International Journal of Technology Assessment in Health Care, 31:4 (2015), 256–263.

doi:10.1017/S0266462315000380

HEALTH PROFESSIONALS' USER EXPERIENCE OF THE INTELLIGENT BED IN PATIENTS' HOMES

Hao Cai
Telehealth & Telerehabilitation Laboratory, SMI, MI, Department of Health Science and Technology, Aalborg University
howardbrutii@foxmail.com

Egon Toft
College of Medicine, Qatar University

Ole Hejlesen, John Hansen
MI, Department of Health Science and Technology, Aalborg University

Claus Oestergaard
Municipality of Esbjerg

Birthe Dinesen
Telehealth & Telerehabilitation Laboratory, SMI, Department of Health Science and Technology, Aalborg University

Background: The intelligent bed is a medical bed with several home healthcare functions. It includes, among others, an "out of bed" detector, a moisture detector, and a catheter bag detector. The design purpose of the intelligent bed is to assist patients in their daily living, facilitate the work of clinical staff, and improves the quality of care. The aim of this sub-study of the iCare project was to explore how health professionals (HPs) experience and use the intelligent bed in patients' homes.
Methods: The overall research design is inspired by case study methodology. A triangulation of data collection techniques has been used: log book, documentation study, participant observations ($n = 45$ hr), and qualitative interviews ($n = 23$). The data have been analyzed by means of Nvivo 9.0.
Findings: We identified several themes: HP transformation from passive technology recipient to innovator; individualized care; work flow redesign; and sensor technology intruding on patient privacy.
Conclusions: It is suggested that functions of the intelligent bed can result in more individualized care, workflow redesign, and time savings for the health professionals in caring for elderly patients. However, the technology intruded on patients' privacy.

Keywords: Health technology assessment, Intelligent bed, Telemedicine, Health professionals, Home telehealth

Today's elderly population chooses to live at home for as long as possible. This group suffers from a variety of chronic diseases, resulting in an increased demand for new assistive technologies for home use to meet the needs of daily life and activities. This has led to the development of an "intelligent bed," equipped with sensors/detectors that can assist patients in their daily living, facilitate the work of health professionals (HPs), and improve the quality of care. The intelligent bed uses the framework of a medical bed and includes, among others, an out of bed detector, a moisture detector, and a catheter bag detector. The functions of the intelligent bed are described in the Methods section. A prototype of the intelligent bed has been tested in the iCare project by elderly patients in Soenderborg Municipality in Denmark from May 2012 to October 2012. The overall goal of the iCare project was to test and evaluate the intelligent bed from the perspectives of HPs, bedridden users, and their families.

The aim of this sub-study of the iCare project was to explore how HPs experience and use the intelligent bed in patients' homes. A health professional in this context is a person who has received minimum 14 months of both theoretical and practical clinical education. The experiences of the patients and their families will be reported in another study.

The following scientific databases were searched: PubMed, Google Scholar, IEEE Xplore, and ScienceDirect. The search terms were: "intelligent bed," "health technology assessment," "patient-centered care," "HP," "telemedicine," "Telehealth," and "user experience." The literature review was performed from 2005 to 2013. Only studies published in English were considered. Citations with abstracts were downloaded to EndNote 7.0 and screened by three reviewers: the first author, the last author, and a research assistant mentioned in the acknowledgement. If none of the reviewers could exclude the article according to the research topic, then the rest of study would be reviewed. When there was disagreement on inclusion of an article, all the reviewers made decisions together by reading its content. Accepted papers were categorized by the research

The project has been funded by Welfare Tech Region in Denmark.We thank the patients and healthcare professionals of Soenderborg Municipality in Denmark. Thanks also to the staff at Linak A/S for technical support during the iCare project. Finally, we thank the research assistant Natasha Soerensen for helping with review of the literature, study design, collection, and analysis of the data.

focus: systematic review, design, implementation, or evaluation of technology.

