Evaluation of tablet computers: quality assurance and effectiveness of the medication process?

Amanda BUUS\textsuperscript{a}, Louise NYVANG\textsuperscript{a}, Sisse HEIDEN\textsuperscript{a} & Louise Pape-HAUGAARD\textsuperscript{a}

\textsuperscript{a}Department of Health Science and Technology, Aalborg University, Aalborg, Denmark

Abstract

Medication errors during admission to hospitals pose a significant problem, as substantial health repercussions and financial costs can be ascribed to these incidents. Most of the severe clinical errors are related to dispensation and administration. The problems are increased by cost savings and staff reductions, which characterise the current health care system. The objective of this study is to evaluate whether implementation of tablet computers has potential to enhance the quality assurance and efficiency of the medication dispensing and administration phases. The study is based on a combination of participant observation, structured workshop and qualitative interviews. Most data is collected in a Danish hospital ward. The study concludes that the technology is not yet mature for implementation and there is a continually need for redesigning the technology. However, the results also indicate that the technology has the potential towards improving patient safety in the dispensing and administration phases due to right patient, drug, dose and time. Additionally, the technology appears to have the potential to streamline work flow in the administration phase due to an improved barcode registration mechanism. However, the potential of a successful implementation depends on prior working routines in the individual hospital ward.

Keywords: medical informatics, handheld computer, health information technology, bar code medication, quality assurance, hospital efficiency

1. Introduction

Patient safety is a major concern in health care practice. Medication errors during admission to hospitals are a significant problem in this regard and demands attention to quality assurance in the medication process\textsuperscript{1} \cite{1-7}. Although errors are identified in all phases of the process \cite{8-11}, most of the severe clinical errors are related to dispensation and administration \cite{12}. Apart from increased morbidity and mortality, substantial financial costs can be ascribed to these incidents \cite{5, 13-17}.

Multiple factors can compromise medication safety. Among these are disruptions during the medication preparation, a high workload and an increased patient/health professional ratio \cite{18-21}. These factors are enhanced by cost savings and personnel reductions, which characterise the current health care system \cite{22-25}. To accommodate these developments, the use of information and communication technologies in the health care sector has become widespread in several countries. Barcode medication systems, such as handheld computers, have been incorporated into the medication process to improve patient safety and to increase effectiveness. \cite{26-29}. Several studies suggest that these technologies decrease the number of medication errors in the dispensing and administration phases \cite{30, 30-32}. However, some of the technologies such as the personal digital assistants (PDA) have only been used to a limited

\textsuperscript{1} The medication process includes prescription, transcription, dispensing and administration.
extent and have not been able to gain full acceptance. [33-37].

The latest development in handheld technologies is the use of tablet computers, which has been predicted to accommodate the problems related to previous handheld technologies [34]. A tablet computer is a mobile device larger than a PDA or mobile phone integrated into a touch screen without a physical keyboard [38].

The objective of this study is to evaluate the usefulness of the tablet computer in the dispensing and administration phases and to investigate whether it has the ability to:

- Increase the quality assurance of the clinical practice?
- Improve efficiency during the medication process?

2. Research Methodology

The methodological approach used in this study is data triangulation. Three data collection techniques are included to explore the area of investigation and gain a profound understanding of its complexity. These are: 1) participant observation, 2) structured workshop approach and 3) qualitative interviews. The specific data collections derived from the techniques and the objectives are presented in figure 1.

![Figure 1: Shows the use of the three data collection techniques and their objectives.](image-url)
2.1. Design

Most data, collected in the present study, investigates the medication process in a Danish neurological hospital ward.

