Necessity for a new technology acceptance model to predict adoption of wireless technology in healthcare

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ABSTRACT

Adoption of new technologies is researched in Information Systems (IS) literature for the past two decades, starting with the adoption of desktop computer technology to the adoption of electronic commerce technology. Issues that have been researched comprise of how users ‘handle’ various options available in software environment, their perceived opinion, barriers and challenges to adopting a new technology, IS development procedures that are directly impacting any adoption including interface designs and elements of human issues. However, literature indicates that the models proposed in the IS literature such as Technology Acceptance Model (TAM) are not suitable to specific settings to predict adoption of technology. Studies in the past few years have strongly concluded that TAM is not suitable in healthcare setting because it doesn’t consider a myriad of factors influencing adoption technology adoption in healthcare. This paper discusses the problems in healthcare due to poor information systems development, factors that need to be considered while developing healthcare applications as these are complex and different from traditional MIS applications and derive a model that can be tested for adoption of new technology in healthcare settings. The contribution of this paper is in terms of building theory that is not available in the combined areas of Information Systems and healthcare.

Keywords: healthcare, Information Systems, adoption factors

INTRODUCTION

Medication errors are defined as any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is administered to a patient (Sparks et al., 2001). Prevention of medication errors has always been a high priority in healthcare due to the high cost involved in providing quality patient care (Simpson, 2003). Events that relate to prevention may be related to professional practice, healthcare products, procedures, and systems including prescribing, order communication, product labelling, packaging and use (Wisniki, 2002). In modern healthcare settings, Information and Communication Technology (ICT) is central to most of these functions. Technologies such as wireless are expected to reduce errors by capturing error free data at point of entry, thus resulting in the smart use of information (Hu et al., 2002).

Institute of Medicine (IOM) in the United States has recognised that frontier technologies such as wireless technology would improve access to information in order to achieve quality health care. A report released by the IOM in 2003 outlined a set of recommendations to improve patient safety and reduce errors using reporting systems that are based on Information Systems (IS). While it is widely accepted that IS assists health related outcomes, how this can be efficiently achieved is an under researched area. Therefore, conflicting outcomes are reported in healthcare studies as to the successful role of IS. In essence, research is needed to investigate the role, and perhaps the use of, frontier technologies in improving information management, communication, cost and access to improve quality healthcare (Oritz & Clancy, 2003).

In healthcare, specific issues relating to the failures of Information Management are being addressed using frontier technologies such as RF Tags and Wireless Handheld Devices (Oritz & Clancy, 2003). The main focus in using these technologies is to collect patient related information in an automated manner, at the point of entry, so as to reduce any manual procedures needed to capture data. While no other discipline relies more heavily on human interactions than health care, it is in healthcare that technology in the form of wireless devices has the means to increase – not
decrease – the benefits derived from the important function of human interaction. Essential to this is the acceptance of this wireless handheld technology as this technology enables to collect data at the point of entry, with minimal manual intervention, with a higher degree of accuracy and precision.

When it comes to the Management of Information Systems, development and implementation of a hospital Information System is different from traditional Information Systems due to the life critical environment in hospitals. Patient lives are dependent upon the information collected and managed in hospitals and hence smart use of information is crucial for many aspects of healthcare. Therefore, any investigation conducted should be multi-dimensional and should cover many aspects beyond technical feasibility and functionality dictated by traditional systems. Successful implementation of health information systems includes addressing clinical processes that are efficient (Simpson, 2003), effective, manageable and well integrated with other systems (Yampel & Eskenazi, 2001). While traditional Information Systems address issues of integration with other systems (Tyndale, 2002), this is more so important in hospital systems because of the profound impact these systems have on short and long term care of patients (Smith & Andrews, 2001). Reasons for failure in Information Systems developed for healthcare include lack of attention paid to the social and professional cultures of healthcare professionals (Goh, 2001), underestimation of complex clinical routines (Sausser, 2003), dissonance between various stakeholders of health information (Freeman, 2003), long implementation time cycles (Dyer, 2003), reluctance to support projects financially once they are delivered (Rozwell et al., 2002) and failures to learn from past mistakes (Wiebusch, 2002). Therefore, any new technologies should address these reasons in order to be accepted in the healthcare setting.

