Sigma's 30th International Nursing Research Congress

Efficacy and Acceptability of Robots to Improve Physical Tasks in Hospital Environments

M. Cynthia Logsdon, PhD, WHNP-BC, FAAN[1]
Dan Popa, PhD[2]
Heather Mitchell, PhD[3]
Diane Chlebowy, PhD[3]
Indika Wijayasinghe, PhD[2]
M. N. Saadatzi, PhD[4]
Sumitkumar Das, BS[2]
(1)Nursing, University of Louisville Hospital, Louisville, KY, USA
(2)Engineering, University of Louisville, Louisville, KY, USA
(3)Nursing, University of Louisville, Louisville, KY, USA
(4)University of Louisville, Louisville, KY, USA

Purpose: This project pushes the boundaries of science and technology by investigating the efficacy and acceptability *of using robots* to help professional nurses deliver healthcare. Healthcare is considered one of the last industries to fully embrace technology that transformed other industries in the past 40 years. The Association of American Medical Colleges warned of a shortage of health care professionals of nearly 104,000 by 2030 (https://news.aamc.org/press-releases/article/workforce_report_shortage_04112018/). The use of robot assisted healthcare could help address this shortage by automating routine tasks and improving productivity and safety. However, research is needed that improves human and robot learning to collaborate in the safe, efficacious, and acceptable delivery of healthcare.

Developed by engineers on research team, an Adaptive Robotic Nursing Assistant (ARNA) is a mobile assistive robot that can navigate in cluttered hospital environments and perform chores as a nursing assistant. Some possible tasks are roles of patient sitter and walkers. From the robot's perspective, these skills still require a high level of intelligence, autonomy, and semi-autonomy to accomplish them in collaboration with a nurse. The necessary intelligence helps efficient communication with humans, autonomous navigation in hospital environments, accurate object identification, and manipulation. For this purpose, the ARNA is equipped with many sensors including cameras, 3D RGB-D sensors, LIDAR, multi-modal skin sensors, and force-torque sensors. With frequent advances in science and technology related to the sensors, development and testing of the robots must be iterative in order to reflect best practices for quality and safety in health care. Testing the use of robots with nursing students in a safe, laboratory learning environment provides a useful foundation for the next series of tests in an actual hospital environment with registered nurses and patients and is *the purpose of this study.*

Research Questions

1. What is the efficacy of ARNA's sensor systems (navigation, object detection, voice recognition, force detection, manipulation, adaptive physical guidance and assisted teleoperation) in patient sitter and patient walker scenarios?
2. Is the use of robots acceptable to nursing students and faculty in patient sitter and patient walker scenarios?

Methods:

Design: The study design is descriptive.

Theoretical Framework: The Technology Acceptance Model (Davis, 1989) served as the theoretical framework of the study. An integrative literature review demonstrated that TAM effectively predicts nurse's acceptance of health care technology (Strudwick, 2015). Ifinedo (2016) found prediction was strengthened by the inclusion of demographics.

Sample: The sample will consist of students (n=48) enrolled in basic undergraduate and second-degree nursing programs. Students will work in pairs, with one student acting as patient and the second student acting as nurse in the 4 scenarios. Each scenario (sitter and walker) will be repeated 3 times on each date with different student pairs (e.g., sitter scenario scheduled for 1/2019 and 3/2019 with each date involving testing with 3 student pairs; walker scenario scheduled for 2/2019 and 4/2019 with each date involving 3 student pairs). Students will receive course credit for clinical/research hours from either NUR 330 undergraduate nursing research course or NUR 474 Culminating Capstone course for participating in the project. Nurse faculty supervising students in the laboratory (n=5) will also be enrolled in the study as participants.

The study has been approved by the university IRB. All students and faculty will complete informed consents.

Procedure for Sitter intervention: A tablet with a custom programmed Android app will be used to send commands to the robot to request 3 fetching tasks and assess the student's temperature and blood pressure. Nursing students will either sit or lie on the bed and interact with the robot. As part of an effort to evaluate the task performance, the time to complete the task will be recorded. The student is allowed to issue emergency stop commands during robot operation. Such commands are given priority and allow the robot to return to a safe position. Initial data for this scenario will be collected in January 2019, adaptations will be made to the robot systems and sensors if needed, and the scenario will be repeated in March 2019.