Participant observation:

Two neurological nurses were observed during medication dispensing and administration in two consecutive days. A semi-structured approach was used to explore the existing work procedures and processes. The observation procedure was based on four pre-selected focus areas defined by an observation guide: 1) work patterns, 2) health professionals, 3) dispensing and 4) administration. In this way our focus was concentrated on specific areas of interest, and still new phenomena could emerge. Field notes were recorded, and interviews of informal character, between the observers and nurses, allowed for clarification of the observations. [39]

Structured workshop approach:

The participants represented a heterogeneous group of health professionals with the objective to clarify issues from different views and interest groups. Participants were informed on the workshop’s objectives both prior through written information and later through oral information. Themes and questions were prepared in advance with inspiration from Edward de Bono’s “six thinking hats”. The aim was to provide a means for groups to think together more effectively, and to plan thinking processes in a detailed and cohesive way to facilitate different perspectives in the discussion (figure 1). [40]

The workshop was held in a conference room at the hospital and ran for two hours. Initially a specific hardware and software were demonstrated, and data were gained from the following semi-structured discussions regarding these products. The hardware in use was a Samsung Galaxy Tab GT-P1000, measuring 19.09 x 12.45 x 1.20 cm. The software consisted of a medication application under development, which communicates with the medication section of the electronic patient record system (EPR) and an online medicine database. Functionality is currently limited to the administration phase but could be expanded to include the dispensing phase [41].

Qualitative interviews:

Qualitative interviews were conducted with health care professionals and experts.

Health care professionals:

A nurse and a nurse manager were individually interviewed using a semi-structured interview guide. Open ended questions were prepared to facilitate emergence of new phenomena and to allow the interviewees to answer from their own frame of reference [42]. The objective was to validate statements from the workshop and participant observation. Among these statements we wanted to explore the usability, work procedures and patient related aspects.

Experts:

A semi-structured interview was conducted to gain insight into implementation and integration of technologies in the medication process. The interviewee was chosen as he has extensive knowledge in the organisation, management and design of technology in the health care system. [35]

To gain understanding of the technical issues, a structured interview with a system developer was conducted. The software provider has been involved in the development of the medication application and has insight within the use of health care technologies. The structured approach allowed
for specific questions to be answered due to technical issues. [41, 42]

3. Results

3.1. The user perspective

One of the objectives was to identify possibilities and limitations in relation to the technology from a user perspective. This is considered important if the technology is to be implemented successfully into the health care unit [43].

According to the interviewees, a number of technical needs must be met before the technology is able to increase the effectiveness and quality assurance. The findings are summarized in table 1.

<table>
<thead>
<tr>
<th>Element</th>
<th>User needs</th>
<th>Does the technology appear to meet the user needs?</th>
</tr>
</thead>
</table>
| Bar code registration        | - Easily accessible.  
- Fast response.                                                                 | - The photo recognition proved too slow and required plenty of light to detect the bar codes. [44, 45]  
- Barcodes may be less readable due to wear [36]. |
| User interface               | - Comfortable size; It must fit into the pocket and should be easy to operate.  
- An easily accessible and uncluttered screen.                                                                 | A contradiction between the request for a small and transportable device and a large user friendly display:  
- It is easily manageable and fits into uniform pockets.  
- The screen is too small for an overview of the complete medical chart and for daily use in the dispensing phase compared to a regular laptop. [44, 45] |
| Battery and recharging       | - Extended battery life in comparison with the laptop.  
- Battery recharging should be adjusted to the work patterns.                                                                 | - Battery life is expected to last through an entire day  
- Unknown how long the battery will last when used by clinicians.  
- Has a rapid recharging mechanism.                                                                 |
| Wireless network             | - Fast and reliable network coverage.                                                                 | - Currently unknown how the tablet computer and the wireless network will cooperate. [41]  
- Previously use of handheld computers has shown limitations. [35] |
| Environmental adaption       | - Must be able to accommodate conditions in clinical practice.                                                                 | - The smooth surface is seen as a benefit from a hygienic perspective. [44, 45]  
- Unknown if the technology can tolerate steam (bath situations) and unintended impacts. [41] |
| Software content             | - Useful and logical composition.  
- Clear structure in relation to the tasks it is to be used in.  
- Must contain at least the same functions as the currently used technology.                                                                 | - Lacks compatibility with existing software, which shows laboratory results, nursing record and medical records.  
- Does not contain the same features as the current technology.                                                                 |

Table 1: Features requested of the tablet technology compared to the current user experiences and other findings.
3.2. Workflow and work routines

According to the interviewees, there is a request to release resources from the medication process for other patient related tasks [44, 45]. The intention with this section is to elucidate whether the tablet computer is capable of streamlining parts of the medication process compared to the existing technology and work routines.