UNSUITABILITY OF CURRENT TECHNOLOGY ACCEPTANCE MODELS TO HEALTHCARE

The acceptance of new technologies has long been an area of inquiry in the MIS literature. The acceptance of personal computer applications, telemedicine, e-mail, workstations, and the WWW are some examples of technologies that have been investigated in the MIS literature. User technology acceptance is a critical success factor for IT adoption and many studies have predicted this using Technology Acceptance Model (TAM), to some extent, accurately by means of a host of factors categorised into characteristics of the individuals, characteristics of the technology and the characteristics of the organizational context. Technology Acceptance Model (Davis, 1985), specifically measures the determinants of computer usage in terms of perceived usefulness and perceived ease of use. While perceived usefulness has emerged as a consistently important attitude formation, studies have found that perceived ease of use has been inconsistent and of less significant. The literature suggests that a plausible explanation for this could be the continued prolonged users’ exposure to technology leading to their familiarity, and hence the ease in using the system. Therefore users could have interpreted the perceived ease of use as ‘insignificant’ while determining their intention to use a technology. The strengths of TAM lies in the fact that it has been tested in IS with various sample sizes and characteristics. Results of these tests suggest that it is capable of providing adequate explanation as well predicting user acceptance of IT. Strong support can be found for the Technology Acceptance Model (TAM) to be robust in predicting user acceptance.

Other models that are dominant in the IS area include Roger’s Diffusion of Innovation (Rogers, 1995) and Kwon and Zmud’s Diffusion/Implementation (Kwon & Zmud, 1987). However, Saga and Zmud (Saga & Zmud, 1994), after reviewing over twenty empirical studies using these models asserted that TAM is the most influential model in predicting the acceptance of technology. Common to almost all previous studies that used TAM is the setting in which the model was tested. In dominant cases, the model was tested in desktop environments using a word processing application or an email application; the model was tested in IT specific settings; and the model was tested with diverse user populations where users were categorised as end users with limited
computing exposure. Many studies in IS found that the model was operationally appealing; and the model provided support for overall explanatory power (Davies et al., 1989).

However, some studies criticise TAM for its examination of the model validity with students who have limited computing exposure, administrative and clerical staff, who do not use all IT functions found in software applications. Studies also indicate that the applicability of TAM to specific disciplines such as medicine is not yet fully established (Hu et al., 1999). Further, the validity and reliability of the TAM in certain professional context such as medicine and law is questioned. Only limited information is found in the healthcare related literature as to the suitability of TAM. Therefore, it appears that the model is not fully tested with various other professionals in their own professional contexts.

Therefore, it can be argued that, when it comes to emerging technology such as wireless handheld devices, TAM may not be sufficient to predict the acceptance of technology because the context becomes quite different. It should be noted that the current context in healthcare related Information Systems is not only the physical environment but also the ICT environment as wireless technology is markedly different from Desktop technology. A major notable change is the way in which information is accessed using wireless technology as the information is pushed to the users as opposed to users pulling the information from desktop computers. In the Desktop technology, users have the freedom to choose what they want to access and the usage behaviour is dependent upon their choice. On the other hand, using wireless devices, it is possible for the information – whether needed or not – to reach these devices. This ‘reach’ can be unstructured as many intermediary applications could be used and users may need to have specialised tools such as Email Response Management Systems (ERMS) to realise a comfortable working context. Users using wireless devices may have a range of preferences to the applications and hence the application environment may not be uniform, as found in the desktop technology. While the applications have become somewhat ‘generic’ in desktop technology (examples are word processing, spreadsheet etc), and in some cases dictated by various service providers such as Microsoft, the application and the environment is dictated by telecommunication service providers in the wireless technology environment. This is because of the cost involved in accessing the information facilitated by the technology. Therefore, users may have limited say in the manner in which information is pushed on to them. In essence, if the information is not controlled in a smart way, cannot be used smarty.