As the intelligent bed is a new concept and product, a review of the literature yields little concrete evaluation data. We have not been able to identify any studies that could serve as a parallel to the kind of intelligent bed tested in the iCare project. Closely related to the intelligent bed are smart home technologies, that is, the use of sensors to monitor and observe the environment, or specific devices such as the stove or home lighting. However, comparing to the intelligent bed, smart home technology focuses on providing convenience to everyone. Yonezawa et al. have developed a care system inside the bed to prevent patients from falling out of bed (1). An intelligent bed robot system was proposed to assist the movement and posture of patients in the bed (2). A pressure sensor system on the bed was tested to evaluate the sleep quality of its users (3). These studies were conducted on a small-scale basis or in a laboratory environment. In these studies, the local social-cultural context, clearly relevant to the implementation of the intelligent bed, was artificially simplified. Furthermore, most of the previous studies focus on achieving some specific technical functions from an engineering perspective. The experiences of patients and HPs using the intelligent bed were inadequately reported. However, suggestions from patients and HPs on the use of the intelligent bed are critical to its successful implementation (4). These oversights represent a knowledge gap between the theoretical design and practical use of the intelligent bed, particularly concerning contextual differences (5).

SUBJECTS AND METHODS

Description of the Intelligent Bed

The intelligent bed has been developed through a user-driven innovation process with workshops. The intelligent bed is based on a communication platform that includes gateways that allow transmission and integration of data from detectors on the bed, ensuring that care staffs obtain timely information about patient's status. The bed consists of the following functions listed in Table 1.

The bed information is sent directly from the bed, by means of mobile devices, or from a central database to the responsible HP carrying out care or monitoring the patient. The system integration allows various HPs to receive the dedicated information to meet the needs of changing personnel during work shifts throughout the week. Data are stored in a central database to ensure documentation of the care and work process, and the same data are transmitted to the mobile device of the person in charge of the information and related activity. The transmission architecture provides secure and safe management of the bed information.

The HP receiving the data acknowledges receipt by means of their mobile device and may then decide if it is necessary to visit the patient to act on the information received. A "call back" function also enables the HPs to contact the patients directly to clarify their needs. One HP had a personal digital assistant (PDA) on which all messages from the intelligent beds were received. The HP then communicated the information to appropriate colleagues responsible for the client, or who happened to be in the area where the client lived. If the HP does not react to the messages sent from the intelligent bed, the message is automatically forwarded to a backup phone. The message is sent three times to the HP's PDA before being forwarded to the backup phone. During the evening shift, there are also three PDAs, one for each team, and one backup phone. During the night shift, two HPs cover an entire district, and they have the backup phone with them on their shift and receive the messages from the intelligent beds.

Five super users were selected. Among them, three were from the day shifts and two were from the evening/night shifts. Their tasks were to facilitate the implementation process of the intelligent bed. They were assigned to educate their colleagues on the use of the intelligent bed and gave a timely response when the colleagues have questions on operating the beds.

Study Environment

The intelligent bed was tested in collaboration with the Department of District Nursing in Soenderborg Municipality. Most of their patients are elderly and require different levels of assistance. The HPs used smart phones, PDAs, and computers in their daily work of taking care of the elderly. During the daytime, each HP had eight to ten patients whom they visit. There were seventeen HPs on duty during the evening shift, and they carried out an average of twenty-three visits per evening. During the night shift, two HPs covered each district and made approximately twenty visits per night.

Target Group

The intelligent bed has been tested by twenty-eight patients in the homecare system. The criteria for selecting the patients to test the bed were the following: (i) relatively equal numbers of female and male; (ii) they must have had an identified care need that used as many functions of the intelligent bed as possible; (iii) a wide range of physical and mental (in-)capacities.

Of the twenty-eight patients, sixteen were female and twelve were male. The sixteen women had a mean age of 70.7 (youngest, 43; oldest, 89), while the men in the study had a mean age of 76.9 (youngest, 67; oldest, 96). One patient died during the study after testing the intelligent bed for 12 weeks, and another moved to a nursing home due to worsening health status.

Ethical Considerations

The Ethical Committee system was asked if the study had to be reported to the Ethical Committee. They responded that the

