Nurses Acceptance of Automated Medication Dispensing Cabinets

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Abstract. The use of automated dispensing cabinets (ADCs) to enhance medication processes in hospitals has been increasing recently. Studies evaluated the effects of this technology on patient safety, workflow efficiency and cost reduction. To evaluate factors affecting nurses' attitudes and acceptance of using ADCs, an online survey, including seven categories with closed-ended questions and one open-ended question, was developed based on technology acceptance model and instruments used in previous studies. Response rate was 29.4% of 1,062 nurses at King Faisal Specialist Hospital and Research Centre, Jeddah, Saudi Arabia. Perceived usefulness, perceived ease of use, perceived usefulness to enhance control systems and training have positive effects on improving nurses' attitudes and increasing acceptance of using ADCs. Perceived risks had negative effects. The qualitative analysis of the open-ended responses supported these results and helped to identify many areas for improvement, especially in addressing perceived risks associated with the use of this technology.

Keywords. Acceptance, Automated Dispensing Cabinets, Hospitals, Nurses.

1. Introduction

Technology and automation in pharmacy practice are increasingly used to improve patient safety, enhance workflow efficiency and reduce healthcare costs [1]. The medication processes in hospital settings consist of three main phases; ordering, dispensing, and administration. One of the automation technologies that are widely used is the automated dispensing cabinets (ADCs) [2]. Based on a survey by the American Society of Health System Pharmacists; 97% of hospitals in USA are using ADCs [3]. In the UK, there has been a rapid adoption of pharmacy automation solutions over the past 15 years [4]. This was motivated by an audit commission report recommending the use of automation technology to reduce medication dispensing errors [5]. However, the adoption of this technology is still limited worldwide due to the high costs, where an ADCs implementation in a medium to a large hospital would cost over one million US dollars [1]. ADCs consist of drawers that contain secured storage compartments, each is used for a single type of medications. Access to the cabinets is computer controlled through finger prints or passwords. Restocking of medications is controlled by bar code technology which prevents errors in the

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replenishment process [6]. Nurses are the main healthcare professionals who use the ADCs daily and hence they have a key role in improving medications safety [7]. Despite the high costs and intensive work needed to implement ADCs, benefits could be limited because of the negative effects associated with lack of staff acceptance and compliance with the new workflow. The attitudes of healthcare staff towards technology are important factors in determining their acceptance and efficient use [8]. Successful implementation of health technology depends not only on designing or purchasing good quality applications, but mainly on the factors that lead end users to accept this technology [9]. In December 2013, King Faisal Specialist Hospital and Research Centre, Jeddah, Saudi Arabia (KFSHRC) started a project to install 31 ADCs in all inpatient wards. The project was completed in June 2014. This research aims at identifying critical factors that affect nurses' acceptance and attitude towards the implementation of ADCs at KFSHRC. The main objective of this research is to support the successful implementation of ADCs at this tertiary healthcare organization.

2. Methods

This study followed mixed methods approach and was initially based on two theoretical backgrounds. The Technology Acceptance Model (TAM); determining the factors that affect users' acceptance of information technology [10], and the Added Variables approach; adding more external variables to the original TAM, where the additional variables should be developed in the context of healthcare IT and specific systems evaluated [9]. A questionnaire was adapted from two previous studies discussing the attitude of nurses and their acceptance of e-prescriptions and automated medication storage and distribution systems [11,12]. The survey contained seven categories of closed-ended questions and one open-ended question. The constructs adapted include Perceived Usefulness (PU), Perceived Ease of Use (PEU), Perceived Usefulness to enhance Control systems (PUC), Training (T), Perceived Risks (PR), Experience Level (EL), Attitude toward using (A). Demographic questions included gender, age group, hospital unit, job role, and self-rated computer knowledge, and an introduction page with information on the study was included. The questionnaire was developed using Survey Monkey (www.surveymonkey.com) and was evaluated by three staff members, holding master degrees in health informatics. As part of a master's degree in health informatics, by the first author, at the University of Sheffield, UK, and implemented at KFSHRC, the research was approved on ethics background by both the University of Sheffield and KFSHRC. The study sample included all 1,062 hospital nurses who have access to ADCs and received the survey link via email. During the survey period of two months, seven reminders were sent to nurses in addition to one email to each head nurse to encourage nurses to participate in the survey. Data was analyzed using simple linear regression analysis in SPSS software. Thematic content analysis of the responses to the open-ended question using coding down technique.