Another notable distinction in a wireless handheld environment is the choice of devices that users carry. While in the Desktop Environment, the weight, size and other features affecting the hardware components of the device are not of significant importance (to users) because the hardware is mounted on a desk top, in a wireless handheld environment these factors matter as users carry these devices in their pockets. Any marginal increase in size and weight might have profound implications on long term usage of these devices. For example, a British study of 2001 found that children using Mobile telephone equipped with ‘thumb pad’ developed deformity on their hands. Therefore, when it comes to handheld devices, weight, size, display screen size, input facilities and other hardware elements associated with user operations become crucial as users need to ‘hold’ these devices for any operations conducted for Information Management.

In the domain of healthcare where wireless handheld devices are used, the issues of size and weight assume significant importance because of the setting in which these devices are used. For example, in an operation theatre patient lives assume importance and information needs must reflect this. If wireless handheld devices don’t support data management that are closely linked with clinical procedures due to device restrictions such as screen size and memory, despite their attractions, users would discard these devices. Therefore, applications developed onto these devices must address complex clinical procedures that can be supported by these devices.

Another major consideration in the domain of wireless technology is the ‘connectivity’. While this is assumed to be always available in a wired network environment, this can not be guaranteed in a
wireless technology due to mobility the network connectivity. As users carry the device and ‘roam’, the signal strength may change from strong to weak and this may interrupt user operations. Therefore, to accomplish smart information management, certain technical aspects must also be addressed.

Current users of wireless technology are concerned with their security and privacy aspects associated in using this technology. This is because they need to reveal their identity in order to receive information. While the privacy is concerned with the information that they provide to others, security threats fall under the categories of physical threat and data threat. Due to the infancy stages and hardware restrictions, handheld devices are not able to implement these features to the expected level on the devices as found in desktop computers. In a healthcare setting, any leak in the privacy issues would have potential adverse impact on the stakeholders. Further, due to other devices that may be using radio frequency or infra-red frequency in providing healthcare to patients, there may be practical implementation restrictions in the usage of wireless devices for ICT.

Our own experience in providing wireless technology solutions to a private healthcare in Western Australia yielded mixed responses. The wireless technology developed and implemented for the Emergency Department was successful in terms of software development and deployment. The Australian Computer Society commended this project for the innovative category in 2002. The project was well ‘accepted’ by the users in the healthcare. However, the wireless solution provided to address problems encountered in the Operation Theatre Management System was not well received by the users, despite the superiority in design, functionality and connectivity. Users were reluctant to use the application due to the hardware and database connectivity restrictions, despite scoring a high level of opinion on acceptance for usefulness and ease of use.

Now, let us assume that TAM is correct in claiming that ‘the intention to use a particular system is a very important factor in determining whether users will actually use it’. Let us also assume that the wireless systems developed for the private healthcare provider in Western Australia exhibited that there were clear intentions to use the system. However, despite a positive affect on perceived usefulness and perceived ease of use, the wireless system was not accepted by users. It should be noted that the new system mimicked the current traditional system, and yet did not yield any interest in terms of user behaviours. While searching for reasons for this ‘hard to explain’ phenomena, supporting evidence for this unexplained behavioural intention was found in Hu et al. (1999), who argued, after studying TAM, that perceived usefulness should also include near-term and long-term usefulness in order to study behavioural intentions. Further evidence was found in Thompson et al., who suggested that facilitating conditions and prior experience are also crucial to the behavioural intentions of using a system and hence these two should also be included while examining intentions to using a system. Other studies that have examined the utilisation of the Internet Technology have also supported Thompson et al.’s view. This has given us a feeling that TAM may not be sufficient to predict the acceptance of wireless technology in specific healthcare setting.