Table 1. Functions of the Intelligent Bed

Name of the function	Design purpose	Description
No power to the bed	To notify the HPs when the bed is not connected to electricity.	When the bed is not operative due to lack of power, a message will be sent to the HPs' mobile phones. The HPs can then go to the patients' residence to reconnect the electricity.
User voice call	To signal the HPs that the patient wants help.	The patient presses a call button, and the assigned HP receives the message "user wants dialogue". The HP can call the user back, and over the voice communication clarify the patient's needs and determine when a visit could be planned. The HP can decide if and when to respond, to avoid the interruption of any current task.
Out of bed detector	To warn the HPs when the patients are out of bed.	This function will alarm the HPs that the user may have fallen or is unable to come back from the toilet within a pre-set time limit (e.g., 10 minutes). It is also relevant to patients who sleepwalk.
Bed in unsafe exit position	To warn the HPs when the bed is in an unsafe height for the patient.	The patient may fall out if the bed's position is too high. This function notifies the HPs that an unsafe height has arisen and that the bed must be lowered down to a safe level.
Bed rails in unsafe position	To inform the HPs that the bedrails are not in a safe position.	This function is designed to ensure that the bedrails are set in the proper position so that the patient does not fall out when he/she is in bed, especially during sleep.
Brake not locked	To signal the HPs when the bed wheels are not locked.	When the brake is not locked, the wheels have a possibility to roll and the bed might move, becoming a potential threat to a patient. An uncontrolled bed may also hurt the HPs' back, arms or legs. This function will remind the HPs to lock the brake.
Moisture detector	To notify the HPs to change the sheets when necessary.	The humidity may rise significantly due to urine or perspiration. This function informs the HPs promptly when the bed sheets need to be changed. It reduces the need for HPs to place their hands around the bed to feel whether or not it is wet.
Catheter bag detector	To remind the HPs that the catheter bag storing urine is full, or that the liquid flow to the bag has been interrupted.	Once the bag is full or the flow is interrupted, the HPs will receive a message on their mobile phones. Then they can respond accordingly. Different sized bags can be used.
Light control	To provide light support for the patients and HPs.	Light devices were installed both under and above the bed. They can be turned on manually using the control panels. This can help patients with reading or using the toilet at night. It also provides convenience for the HPs when checking on the patients at night.
Ergonomics movement	To adjust the appropriate ergonomical position for the patients and HPs.	This function provides assistance when bedridden patients need to sit in the bed for long periods of time. The HPs can avoid adjusting the height of the bed manually, reducing the risk of back injuries.

study did not have to be reported, as the functions of the bed did not directly intervene or show any negative effect on the care of the patients in homecare according to the research protocol. The study was performed according to the Helsinki Declaration and the guidelines of the Ethical Committee system. All patients included in the study signed an agreement of informed consent before participating in the project. The study was reported to the Danish Data Protection Agency in the spring of 2011. All participants are anonymous.

Authors' Backgrounds and Theoretical Framework

Before commencing the data collection and analysis, it was critical to acknowledge how the individual perspectives and philosophies of various authors would have a major impact on the research process. Hence, the research group has conducted several internal discussions on various theories, data collection techniques, analytical approaches, and local contextual factors in relation to the research. The purpose was to obtain a comprehensive understanding of the research questions from different perspectives and to minimize knowledge gaps within the group resulting from their diverse educational and cultural backgrounds. It was noted that our research group consists of scholars from several disciplines, including clinical science, engineering, management, and political science, from both Denmark and China. This gave us a comprehensive mix of relevant expertise with which to study the phenomenon and review the practices of the participants on different levels, both within the organizations and among them. We understand that the adoption of the intelligent bed technology is a dynamic process, and that human beings are both an individual and societal unit in the implementation of any new technology.

The theoretical framework of this study is based on learning theory. Learning theory refers to how a learning process affects the knowledge and values of an organization (6). As the intelligent bed is a prototype, the HPs had no experience in using the intelligent bed before this study. Hence, a learning perspective can help elucidate the learning barriers that HPs must overcome to successfully operate the intelligent bed and carry out effective user care. We paid special attention to the model of "double loop learning," to understand how learning to operate new technology affects organizational strategies, including organizational learning mechanisms and the design and implementation of workflows, and how these affect the new technology in turn. This framework sheds light on factors that have affected the adoption of the intelligent bed and the performance of daily care tasks as well.

Study Design

The overall study design is inspired by case study methodology (7). This design facilitates identifying inter-relationships between social phenomena and their context (8). It enables the researcher to explore the experiences of HPs using the intelligent bed in the specific situations that arise in the course of their work. Data triangulation techniques have been applied to ensure the validity and reliability of the research (9). Documentation study, participant observation, and semi-structured qualitative interviews have been conducted to provide different sources of evidence. They were performed by the first author, the fifth author, the last author, and a research assistant.

In the following section, the different data collection techniques are described.