Procedure for Walker intervention: A patient walker walks alongside a patient providing assistance. Tasks performed by a patient walker may include watching for the risk of falls, applying supporting forces for comfort and navigation, pushing wheelchairs, and bringing along medical equipment such as IV poles and respirators. A robot providing patient walker assistance needs capability to: (1) assess the risk of falls by detection of deviation from normal walking patterns, (2) provide sturdy support for the patient, and (3) adaptively respond to the contact load and stabilize the patient. Additionally, a robot may need to push a gurney or bed transporting patients from one place to another in the hospital. Initial data for this scenario will be collected in February 2019, adaptations will be made to the robot systems and sensors if needed, and the scenario will be repeated in April 2019.

Instruments: Data related to the efficacy of the robots will be collected from each sensor by the engineering co-authors, including time to complete each task and accuracy of task completion. Formative data will be discussed by the research team after the January and February testing and will inform the next iteration of the sensors and robots. Efficacy is defined as full functioning of each sensor in each case scenario, with improvements in time and accuracy for the final two scenarios.

Acceptability will be measured using the two subscales of the Technology Acceptance Model (Davis, 1989), Perceived Usefulness and Perceived Ease of Use. Strong reliability and validity data have been demonstrated (Davis, 1989). Each subscale consists of 6 items in a Likert scale format with 7 response options from likely to unlikely. The Technology Acceptance Model is the gold standard for investigation of technology adoption in health care.

EVALUATION

Descriptive data will be used to describe the effectiveness of the robot in each scenario, including the accuracy and the time completion for each task. In addition, qualitative data will be captured from the engineering co-authors in terms of sensor expected and observed performance. The rationale for adaptions of each sensor and the actual change will also be recorded. A full description of the sensors and systems used in the last testing will be captured. The sensor performances in the scenarios between January-March and February-April will be compared by t-tests.

The acceptability data will be described separately for faculty and students. Mean scores will be reported for each sub-scale. The student data for the 4 scenarios will be combined for regression analysis, with demographic data and perceived ease of use as independent variables and perceived usefulness as the dependent variable.

Results:

Data collection for the study will occur January-April, 2019.

Conclusion:

Technology will continue to be used in health care organizations to enhance the effectiveness of the workforce and to ensure safe and effective health care for patients. Careful testing of the technology for efficacy and acceptability will provide evidence for effective purchasing and implementation decisions, and provide the evidence for change.

Title:
Efficacy and Acceptability of Robots to Improve Physical Tasks in Hospital Environments

Keywords:
Nursing, Robots and Workforce

References:
Cremer, S., Doelling, K., Lundberg, C. L., McNair, M., Shin, J. & Popa, D. (2016). Application requirements for robotic nursing assistants in hospital environments, in [SPIE Commercial+ Scientific Sensing and Imaging], 98590E-98590E, International Society for Optics and Photonics.

Davis, F. (1989). Usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13, 319-340.

Ifinedo, P. (2016). The moderating effects of demographic and individual characteristics on nurses' acceptance of information systems: A Canadian study. International Journal of Medical Informatics, 87, 27-35.

Kretzschmer, S., Walker, M., Myers, J., Vogt, K., Massouda, J., Gottbrath, D., Pritchett, M. Stikes, R., & Logsdon, M.C. (2017). Nursing empowerment, workplace environment, and job satisfaction in nurses employed in an academic health sciences center. *Journal for Nurses in Professional Development, 33(4):196-202. doi: 10.1097/NND.0000000000000363.PMID: 28683033*

Strudwick, G. (2015). Predicting nurses' use of healthcare technology using the technology acceptance model: An integrative review. Computer Informatics Nursing, 33, 189-198.

Abstract Summary:
An interdisciplinary research team will evaluate efficacy and acceptability of robots in patient walking and sitting scenarios, with the long term goal of enhancing the nursing workforce and patient safety. Testing will take place in a school of nursing laboratory with undergraduate and second degree students and faculty as participants.

Content Outline:

1. Introduction

This project pushes the boundaries of science and technology by investigating the efficacy and acceptability *of using robots* to help professional nurses deliver healthcare.

1. Main Point

Research is needed that improves human and robot learning to collaborate in the safe, efficacious, and acceptable delivery of healthcare.

Supporting points

Developed by engineers on research team, an Adaptive Robotic Nursing Assistant (ARNA) is a mobile assistive robot that can navigate in cluttered hospital environments and perform chores as a nursing assistant.

Testing the use of robots with nursing students in a safe, laboratory learning environment provides a useful foundation for the next series of tests in an actual hospital environment with registered nurses and patients.