This has prompted further review of healthcare literature. A brief review of prior studies in healthcare indicated that a number of issues associated with the lack of acceptance of wireless handheld devices are highlighted but not researched to the full extent that they warrant. For example, drawbacks of these devices in healthcare included perceived fear for new learning by doctors, time investment needed for such learning, cost involved in setting up the wireless networks and the cost implications associated with the integration of existing systems with the new wireless system (Wisnicki, 2002). A vast majority of these studies concur that wireless handheld devices would be able to provide solutions to the Information Management problems encountered by healthcare. While these studies unanimously agree that the information management would be smarter using wireless technology and handheld devices, they seldom provided details of those factors that enabled the acceptance of wireless technology specific to healthcare setting. MIS journals appear to be lagging behind in this area.
Therefore, it is safe to assume that current models that predict the acceptance of technology based on behavioural intentions are insufficient. This necessitates a radically new model in order to predict the acceptance of wireless handheld technology in specific professional settings.

**INGREDIENTS FOR A NEW MODEL TO PREDICT ACCEPTANCE OF NEW TECHNOLOGY**

Some of the previous models measured actual use through the intention to use and input to these models are perceived usefulness, perceived ease of use, attitude, subjective norm, perceived behavioural control, near term use, short term use, experience, facilitating conditions and so on. In recent years, factors that impacting technology acceptance included job relevance, output quality and result demonstrability. In the field of electronic commerce and mobile commerce, factors such as security and trust are considered as factors of adoption of these technologies. In end user computing, factors such as user friendliness and maintainability appear to be influencing the applications. Therefore, any new model to determine the acceptance of wireless technology would include some of the above factors.

In addition to these, when it comes to wireless technology, any acceptance factors should hinge on two dominant concepts – hardware (or device) and applications that run on the hardware – as the battle continues to accommodate more applications on a device that is diminishing in size, but improving in power. Further, mobile telephones and PDA’s, appear to be accepted based on their attractiveness, hardware design, type of key pad that they provide, screen colour and resolution, ability to be carried around etc. In effect, the hardware component appears to be an equally dominant factor in the adoption of wireless technology.

Once the hardware and software applications are accepted, the third dominant factor in the acceptance of wireless technology appears to be the ‘telecommunication’ factor. This factor involves various services provided by telecommunication companies, the cost involved in such services, the type of connectivity, roaming facilities, ability to access the Internet, provision for Short Messaging Services (SMS), ability to play games using the mobile devices etc. These factors are common to both mobile telephones and emerging PDA’s. Some common features that the user would like to see appear to be alarming services, calendar, scheduler, ability to access digital messages – both text and voice etc.

Therefore, studies that investigate the adoption of wireless technology should aim to categorise factors based on hardware, applications and telecommunication as these appear to be the building blocks of any adoption of this technology. Specific factors for applications, perhaps, could involve portability across various hardware, reliability of code, performance, ease of use, module cohesion across different common applications, clarity of code etc. In terms of hardware, the size of the device, memory size, key pad, resolution of screen, various voice tones, portability, attractiveness, brand names such as Nokia, capability such as alarms, etc. would be some of the factors of adoption or acceptance. In terms of service provision, plan types, costs, access, free time zones, SMS provision, cost for local calls, cost to access the Internet, provision to share information stored between devices etc. appear to be dominant factors. Factors such as security etc form a common theme as all the three dominant categories need to ensure this factor.