Logbook

A logbook was used to document the process of data collection and reflection during the study. In this manner, the assumptions, ideas, and observations of the researchers could be linked to the phenomenon objectively. The data from the logbook were then taken into account in the analysis.

Documentation Study

Documentation was conducted three months before the test began (10). The purpose was to obtain basic knowledge concerning the social, cultural and economic context, as well as the local healthcare strategies used in information technology and telemedicine in the municipality of Soenderborg and the homecare service. A range of documentary materials was studied before identifying the data collection techniques and process. We reviewed the homepages of the local government, health institutions, and industries pertinent to our research. We also studied the local newspaper and on-line reporting on this topic, to better understand the use of the new technology in this region.

Participant Observations

Participant observation was performed in the homecare service from August 2011 until the end of the study (11). The purpose was to gain insight into the workflows of the HPs, the organizational culture, the procedures in delivering healthcare services, and the HPs' attitudes toward new technologies. The observations took place in the following situations and totaled 45 hours: (i) training sessions with HPs on how to use the intelligent bed; (ii) meetings of HPs and between HPs and their supervisors; (iii) HPs at work during day, evening, and night shifts.

Table 2. Overview of Participants Interviewed

Respondents by profession	Sample size
Director of homecare service	1
Administrator of homecare service	3
HP working day shift	9
HP working evening shift	7
HP working night shift	2
Occupational therapist	1
Total	23

At the monthly steering committee meeting, the observations were reported so that the project management and homecare management teams could discuss the issues that arose and carry out necessary interventions. These interventions had either an organizational or technical character.

The researchers documented the interventions carried out in a logbook, and the data have been used for further analysis.

Although we are aware of the classic criticism that interventions of this kind may influence a study's results, data from participant-observation were used to give the project management and management in the homecare service a more precise picture of the implementation process. The participant-observation data were used by the project and homecare management teams to make organizational and technical improvements to the intelligent bed and to provide better operating information to the HPs.

Qualitative Interviews

The purpose of the interviews was to gain insight into the experiences and attitudes of the HPs with regard to the use of the intelligent bed in the daily care of elderly patients. Participants in the interviews were either: (i) HPs who worked directly with the intelligent bed on a daily basis (daytime, evening, and night); or (ii) management and administration staff of the homecare service.

A total of twenty-three participants were interviewed individually before, during, and after the implementation of the intelligent bed, in either their office or a meeting room (12). A focus group interview was conducted afterward for 1 hour, to identify missing information and verify the data obtained from the individual interviews. The age distribution of participants was between 19 and 60 years, and the average age was 43.5 years. Of the twenty-three persons interviewed, twenty-two were female. Table 2 provides an overview of the participants.

The interviews were carried out using semi-structured interview guidelines, and all interviews were tape recorded. The interviews lasted from 60 to 90 minutes. The participants are anonymous. The interviews were transcribed.

The interviews were carried out by the first and last author of this article and by a research assistant. The first author of this sub-study does not speak Danish, so the interviews were translated into English. The English version of the interviews was validated by a native Danish speaker and by the last author of this study.

Data Analysis

Data analysis was conducted after the test of the intelligent bed (13). The analysis included data from notes and reflections from the log book, documents, observations, and transcribed qualitative interviews. The main qualitative method used in analysis was analytic induction approach (14;15). The software program Nvivo 9.0 was applied to code the data. A combination of etic and emic coding was used as well. A predefined list of topics or categories was not used to avoid bias and facilitate to identify new topics and patterns.

The analysis of data followed the following steps:

- Design of a code tree, comprised of nodes, descriptions/definitions of nodes, and child nodes, was carried out during dialogue sessions within the research group. The code tree was constructed based on the central concepts (in vitro nodes), from the theoretical framework of learning theory (in vivo nodes), from qualitative interviews carried out with informants, and from participant observation. When formulating the concepts from the respondents, five qualitative interviews with HPs were analyzed and coded on the basis of initial impressions.
- The remaining interviews were then transcribed and reviewed to gain an overall impression of the topics, context, etc.
- Rough coding of all interviews was conducted in Nvivo 9.0.
- Refined coding was carried out following a review of the coded material and adjustments to both the code tree and the coding of interviews, for example, node merging. The passages were analyzed with reference to the context.
- The next step aimed at the identification of topics and patterns, and the interpretation was widened to include a framework of understanding beyond the respondent. What was the topical content of the interview, and what motivated the informant's views? What was the scope of potential actions? An in-depth interpretation was included in this phase and compared with a conventional understanding. In this phase, the interviews were analyzed to draw inferences regarding motivations and underlying perceptions.
- In the final phase, data were analyzed based on the theoretical framework to be able to derive effects and generate causal explanations.