The case ward use a computer on wheels (COW), a laptop placed on a trolley, when dispensing and administrating medication. Nurses move between patients and back and forth between patient rooms and the medication room. This routine is considered an impractical mobile solution due to the following reasons: 1) the technology is considered a hassle to move around 2) the nurse cannot leave the COW unattended in case of interruptions due to security issues 3) It is considered difficult and time consuming switching between patients in the computers medication system.

We found that the current mobile device sometimes limits the nurse’s mobility. In response, nurses may initiate workarounds to compensate and leave the COW in the medication room [44, 45]. Therefore, the technology can not directly be considered a technology that supports the term “the clinician on-the-go” [46].

According to the interviewees the tablet computer could have the potential to be less time consuming in the administration phase compared to the existing technology [44, 45]. The expectation is that the personnel will get easy access to patients in the medication system, if the bar code mechanism can be used to register the patient’s wristband [44, 45]. In regard to interruptions, the tablet computer is considered a more user-friendly solution because the tablet computer fits into the uniform pockets. The technology can be stored in a pocket during interruptions and thereby make for a more flexible solution compared to a COW. This does not take into account the medicine, which is also carried along during rounds and still demands attention. [44, 45]

The barcode registration system can be used in the dispensing phase for automatic registration of the medication packaging so the staff does not have to manually enter medicine information for each patient. This is considered impractical and less safe because of the small screen size and a decreased overview. A fixed barcode scanner linked to a laptop is considered more user friendly at this step in the medication process [44, 45].

The advantages of the tablet computer can only be achieved if the personnel are willing to adapt to the technology. According to the interviewees, there may be different opinions towards the technology. Some of the health care personnel are expected to find the technology innovative, while others are inclined to work against an implementation because they are sceptic about the usability, find it pointless or are uncomfortable around new technologies. [44, 45] Additionally, lack of training may be a reason for nurses’ reluctance to use new technologies [47, 48]. Therefore, a successful implementation must be preceded by a thorough user introduction as well as leadership support [35, 44, 45]. The leader has a significant role in fostering positive change among the personnel. Lack of leadership support is an essential factor in the reason the PDA has failed to be successfully integrated in clinical practice [35, 48]. These perspectives need to be considered before, under and after an implementation to avoid conflicts in the staff group [44, 45].

3.3. The patient perspective

According to the interviewees the technology has the potential to increase the information given to the patients assuming the
technology is developed to communicate with laboratory results, nursing record and medical record. The mobility and content of the technology will allow the personnel to inform and readily answer questions the patients might have [44, 45].

If the technology must be prioritised economically in the hospital ward, it is a decisive argument that it increases patient safety. According to the data collection and literature new tablet computers have the potential to increase patient safety in several areas [30-32, 34]. These are presented in table 2.

<table>
<thead>
<tr>
<th>Area</th>
<th>The potential of the tablet computer to increase patient safety</th>
</tr>
</thead>
</table>
| **Right drug and dose** [dispensing] | Registration of medicine packaging barcodes is related to an extended security routine:  
  - Visual registration is now combined with an electronic registration of the medication.  
  - Studies show that the incidence of medication errors can be reduced by using bar code technology in dispensing [30, 31]. However, there is a limitation: tablets and mixture cannot be scanned directly. [44, 45] |
| **Right patient** [administration] | The barcode registration system can be used for patient identification through the barcode on the patient’s wristband:  
  - Especially beneficial when patients cannot say their own name and personal identification number.  
  - Double protection of patient identification if combined with existing routine [asking the patient]. [44, 45] |
| **Right time** [administration] | The technology as a mobile solution enables healthcare professionals to make a real-time confirmation of the administration:  
  - Increases the certainty that patients do not get a double dose of medication and a comfortable interval between administrations in the course of the day [44].  
  - The integrated alarm might increase safety compared to patients in need of medication more than four times a day so it is given as prescribed.  
  - Can easily look up pro P.n.2 medication at bedside [44, 45] |

Table 2: The areas in which, the tablet computer has the potential to increase patient safety.

