nu.12424.
8. Tietze M, McBride S. Robotics and impact on nursing practice: case study and pilot site analyses. *American Nurses Association*. 2020;1–84.
9. Cresswell K, Sheikh A. Can disinfection robots reduce the risk of transmission of SARS-CoV-2 in health care and educational settings? *Journal of Medical Internet Research*. 2020;22(9): e20896. doi:10.2196/20896.
10. Eriksson H, Salzmann-Erikson M. Twitter discussions about the predicaments of robots in geriatric nursing: forecast of nursing robotics in aged care. *Contemporary Nurse*. 2018;54(1): 97–107. doi:10.1080/10376178.2017.1364972.
11. Saadatzi MN, Logsdon MC, Abubakar S, et al. Acceptability of using a robotic nursing assistant in health care environments: experimental pilot study. *Journal of Medical Internet Research*. 2020;22: e17509. doi:10.2196/17509.
12. Chang HY, Huang TL, Wong MK, Ho LH, Wu CN, Teng CI. How robots help nurses focus on professional task engagement and reduce nurses' turnover intention. *Journal of Nursing Scholarship*. 2021;53(2): 237–245. doi:10.1111/ju.12629.
13. Stokes F, Palmer A. Artificial intelligence and robotics in nursing: ethics of caring as a guide to dividing tasks between AI and humans. *Nursing Philosophy*. 2020;21(4): e12306. doi:10.111/nup.12306.
14. Bowtell L, Moloney A, Kist A, Parker V, Maxwell A, Reedy N Using remote access laboratories in nursing education. Paper presented at: 2012 9th International Conference on Remote Engineering and Virtual Instrumentation; Bilbao, Spain; July 2012. 2012; 1–7. doi:10.1109/REV.2012.6293148
15. McAllister M, Wood D. The robots are here, but are nurse educators prepared? *Collegian*. 2021;28(2): 230–235. doi:10.1016/j.colegn.2020.07.005.
16. Sampsel D, Bharwani G, Mehling D, Smith S. Robots as faculty: student & faculty perceptions. *Clinical Simulation in Nursing*. 2011;7(6): e209–e218. doi:10.1016/jecns.2010.02.009.
17. Yancey NR. Robotics in teaching-learning: but in nursing? *Nursing Science Quarterly*. 2021;34(1): 247–252. doi:10.1177/08943184211020703.
18. Vancil B, Michael L, Wagoner J, et al. Improving patient sitter use with care companions. *Nursing Management*. 2020;51(11): 47–53. doi:10.1097/01.NUMA.0000719400.30792.a2.
19. Greeley AM, Tanner EP, Mak S, Begashaw MM, Miake-Lye IM, Shekelle PG. Sitters as a patient safety strategy to reduce hospital falls: a systematic review. *Annals of Internal Medicine*. 2020;172(5): 317–324. doi:10.7326/M19-2628.
20. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *Management System Quarterly*. 1989;13(3): 319–340. doi:10.2307/249008.
21. Abubakar S., Das S. K., Robinson C., Saadatzi M.N., Logsdon C., Mitchell H, Chlebowy D., Popa D. O. ARNA, a service robot for nursing assistance: system overview and user acceptability. Paper presented at: 2020 IEEE 16th

International Conference on Automation Science and Engineering (CASE) Hong Kong; August 20-21, 2020; 2020; 1408–1414. doi:10.1109/CASE48305.2020.9216845.

22. Song Y, Qin Z, Kang T, Jin Y. Robot helps when robot fits: examining the role of baby robots in fertility promotion. *Healthcare*. 2019;7(4): 147. doi:10.3390/healthcare7040147.
23. Limthongchai P, Speece M. The effect of perceived characteristics of innovation on e-commerce adoption by SMEs in Thailand. In: Proceedings of the Seventh International Conference on Global Business and Economic Development; 2003; Bangkok, Thailand.
24. Beer JM, Prakash A, Smarr CA, et al. Older users' acceptance of an assistive robot: attitudinal changes following brief exposure. *Gerontechnology.* 2017; 16(1): 21–36. doi:10.4017/gt.2017.16.1.003.00.
25. Carter-Templeton H, Frazier RM, Wu L, Wyattt T. Robotics in nursing: a bibliometric analysis. *Journal of Nursing Scholarship*. 2018;50(6): 582–589. doi:10.1111/jnu.12399.