- The analysis was performed by the first author, the fifth author, the last author, and a research assistant introduced in the acknowledgement. The last two persons transcribed all the Danish interviews. The first two persons then translated the interviews into English. The coding of all interviews was conducted together by these four persons both in English and Danish. These researchers then conducted a joint work on designing and refining the code tree, identifying topics and patterns and widening the interpretations. When there is disagreement between interpretations, the rest of the authors were invited to comment and reach agreement. The final draft was sent to the participants for review and verified in a focus group interview with the super users.

The application of a computer program for qualitative data coding is associated with several biases and limitations. First, a decontextualization of data may occur. Second, the program was developed based on grounded theory (an inductive approach), which is at odds with the combined etic and emic coding strategy used in this study. Third, when using a computer program, there is a risk of distancing the researchers from the data.

Minimizing Methodological Bias

A triangulation of data collection techniques has been used to minimize methodological bias, improve construct validity, and establish quality in the study design. Four tests have been carried out, on construct validity, internal validity, external validity, and reliability, respectively. These criteria and approaches are elaborated in Table 3 (7).

Table 3 illustrates how the four criteria are incorporated to the study design by using different approaches. The tests were conducted by the first author, the fifth author, and the last author.

FINDINGS

The findings of the analysis of the data are described in Table 4. The HPs were proactive about sharing their experiences with the intelligent bed. They believed their advice was considered carefully in the development of the intelligent bed, and they were happy about that. They expressed confidence in the intelligent bed, especially with regard to its future. We found that when HPs had questions about using the beds. They were able to get assistance immediately. This phenomenon encouraged the HPs and gradually improved the learning atmosphere internally.

The individual health situations of the patients varied. The HPs stated that by using bed functions such as the moisture detector, they were able to identify a pattern of incontinence for some patients, which allowed them to implement shorter or fewer visits while still meeting patients' needs. It improved the quality of care and prevented the patients from lying in a wet bed for an extended period of time. We have found that in some cases, the health situation of the patients worsened rapidly over time, which called for continuous reflection and adaption of the beds' functions to meet the patients' changing needs.

Functions like the user voice call provided an additional way to communicate with the HPs, other than landlines or mobile phones. It was also much easier for the patients to press the button for this function than to dial an HP's phone number. This benefit was especially significant for patients who were disabled. Because this function facilitated communication, we observed more frequent dialogue between the patients and the HPs, which had a positive effect on quality of care, improving their interpersonal relationships.

The applications of the intelligent bed reduced the number of unnecessary visits by homecare staff, and this was planned in the work schedule before implementation. Unnecessary visits frustrate HPs and increase their workload overall. We observed

Table 3. Tests of Validity and Reliability

Criterion	Approach	Description
Construct validity	-Review of the study design. -Multiple sources of evidence.	Are the data collection techniques operational and reliable for the topics being explored?
Internal validity	-Designing and testing rival explanations with participants. -Continuous reflections with researchers and participants. -Pattern matching. -Explanation building. -Participant observation. -Use of triangulation of data collection techniques: study documentary materials, participant observation, qualitative interviews, and focus group interviews. -Log book.	The research contains inference when there is a phenomenon is unable to be observed directly. Hereby, the question is about whether the rival opinions have been discussed and considered thoroughly.
External validity	-Application of the theoretical framework (learning theory).	This establishes the domain into which the results of the study can be generalized. The external validity problem has led to concerns about the transferability of qualitative research methods, especially if only a single study is carried out. By using a theoretical framework, one can rely on analytical generalisation.
Reliability	-Design of the study. -Log book.	The question is whether the data collection methods are repeatable and produce the same results. The goal of ensuring reliability is to minimise errors and biases. It is critical that the design of the study is beyond the initial design phase. Discussions on this criterion were implemented throughout the data collection process and data analysis.

this in the testing district, after the HPs became more familiar with the functions of the intelligent bed. The HPs were able to be aware of the living pattern of the patients, for instance, the time of changing the catheter urine bag can be estimated by the HPs. They gradually adjusted their work routines during ongoing discussions on how to integrate the advantages of the bed into the schedule throughout the implementation process.