---

2 *P.n.* refers to "Pro necessitate": medication is to be given as needed.
An important part of patient safety is associated with the protection of patients’ personal data including name, personal identification number and medical data. There is scepticism about security features of the tablet computer in this area. It is hard to conclude whether the scepticism is entitled but there seems to be different solutions to increase security before implementing the technology: 1) A personal login is a necessity to use the hospitals’ systems 2) data will be encrypted 3) a security manager can be used to lock the device if it has been idle for a while and 4) a app-center can be installed in order to avoid that the user changes some important settings that can compromise safety. [41, 49]

Studies indicate that technology is not exclusively associated with higher quality since there is a risk that new types of errors can occur. Problems have been associated to the current use of handheld computers in the medication process [35, 36, 50]. These errors can be related to “workarounds” when personnel find technology difficult and time consuming. This may be due to technical issues. [36, 47, 50]

Another risk is associated with possible ethical dilemmas. First, there appears to be a potential risk that bar code registration of patient wristbands could objectify the patient. This could be aggravated if the function does not work immediately. Second, there is a risk associated with the use of the technology, if important patient related tasks and communication related aspects are “forgotten” or downgraded in the interaction with the patient. If the technology receives too much focus, it possible can impact the contact with the patient. It follows from these reflections that the personnel must think about their use of the technology to sustain a beneficial interaction with the patient. [44, 45]

4. Discussion

The research set out to evaluate whether it is advantageous to implement tablet computers into the dispensing and administration phases of the medication process.

4.1. User needs

We found that the health care professionals have positive expectations towards the integration of tablet computers as an aid in the medication process [44, 45]. However, our findings also suggest that the technology is still in need of several improvements before an implementation [41, 44, 45]. The limitations and disadvantage of the technology were identified in a setting outside the hospital ward and may be worse when adapted into real work settings [36, 41, 44]. Thus, future research is considered necessary to evaluate the usability of the technology in its intended work settings. The importance of this perspective is enhanced by the fact that other handheld barcode technologies have been related to different problems, which has complicated an implementation [35, 36, 50].

We found that the staff emphasis to get access to information at the patient’s bedside. There was a request for the tablet computer to include more functionality and serve a more diversified use by making it compatible with the existing electronic patient record system (EPR) [45]. In this regard, our findings suggest that the new technology must contain at least the same possibilities and functions as the current technology to meet the staff’s requirements [45]. New innovation and developments, using tablet computers, are emerging. These initiatives are related to increased accessibility to the EPR-system, which enhances the staff’s admission to patient data [51].
Furthermore, the tablet computer is predicted to have a better future compared to previous handheld computers due to increased battery life and improved user interface [34, 51, 52].

Clinical work is characterised by a complex mixture of routine and unexpected events and involves close collaboration among staff [43, 53]. Our findings suggest that if the technology could include multi functionalities, it would be able to facilitate the cooperation between the staff members and strengthen “the clinician on-the-go” [45]. The tablet computer is mobile and has the ability to enable information exchange between staff members on different locations. In addition, there is a contradiction between the request for a small and transportable device and a large display [44, 45]. The tablet computer should be pocket sized and lightweight combined with the largest screen possible. Because of the restricted screen size, it is necessary to prioritise which data should be accessible on the device [44, 45]. Objections were raised that the prototype demonstrated in our study did not include a complete overview of the medical chart [44]. This could provoke different safety issues and decrease the efficiency of different working procedures. For instance, it could decrease the recognition of erroneous prescriptions and it is a risk that the elimination of different sections could result in a less functional product compared to the existing technology [44, 45]. These considerations are essential when deciding if technology should be implemented into the medication process.