Factors mentioned above are crucial to determine the development aspects of Wireless Information Systems (WIS) for healthcare as these factors dictate the development methodology, choice of software language, user interface design etc. Further, the factors of adoption in conjunction with methodology would determine the integration aspects such as coupling the new system with existing systems. This would then determine the implementation plans. In essence, an initial model that can determine the acceptance of wireless technology in healthcare can be portrayed as follows:
Diagram 1: Proposed Model for Technology Adoption in Healthcare Settings

In the above model, the three boxes in dark borders show the relationship between various factors that influence the acceptance of technology. The box on the left indicates various factors influencing wireless technology in any given setting. The three categories of factors – hardware, software, and telecommunication – affect the way in which wireless technology is implemented. The factors portrayed in the box are generic and their role to specific healthcare settings varies depending upon the level of implementation. Once the technology is implemented, it is expected to be used. In healthcare settings, it appears that usage, relevance, and need are the three most important influencing factors for the continual usage of new technology. Following the terminology used by Davies et al. (1989), we call these as mapping factors, as these mappings influence adoption of technology in healthcare settings. When the correct balance is established, users exhibit positive perceptions about using a new technology such as wireless handheld devices for data management purposes. This, in turn, brings out positive attitude towards using the system, both short and long-term usage. The positive usage would then determine the intentions to use, resulting in usage behavior. The usage behavior then determines the factors that influence the adoption of new technology in a given setting. This is shown by the arrow that flows from right to left.

Based on the propositions made in the earlier paragraphs, it is suggested that any testing done to predict the acceptance of new technology in healthcare should test the following hypotheses:

1. **Hardware factors have a direct effect on the development, integration, and implementation of wireless technology in healthcare for data management**
2. **Software factors have a direct effect on the development, integration, and implementation of wireless technology in healthcare for data management**
3. **Telecommunication factors have a direct effect on the development, integration, and implementation of wireless technology in healthcare for data management**
4. **Factors influencing wireless technology in healthcare setting have direct positive effect on usage, relevance, and need**
5. **User perception of new technology is directly affected by usage, relevance, and need**
6. **User perception of new technology has a direct effect on user attitude in using such technology**
7. User attitude has a direct effect on intentions to use a new technology
8. Usage behaviour is determined by intentions to use a new technology

**RESEARCH METHODOLOGY THAT CAN BE APPLIED TO TEST THE MODEL**

Any methodology to test the model should be designed to capture a cross-sectional snapshot and a dynamic longitudinal picture of the acceptance of wireless applications in healthcare. The data should be collected from healthcare staff involved in patient care about their perceived opinion of adoption and usage behaviour of using current technologies. In TAM and other models used in MIS, this is done with students as surrogates for convenience. If one is keen to predict the acceptance of technology, then data should emerge from people using the technology in their settings. Suitable healthcare organisations where wireless technologies are used should be considered for data collection as this would achieve the intended purposes.

Inference from the literature reveals that this is an under explored area which demands an investigation into the role of technology and that of human context in using the technology. Although prior studies indicate that a quantitative approach would suffice, recent studies recommend that a combined approach (mixed methodology) of qualitative and quantitative methods will provide strength to the research outcome. Experienced researchers indicate that there is a need to include qualitative approach to study the human social and psychological factors (Remenyi et al., 1998). Moreover, any study undertaken to investigate the suitability of the proposed model should investigate factors influencing the adoption of new technology in a specific healthcare setting. Factors identified for this may be limited and needed to be expanded further to accommodate other unknown factors that effect the adoption of wireless technology in a given setting. Hence inclusion of qualitative approach such as interview method would strengthen the research outcome.

In summary, it is recommended that a qualitative-quantitative interactive continuum model be employed as suggested by Zikmund (994) and Remenyi et al. (1998). Further, it is also suggested that a qualitative method such as semi-structured in depth-interviews be employed to gain sufficient understanding on the topic from healthcare professionals using wireless technology. These interviews may help to identify any unknown factors that affect the adoption of wireless technology.