Some patients preferred not to be disturbed at night, or had a healthy spouse who preferred more privacy. We were told by the HPs that some of the patients turned off the bed at night. In this case, the bed would not perform any of its electronic functions.

DISCUSSION

The aim of this sub-study of the iCare project has been to explore how HPs experience and use the intelligent bed in patients' homes. A review of the literature has shown that this is the first study to report on how HPs experience the implementation of the intelligent bed.

One theme identified in the analysis was the transformation of the HPs from passive technology recipients into active innovators involved in the development of the intelligent bed. The study did not identify any barriers to using the new technology in the HPs' performance of clinical tasks and collaboration with the elderly (16–18). The fact that the concept of the intelligent bed is being developed through a user-driven innovation process may also have had an effect on the HPs and other stakeholders, facilitating a learning process in the homecare service organization.

Patient health status and need for care can change rapidly, and the bed's functions may not always suit their needs. This indicates that the design of the intelligent bed must be standard-based with a module design perspective (19). The applications can then be made more flexible and responsive to patients' needs. Some studies advocate this strategy, but within a larger system, such as the smart home (20;21). We have not identified any study with such a finding that examines the intelligent bed technology described here.

Following the implementation of the intelligent bed, the workflows of the HPs were redesigned. This demonstrates the potential of this technology for the current healthcare delivery system. The HPs stated that the intelligent bed helped to reduce unnecessary visits, saving travel time to patients who do not need assistance (22;23).

Unlike in other studies, the HPs we interviewed did not believe that their patients were subject to any stress due to being monitored (24;25). However, the HPs pointed out that the

Table 4. Impact of the Intelligent Bed on the HPs' Work

Themes	Sub-themes	Examples
HP transformation from passive technology recipient to innovator (14 of 23 HPs)	-Feeling engaged in the development of the intelligent bed -More open and trusting in relation to the new technology -Improved learning atmosphere inside the organisation	-"I have never been able to come up with new ideas for development of new technologies in the healthcare sector . . . " -"The managers listen to our ideas and are open towards our ideas" -"We've had it (conversations on the intelligent bed) in team meetings and we've had it at the group (level) and we have had it individually, so we actually talked very, very much about this bed . . . "
Individualised care (23 of 23 HPs)	-Identify individual living patterns -Improved quality of care -Protect both patients and HPs from potential injuries -Match the patients with appropriate technology -Feeling of security on the part of patients	-"Well, if I can see that every day when the bell is 9 and when it is 12, so, there will be a wet sensor alarm, . . . , or just call and say hey, you must remember that you have to go to the toilet now." -"If we take the bed lamp, it is super good for when we do our work so that we have a proper light." -"I see clearly it can be a huge advantage for the care that they need and (prevents me from) getting a work injury." -" . . . it would indeed be nice that the option is there for the citizens who really need (it)." -"It was also good for everyone to feel safe on it? [interviewer] Very much. [Respondent]"
Work flow redesign (12 of 23 HPs)	-Functions of the beds make workflows simpler and more automated -Functions of the beds save time for the HPs	-" . . . We can redesign our workflows and get benefits from the technology . . . " -" . . . so we will not and (sic.) run more unnecessary (visits) than necessary . . . "
Sensor technology intruding on patient privacy (5 of 23 HPs)	-The moisture sensor technology often signals the HPs when the linen has absorbed a little moisture and HPs change the linen	-"The moisture sensor is very sensitive and alerts us as caregivers and that way we check the patient more often at night and some patients feel intruded (on)"

patients themselves found that bed functions like the moisture detector intruded on their privacy. Some patients, especially those with a spouse nearby, preferred not to be disturbed, especially at night. This feedback reminded us to consider the social context when patients have relatives living in close proximity.

One limitation of this study is that the intelligent bed was tested on a small scale and over a short period of time. If more beds had been tested for a longer period of time, more robust effects would have been identified. Second, only one HP in the test was male; gender differences might affect the results.