3. Results

We received 312 valid responses from 27 nursing sections with a response rate of 29.4%. Despite that the number of responses was large, the response rate is still considered low, mainly due to the busy nature of nurses' work. Most respondents were

in the (30-39) age group (39.7%) and with Staff Nurse I job role (88.5%). Most of the respondents rated their computer knowledge as very good (46.5%). Level of experience with the use of electronic health records (EHRs) and ADCs was generally low. Most respondents reported less than five years of experience in both areas. Questions reliability was tested using the Cronbach's alpha coefficient, which showed acceptable levels for all the seven categories of questions. Correlation and consistency of variation between items in each construct was further tested using principal component analysis. The quantitative analysis showed, with a P<0.001, that Perceived Ease of Use is a significant predictor of Perceived Usefulness and Attitude toward using ADCs. Perceived Usefulness is a significant predictor of Attitude toward using ADCs. Perceived Usefulness to enhance Control systems is a significant predictor of Perceived Usefulness and Attitude toward using ADCs. Perceived Risks is a significant predictor of Perceived Usefulness and Perceived Ease of Use. Training is a significant predictor of Perceived Usefulness and Perceived Ease of Use. On the other hand, with a P >=0.05, Experience Level with EHRs is neither a significant predictor of Perceived Usefulness nor Perceived Ease of Use. The Experience Level with ADCs is also neither a significant predictor of Perceived Usefulness nor Perceived Ease of Use.

A total of 144 open-ended responses were received, answering the question "In your opinion what are the advantages and disadvantages associated with the use of ADCs?". Analysis showed that 28 responses were positive, 42 were negative, 66 were mixed, and 8 were invalid. Under Perceived Usefulness; ADCs helped saving time (n=33), enhanced patient safety (n=14), improved medications availability (n=11), increased efficiency (n=5), had some usefulness in emergency cases (n=5) and helped organizing work (n=3). On the other hand, some medications were unavailable (n=20), they were time consuming (n=13), and one respondent thought ADCs are not useful (n=1). Under Perceived Ease of Use; ADCs were easy to use (n=25), convenient (n=7), accurate (n=5), reliable (n=3), and user friendly (n=1). One respondent reported ADCs added more work restrictions (n=1). Under Perceived Usefulness to enhance Control systems; ADCs enhanced medication error control (n=26), improved inventory control (n=7), and improved control of narcotic medications (n=7). On the other hand, some respondents reported that ADCs lead to poor inventory control (n=4), and poor control over narcotic medications (n=4). Under Training category; only one negative response was identified which described training as inadequate. Under Perceived Risks; using ADCs is not suitable in emergency cases (n=33), had frequent hardware failures (n=22), frequent system failure (n=19), delayed urgent medication orders (n=16), delayed medications restocking (n=1), showed problems in storing liquid narcotic medications (n=1), medications restock errors (n=1), poor computer knowledge (n=1), system errors (n=1), and that the number of ADC machines in the unit is not enough (n=1).