Research Questions

1. What is the efficacy of ARNA's sensor systems (navigation, object detection, voice recognition, force detection, manipulation, adaptive physical guidance and assisted teleoperation) in patient sitter and patient walker scenarios?
2. Is the use of robots acceptable to nursing students and faculty in patient sitter and patient walker scenarios?

III. Main Point

The descriptive study is framed by the Technology Acceptance Model. An interdisciplinary research team will evaluate efficacy and acceptability of robots in patient walking and sitting scenarios, with the long term goal of enhancing the nursing workforce and patient safety. Testing will take place in a school of nursing laboratory with undergraduate and second degree students and faculty as participants.

Supporting points

Data related to the efficacy of the robots will be collected from each sensor by the engineering co-authors, including time to complete each task and accuracy of task completion. Formative data will be discussed by the research team after the January and February testing and will inform the next iteration of the sensors and robots. Efficacy is defined as full functioning of each sensor in each case scenario, with improvements in time and accuracy for the final two scenarios.

Acceptability will be measured using the two subscales of the Technology Acceptance Model (Davis, 1989), Perceived Usefulness and Perceived Ease of Use.

Descriptive data will be used to describe the effectiveness of the robot in each scenario, including the accuracy and the time completion for each task. In addition, qualitative data will be captured from the engineering co-authors in terms of sensor expected and observed performance. The rationale for adaptions of each sensor and the actual change will also be recorded. A full description of the sensors and systems used in the last testing will be captured. The sensor performances in the scenarios beween January-March and February-April will be compared by t-tests.

The acceptability data will be described separately for faculty and students. Mean scores will be reported for each sub-scale. The student data for the 4 scenarios will be combined for regression analysis, with demographic data and perceived ease of use as independent variables and perceived usefulness as the dependent variable.

IV Conclusions

Technology will continue to be used in health care organizations to enhance the effectiveness of the workforce and to ensure safe and effective health care for patients. Careful testing of the technology for efficacy and acceptability will provide evidence for effective purchasing and implementation decisions, and provide the evidence for change.

First Primary Presenting Author
Primary Presenting Author
M. Cynthia Logsdon, PhD, WHNP-BC, FAAN
University of Louisville Hospital
Nursing
Associate Chief of Nursing for Research
Louisville KY
USA

Author Summary: My experience in conducting and teaching nursing research, as well as my clinical experience as a clinical nurse specialist and nurse practitioner, created the foundation for this project.

Second Author
Dan Popa, PhD
University of Louisville
Engineering
Professor
Louisville KY
USA

Author Summary: Expert in simulation, control, and packaging of microsystems, and in control and adaptation aspects of human robot interaction. Extensive funding from national science foundation. Head of the Next Generation Systems (NGS) Research Group. Recipient of several prestigious awards and author of over 100 publications.

Third Author
Heather Mitchell, PhD
University of Louisville
Nursing
Assistant Professor
Louisville KY
USA

Author Summary: Dr. Mitchell has been the recipient of numerous awards to recognize her expert teaching, including the University of Louisville Distinguished Faculty in Teaching Award. She regularly receives Faculty Favorite Awards for her clear and supportive communications with students. She models effective teaching for over 20 undergraduate nursing faculty at 2 campuses.

Fourth Author
Diane Chlebowy, PhD
University of Louisville
Nursing
Associate Professor
Louisville KY
USA

Author Summary: Dr. Chlebowy is an expert nurse educator, with experience in teaching across undergraduate and graduate programs. She models the role of nurse researcher and research mentor for faculty across all programs in the School of Nursing.

Fifth Author
Indika Wijayasinghe, PhD
University of Louisville
Engineering
Post doctoral associate
Louisville KY
USA

Author Summary: Dr. Indika Wijayasinghe is a post doctoral associate in the New Generation System laboratory. He has extensive research experience in the development and testing of new technology.

Sixth Author
M. N. Saadatzi, PhD
University of Louisville
Post doctoral associate
Louisville KY
USA

Author Summary: Dr. Saadatzi has extensive experience with developing and testing technology, including robotic systems. He is member of the NGS team at the Speed School of Engineering, University of Louisville, with extensive relevant publications.

Seventh Author
Sumitkumar Das, BS
University of Louisville
Engineering
PhD candidate
Louisville KY
USA

Author Summary: Mr Das is a PhD candidate in the Speed School of Engineering, University of Louisville. He has extensive research experience with the NGS team in developing and testing technology including robotic systems.