CONCLUSION

Health professionals involved in the introduction of the intelligent bed experienced a transformation from passive technology recipients to innovator. All health professionals who used the intelligent bed were able to provide more individualized care for their elderly clients. It is suggested that functions of the intelligent bed can result in the redesign of workflows and time savings for the health professionals in providing care of the elderly patients. The staffs found that the new technology intruded on the privacy of some patients. Future research is needed to test the intelligent bed in a large-scale clinical context to identify its economic and organizational effects.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

REFERENCES

1. Yonezawa Y, Miyamoto Y, Maki H, et al. A new intelligent bed care system for hospital and home patients. *Biomed Instrum Technol.* 2005;39:313-319.
2. Jung JW, Do JH, Kim YM, et al. *Advanced robotic residence for the elderly/the handicapped: Realization and user evaluation*. ICORR 2005: 9th International Conference on Rehabilitation Robotics; 28 June-1 July 5, 2005; Chicago, IL: IEEE; 2005:492–495.
3. Gaddam A, Kaur K, Gupta GS, Mukhopadhyay SC. *Determination of sleep quality of inhabitant in a smart home using an intelligent bed sensing system*. I2MTC 2010: Instrumentation and Measurement Technology Conference; May 3–6, 2010; Austin, TX: IEEE; 2010:1613-1617.
4. Hatler C. How intelligent are smart beds? *Nurs Manage.* 2008;39:20-26.
5. Kidholm K, Ekeland AG, Jensen LK, et al. A model for assessment of telemedicine applications: Mast. *Int J Technol Assess Health Care.* 2012;28:44-51.
6. Argyris C, Schon DA. *Organizational learning II: Theory, method, and practice*. Reading, MA: FT Press; 1995.
7. Yin RK. *Case study research: Design and methods*, 5th ed. Los Angeles: SAGE Publications; 2013.
8. Denzin NK, Lincoln YS. *The SAGE handbook of qualitative research*, 4th ed. New York: SAGE Publications; 2011.
9. Golafshani N. Understanding reliability and validity in qualitative research. *Qual Rep.* 2003;8:9.

10. Ritchie J, Lewis J, Nicholls CM. *Qualitative research practice: A guide for social science students and researchers*, 2nd ed. New York: SAGE Publications; 2013.
11. Kawulich BB. Participant observation as a data collection method. *Forum Qual Soc Res.* 2005;6:Art.43.
12. Patton MQ. *Qualitative research & evaluation methods: Integrating theory and practice, 4th ed.* Los Angeles: SAGE Publications; 2014.
13. Brinkmann S, Kvale S. *InterViews: Learning the craft of qualitative research interviewing*, 3rd ed. Los Angeles: SAGE Publications; 2014.
14. Ratcliff D. Qualitative data analysis and the transforming moment. *Transformation.* 2008;25:116-133.
15. Thomas DR. A general inductive approach for analyzing qualitative evaluation data. *Am J Eval.* 2006;27:237-246.
16. Dinesen B, Toft E. Telehomecare challenge collaboration among healthcare professionals. *Wireless Pers Commun.* 2009;51:711-724.
17. Loh PK, Flicker L, Horner B. Attitudes toward information and communication technology (ICT) in residential aged care in Western Australia. *J Am Med Dir Assoc.* 2009;10:408-413.
18. Lee S, Martinez G, Ma GX, et al. Barriers to health care access in 13 Asian American communities. *Am J Health Behav*. 2010;34:21-30.
19. Martinez I, Escayola J, Trigo JD, et al. Recent innovative advances in telemedicine: Standard-based designs for personal health. *Int J Biomed Eng Technol.* 2011;5:175-194.
20. Sixsmith AJ. An evaluation of an intelligent home monitoring system. *J Telemed Telecare.* 2000;6:63-72.
21. Pietrzak E, Cotea C, Pullman S. Does smart home technology prevent falls in community-dwelling older adults: A literature review. *Inform Prim Care.* 2014;21:105-112.
22. Blozik E, Wildeisen IE, Fueglistaler P, von Overbeck J. Telemedicine can help to ensure that patients receive timely medical care. *J Telemed Telecare.* 2012;18:119-121.
23. Casey M, Hayes PS, Heaney D, et al. Implementing transnational telemedicine solutions: A connected health project in rural and remote areas of six Northern Periphery countries. *Eur J Gen Pract.* 2013;19:52-58.
24. Boise L, Wild K, Mattek N, et al. Willingness of older adults to share data and privacy concerns after exposure to unobtrusive in-home monitoring. *Gerontechnology.* 2013;11:428-435.
25. Courtney KL. Privacy and senior willingness to adopt smart home information technology in residential care facilities. *Methods Inf Med.* 2008;47:76-81.