4. Discussion and Conclusion

In agreement with other recently published research, nurses' acceptance of the use of ADCs is one of the main factors that lead to successful implementation of this technology in healthcare institutions [13,14]. Our research aimed to identify the factors that drive nurses' acceptance towards ADCs use and the factors that prevent this acceptance. The findings showed that perceived usefulness, perceived ease of use, perceived usefulness to enhance control systems and training were all positively affecting nurses' attitudes and acceptance of using ADCs. The findings also showed

that perceived risks are negatively affecting nurses' acceptance of ADCs use. Perceived usefulness is the most influencing factor on nurses' attitudes towards ADCs use and training is the most influencing factor on perceived usefulness. This indicates that healthcare management and ADCs implementation teams should focus on the usefulness and the benefits of this technology in the training programs in order to maximize nurses' acceptance and to ensure smooth and successful implementation. Perceived risks associated with the use of ADCs is a major factor that prevents nurses' acceptance of this technology. Hospital management and implementation teams should engage nurses in all phases of the implementation plan, get their feedback as end users on the perceived risks and work with them in order to mitigate the effects of these risks on their work and on patients' care. This research helped in identifying some of the perceived risks that were reported in the survey. The researchers and the implementation team at KFSHRC will work with nursing management and end users to find appropriate solutions to the reported issues. This research was done based on TAM theory. The findings showed the validity of this theory in predicting factors that affect nurses' attitudes and acceptance of using ADCs. However, additional variables were added to the original theory variables in order to create a model that can fit with the research setting specifically and healthcare IT context in general.

References

[1] W.N. Kelly, Pharmacy: what it is and how it works. Routledge (2018).

[2] C. Chapuis, M. Roustit, G. Bal, C. Schwebel, P. Pansu, S. David-Tchouda, J.L. Bosson, Automated drug dispensing system reduces medication errors in an intensive care setting, *Critical care medicine* **38** (12) (2010), 2275-2281.

[3] C.A. Pedersen, P.J. Schneider, D.J. Scheckelhoff, ASHP national survey of pharmacy practice in hospital settings: dispensing and administration—2014, *American Journal of Health-System Pharmacy* **72** (13) (2015), 1119-1137.

[4] S. Goundrey-Smith, Information Technology in Pharmacy: An Integrated Approach. Springer Science & Business Media (2012).

[5] Audit Commission for Local Authorities in England and Wales, A spoonful of sugar: medicines management in NHS hospitals, Audit Commission for Local Authorities in England and Wales (2001).

[6] M. Stephens, Hospital pharmacy. Pharmaceutical Press (2011).

[7] M. Mandrack, M.R. Cohen, J. Featherling, L. Gellner, K. Judd, P. C. Kienle T. Vanderveen, Nursing best practices using automated dispensing cabinets: nurses' key role in improving medication safety, *Medsurg Nursing* **21** (3) (2012), 134-141.

[8] R. Ward, C. Stevens, P. Brentnall, J. Briddon, The attitudes of health care staff to information technology: a comprehensive review of the research literature, *Health Information & Libraries Journal* **25** (2) (2008), 81-97.

[9] R.J. Holden, B.T. Karsh, The technology acceptance model: its past and its future in health care, *Journal of biomedical informatics* **43** (1) (2010), 159-172.

[10] F.D. Davis, Perceived usefulness, perceived ease of use, and user acceptance of information technology, *MIS quarterly* (1989) 319-340.

[11] T. Escobar-Rodríguez, P. Monge-Lozano, M.M. Romero-Alonso, Acceptance of e-prescriptions and automated medication-management systems in hospitals: An extension of the technology acceptance model, *Journal of Information Systems* **26** (1) (2012), 77-96.

[12] T. Escobar-Rodriguez & M.M. Romero-alonso, Modeling nurses' attitude toward using automated unit-based medication storage and distribution systems: an extension of the technology acceptance model, *CIN: Computers, Informatics, Nursing* **31** (5) (2013), 235-243.

[13] M. Zaidan, F. Rustom, N. Kassem, S. Al Yafei, L. Peters & M.I.M. Ibrahim, Nurses' perceptions of and satisfaction with the use of automated dispensing cabinets at the Heart and Cancer Centers in Qatar: a cross-sectional study. BMC nursing, **15** (1) (2016), 4.

[14] M. Marefat, Inventory improvement and optimization of pharmacy Automated Dispensing Cabinet (ADC) (2018).