4.2 Workflow and work routines

Our results show that the current work procedures, involving a COW, are seen as cumbersome, but there is still broad consensus that it enhances the quality of patient care [44, 45]. Due to cost savings and a high work load in the healthcare system there is a request to redistribute resources from the medication process to other patient related tasks. [24, 45] This could prove significant since a substantial proportion of nurses’ work consists of medication related tasks [54-56]. It can be discussed whether the tablet computer will be able to streamline workflows in clinical practice since adapting similar new information systems to health care has proven difficult and rates of use have been limited [43, 53, 57]. Our findings suggest the tablet computer has not yet proved to accommodate these previous difficulties entirely. However, if the technical difficulties are solved, the tablet computer is viewed as a method to improve the patient safety and efficiency, especially in the administration phase [44, 45]. Other health professionals, in contrary, have associated the use of handheld computers in medication routines as more time consuming than traditional medication administration [58]. Though, there are only few studies, which make a direct comparison between traditional and barcode administrations systems and it is problematic to generalise these onto Danish conditions [55, 56]. A thorough time recording study, before and after an implementation, could be relevant to conclude whether the tablet computer is capable of streamlining the work procedures. Though, this perspective has to be seen in relation to current working procedures in the individual unit. Some personnel will consider the technology time consuming and think of it as a hassle compared with existing work routines while others will find it innovative and helpful [44, 45, 47, 58].

We found that the tablet computer was viewed as less beneficial in regard to streamlining the work routines in the dispensing phase compared to the administration phase [44, 45]. These issues can be
seen from different perspectives. The current work procedures, according to the interviewees, seem fluent and unproblematic in the dispensing phase. In addition, an external scanner connected to a larger screen could be a better solution to get a more user-friendly overview of the medication in the EPR-system. Second, the current work procedures in the administration phase seem cumbersome and there is a need for efficiency improvement in this area. [44, 45]

4.3 Quality assurance

Quality assurance is considered to be closely related to patient safety and satisfaction during admission. The question is whether tablet computer can support the nurses’ practice and accommodate patient safety and patient needs.

Patients should have the assurance that their treatment will proceed correctly and safely so they have the best chance possible of achieving the desired outcome [44, 45]. Nurses have been educated to practice “the five rights”\(^3\) in the medication process, which is a basic international standard for medication patient safety [44, 59]. The question is whether the tablet computer is able to support these routines and procedures in regard to medication safety.

We found that tablet computer is viewed to enhance quality assurance in different areas of “the five rights”. In the dispensing phase, the technology has the potential to prevent potential medication errors through verifying right drug and right dose, assuming the technology is accessible to register barcodes at medicine packaging. Additionally, the technology has the opportunity to secure patient safety through verifying right patient and right time through registration of the patient’s wristband. [30, 44, 45] Still, new technologies should be introduced with care because they may result in new types of errors [36, 60]. It appears that limitations related to the technology could disrupt the work flow and lead to frustration among the staff [44, 45]. This raises our concerns that technology would possibly promote unsafe use of the technology. It has been demonstrated that some users deviate from the written protocols and instructions and make use of workarounds if the technology shows to be inefficient [36]. In this way unauthorized use could give rise to new kind of errors in the medication process contradicting with the original purpose of enhancing patient safety. It is particularly important that the technology fulfils the users’ requirements because health care providers will be dependent on the technology of their daily tasks [44]. If the technology results in increased time spend during dispensing and administration, the consequence will unambiguously result in time lost from other important patient related tasks, which can result in impaired patient outcome [61, 62]. These perspectives must be taken into consideration before implementation, especially due to the fact that high work load and cost savings characterise the modern health care system [24]. Nurses’ medication related tasks require high levels of mobility [43]. Thus, in developing handheld devises, considerations should be given to those who will be using the system, and the nature and location of their clinical tasks [53].

We found that the technology is viewed to be able to provide advantages for patients because of a potential to improve patient involvement [44, 45]. This is considered central since several studies indicate that patients do not feel sufficiently involved in their own care and treatment which may lead to confusion, anxiety and insecurity [63, 64]. Though, the usability of this po-

\(^3\)“The five rights”: Right patient, right drug, right dose, right route and right time.
potential is only considered relevant if the patient is open to the information given. This is viewed as a limitation if patients are in a bad condition or are incapable of perceiving the information. Some of the patients in the neurological ward are in bad physical and mental condition and may not be open to such information. Still, our opinion is that increased patient involvement could be advantageous to many patients both in neurological settings and in other hospital wards, maybe especially to chronically ill patients [44, 45]. This is substantiated by the facts that more and more patients seem to have an increased need for information [65]. Another considerable aspect is the relatives’ need for information. This could possibly be met, if the technology can be used as a communication tool.