Subsequent to the qualitative study, it is suggested that quantitative methods such as survey/questionnaire can be employed to collect data. The quantitative study would elicit open-ended responses to obtain factors that are not constrained by a pre-determined identification of constructs found in traditional surveys, as well as to determine the importance of the pre-determined factors. The nature of the quantitative study would then be determined by the pilot study (exploratory study), which may demand specific approach to research issues. Employing positivist philosophical approach and combine both qualitative and quantitative methods would precisely determine the factors influencing the adoption of new technologies in healthcare. Given that any initial study conducted would be exploratory in nature, these two techniques are essential.

**INSTRUMENTS**

The instruments typically would constitute two broad categories of questions. The first category of questions would be related to the adoption and usage of wireless applications in healthcare for data collection purposes. The second category would consist of demographic variables, as these variables determine the granularity of the setting. Open ended questions can be included in the instrument to obtain unbiased and non-leading information. Prior to administrating the questions, a complete peer review and a pilot study are insisted in order to ascertain the validity of the instrument. A two stage approach can be used in administrating the instrument, where the first stage would gather information about the key factors influencing user’s decisions to use wireless applications and the second stage on the importance of those key factors. This approach would complement the open ended questions so as to determine the importance of the individual factors determining the adoption and usage of wireless devices and applications.
DATA COLLECTION

In order to perform validity and reliability tests, a minimum of 250 samples are required. Any study to test the model should consider the randomness of the samples to avoid any collective bias. Similarly, about 50 samples may be required to undergo the interview process, with each interview to last for 60 minutes. This method has been employed by many studies (Remenyi et al., 1998; Zikmund, 1994).

Any instruments developed for testing the model should be able to elicit responses of 'how' and 'why'. This is essential in order to discern differences between adoption and usage decision of wireless handheld applications. In addition, comparing responses to the question about adoption and questions about use would provide evidence that respondents were reporting their adoption drivers and not simply their current behaviour.

The interview questions should be be semi structured or partially structured to guide the research. There are variations in qualitative interviewing techniques such as informal, standardized and guided. Structured interviews and partially structured interviews can be subjected to validity checks similar to those done in quantitative studies. Samples could be asked about their usage of wireless devices including mobile telephones and other hospital systems during the initial stages of the interview. They could be interviewed further so as to identify factors that would lead to the continual usage of these devices and any emerging challenges that they foresee such as training. The interviews can be recorded on a digital recording system with provision to convert automatically to a PC to avoid any transcription errors. This approach would also minimize transcription time and cost. The interview questions should be developed in such as way that both determinants and challenge factors could be identified. This then increases or enhances the research results, which is free of errors or bias. Also validity tests should be done on interview methods to avoid or overcome the criticism often laid out in conducting pilot/exploratory studies as stated by Zikmund (1994) as being informal, lacking rigor and precision.

DATA ANALYSIS

Data should be coded by two individuals into a computer file prior to analysis and a file comparator technique should be used to resolve any data entry errors. A coding scheme should also be developed based on the instrument developed. The coders should be given sufficient instructions on the codes, anticipated responses and any other detail needed to conduct the data entry. Coders should also be given a start-list that will include definitions from prior research for the categories of the construct. Some of the categories would include utilitarian outcomes such as applications for personal use and barriers such as cost and knowledge.

Data should be analyzed using statistical software applications using both quantitative and qualitative analyses. Initially a descriptive analysis needs to be conducted, including a frequency breakdown. This should then be followed by a detailed cross sectional analysis of the determinants of behaviour. A factor analysis should also be conducted to identify factors of adoption. Once this is completed, tests for significance can be performed between various factors.

CONCLUSION

We argued in this paper that there is a necessity for a new model to accurately predict the adoption of new technologies in specific healthcare setting because current models available in the Information Systems domain are yet to fulfil this need. Based on our experience and available literature, we identified some initial factors that can influence and determine acceptance of technology. We also proposed a theoretical model that can be tested using these initial factors. In order to be complete, we suggested a proposed methodology for testing the model.

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