Overall, it is necessary to focus on the patient related issues before, under and after an implementation to secure that the technology will contribute to quality assurance. It is considered relevant to evaluate the patients’ experiences and attitudes towards the technology both in regard to their perspectives on bar code registration and the impact of the technology in the interaction with the health care professionals.

4.4. The usability and generalisability of the study

The case study’s approach has allowed for different user perspectives to be identified and has facilitated an insight into the complexity of work procedures of the medication process [66, 67]. This has clarified aspects that might hinder or facilitate the user’s performance during dispensing and administration. Moreover it has helped us obtain an evaluation of the tablet technology in the view of the health care professionals and to gain the clinicians’ suggestions for future development.

One of the recurring discussions in relation to our study centres on the generalisability since most of our findings are limited to one ward. Both unique and typical characteristics can be singled out in hospital wards [23, 66-68]. This creates an assumption that parts of the results can be generalised given that some features are applicable to all or most health care units. [66]. A part of our data is expected to be generalised to other wards because they are all a part of the public health system and influenced by some general trends [7, 69]. Some other parts of the data are unique and influenced by local conditions which affects the tasks and may only occur at this specific ward [66, 67].

The technological conditions in this case ward are probably more evolved than in some other hospitals because they have a full integrated EPR-system and uses COWs in the dispensing and administration phases [44, 45]. If fully computerized patients records are in use, an increased demand for access to hardware devises are expected, which may have affected the results. [70]. Therefore, it is likely that studies in other hospital wards would have found other results. Furthermore, a specific hardware and software product was demonstrated in regard to simplifying the discussions, which may have influenced the results. Whether the results from this study can be applied to other hospital wards depends on the current practice of the specific ward, the electronic medication system and if they use a COW during administration, before implementation.

In conclusion, the technology is not yet mature for implementation and there seems to be a continually need for redesigning the technology to prevent new kinds of errors and adverse drug events.
However, the results of the study indicate that:

- The technology offers an opportunity to increase patient safety in the dispensing and administration phases due to right patient, drug, dose and time.
- The technology has the potential towards streamlining the work flow in the administration. Contrary, it was viewed as less beneficial in the dispensing phase compared to the existing technology.

- A successful implementation depends on prior working routines in the individual hospital ward and attitude among staff and leaders.

References

[23] Indenrigs- og Sundhedsministeriet. Sundhedsvæsenet i nationalt perspektiv [Internet]. Accessed 16/12, 2011.
[26] Computerworld. Styr på medicinen med PDA [Internet]. Accessed 14/12, 2011.
[34] Dagens Medicin. Nu skal Lægerne være rigtig mobile [Internet]. Accessed 19/11, 2011.
[40] De Bono, E, Médecin, I, Malta, GB, de Bono, E, de Bono, E, Arzt, E. Six thinking hats. Penguin books; 1990.
[41] Structured interview. System developer, it company [ekspert interview1]. 2011
[47] [Internet] Vol. 2, 2007 -
[57] Valdes I, Kibbe DC, Tolleson G, Kunik ME, Petersen LA. Barriers to prolifera-
[61] Clarke SP, Aiken LH. Failure to rescue: Needless deaths are prime examples of the need for more nurses at the bedside. AJN. 2003;103(1):42.
[64] Stewart MA. Effective physician-patient communication and health outcomes: A review. CMAJ. 1995;152(9):1423.
[70] Andersen P, Lindgaard AM, Prgomery M, Creswick N, Westbrook JL. Mobile and fixed computer use by doctors and nurses
on hospital wards: Multi-method study on the relationships between clinician role, clinical task, and device choice. Journal of medical Internet research. 2009;11(3).