Role of Wireless Handheld Technology by Nurses in Healthcare Environment

Abdul Hafeez-Baig and Raj Gururajan

Faculty of Business and Law, School of Information System, University of Southern Queensland, QLD 4350, Australia

Abstract: One of the emerging technologies is wireless handheld technology. Implication of these devices is enormous for business community and healthcare domain is not an exception to this phenomena. This research paper provides some useful findings about the use of PDA's in the healthcare environment through actual usage of PDA in the healthcare ward. A qualitative and quantitative approach is adopted to explore these phenomena due to the exploratory nature of the research. Findings of this study identify some of the motivators and issues associated with the wireless handheld technology in healthcare environment. Furthermore, it is also found that these wireless handheld devices can help to improve the quality of care through better decision making processes. This study is limited to only one sate of Australian and further research is needed to see the implication of the findings to wider community and other domains in the Australian environment.

Key words: Smart technology, ICT (information and communication technology), wireless handheld devices, healthcare, adoption and actual use, decision.

1. Introduction

Over the last three decades, investment in Information and Communication Technology (ICT) has had dynamic effects on various industries including healthcare. This has resulted in increased productivity, higher quality of services and development of new processes. However, the healthcare industry has not enjoyed all these benefits as it has always operated with limited resources. Recently, the stakeholders of healthcare have become aware of the potential of ICT and realised an opportunity to address some of the problems the healthcare sector is facing. It has been suggested that ICT has the potential to address issues such as reducing costs, errors and shortages of human resources; and improving funding, quality of care and satisfaction levels among customers and employees [1-4].

Previous studies have clearly demonstrated that technological solutions alone will not solve the problems encountered in healthcare. For example, access to basic services is more critical than just reducing costs by automating or deploying some technology [5]. Here, "access" can be defined as access to basic medical information at an affordable cost. Authors of Ref. [6] conclude that deploying the latest technology alone will not solve the problems of the healthcare industry; it is important also to understand the adoption phenomena of a technology.

An example of ICT in healthcare would involve a hospital patient issued with electronically readable code, and hospital staff using wireless devices that can enter critical information directly into the hospital's data network. Through wireless devices, the patient's body could be connected to various hospital devices or equipment to record medical data such as blood pressure and heart function. These could be directly monitored, recorded and analysed by doctors located within the hospital or externally. Through wireless

---

Raj Gururajan, research field: signal processing.

Corresponding author: Abdul Hafeez-Baig, research fields: telecommunications, radio spectrum management, cognitive radio, signal processing. E-mail: abdul.hafeez-baig@usq.edu.au.

networks, doctors could order tests, prescribe medicines, and request other services generated directly from the bedside of the patient.

2. Literature Review

The healthcare industry has predicted that the development of ICT technologies, especially PDAs and smart phones, will have significant potential on its professionals to realise significant advantages. This is aptly reflected in the recent infrastructure investment and other technological developments in the healthcare environment [7]. The last three decades of investment in information and communication technology have had dynamic effects on various industries including healthcare. Such an investment has resulted in increased productivity, high quality of services and development of new processes. However, the healthcare industry has not enjoyed all these benefits as the industry has always been concerned with the risk associated with new technological developments. Recently, the stakeholders of healthcare have realised the potential of ICT and have seen a window of opportunity to address certain issues the healthcare sector is currently facing. It is suggested that ICT, through PDAs, has the potential to address issues such as quality of care, reduction in cost, shortages of human resources, reduction in errors, reduction in funding, and high satisfaction levels among customers and employees [7].

For example, a patient registering in a hospital may be issued with an electronically readable code and staff with wireless devices can enter critical information directly into the hospital network. Through wireless devices, a patient's body can be connected to various hospital devices or equipment to record medical data, such as blood pressure. Furthermore, other procedures such as the heart function can be directly monitored, recorded, and analysed by doctors internally and externally. Through wireless networks, healthcare professionals can order clinical tests, prescribe medicines, and request other services directly from the

patient's bed [8- 9].

Among various other technologies, the use of wireless technologies is emerging rapidly in the Australian healthcare sector. Now the race is on to automate or redesign the clinical processes and increase the efficiency, productivity, quality of care, and to meet future challenges of the Australian healthcare sector. As it can be implemented quickly and relatively cheaply, wireless networking infrastructure can play an integral role within Australian healthcare. However, wireless technology in general can be used to automate processes, reduce paperwork, reduce duplicate processes, produce timely and up to date information, and standardise information. Wireless technology can also be used to support new and innovative processes and services in the primary, secondary, public, and private healthcare sector [10-11].

Authors of Ref. [12] have suggested that in the future, healthcare delivery will clearly be predicated on two factors: the provision of an infrastructure based on ICT, and the availability of healthcare and other professionals who are able to utilise such infrastructure in order that healthcare be delivered in the best possible way.

Ref. [13] discusses the implications of wireless technology to the healthcare industry and argues that it would improve patient care, make it more personalised, and provide analytical information to the medical practitioner that would allow for better decision making. Wireless healthcare systems can increase productivity and reduce costs, thus providing benefits for physicians, patients, healthcare professionals and insurance providers. It also identifies factors like learning processes, device acceptability, control and the changing roles of doctors as potential difficulties in the adoption of this technology.

Ref. [14] studies the implications of the Graphical User Interface (GUI) technology on healthcare, with respect to wireless devices. The developments in GUI tools reduce not only timelines for the adoption of new applications but also overall costs and have positive

implications for insurers and government agencies. These authors identify that resistance to the adoption of existing GUI and existing limitations of the wireless devices for healthcare applications are the main barriers to the adoption of wireless devices in the healthcare industry.

Ref. [15] identifies that features such as screen size, memory, slow data transfer rates, lack of single connectivity and storage capabilities can have a limiting effect on the use of wireless devices. The view of the author of Ref. [15] is that the use of wireless devices would improve workflow and efficiency in professional healthcare settings. Alexander [16] argues that current paper-based processes are costly and time consuming. He suggests that a transformation from paper-based systems to electronic systems would allow evidence-based healthcare data to be integrated with clinical and research data collected at the point of care.

The wireless technology, such as tablet PC or smart handheld PDA's in the existing ICT environment appears to be radically different from the 'desktop environment' domain for the following reasons:

- Mobility and wireless connectivity;
- Security and ethical issues associated with mobility and location base information;
- Physical features of wireless handheld devices, such as screen size, weight, processing, security, and location base issues are few to mention hear;
- Connectivity and bandwidth of data transmission;
- Issues associated privacy and personal information associated with the mobility of these devices;
- Training and integration issues associated with these handheld devices and the existing procedures and processes in an healthcare environment;
- Life span of hardware's, such as battery life time, cost, ability to retrieve and input information some of the issues associated as with handheld devices for a healthcare environment.

Though the literature is evident that wireless handheld technology in the healthcare environment can

have serious implications, such as ability to reduce errors, cost reduction, high quality of services, efficiency and effectiveness of business processes are some of the benefits associated with these technologies for a healthcare setting. However, these wireless handheld devices have some serious issues for the healthcare environment, such as security, privacy, mobility, integrations, training, and physical features are few to mention. The literature demonstrates clearly that there are clear evidences that the health care industry can benefits from the instigations of smart devices and wireless handheld devices. However, there is a need for further research on a large scale to understand the implications of these ICT devices for the healthcare industry. Therefore, this research study will try to answer the following research question:

How do wireless handheld devices influence the decision-making aspects of nursing services in healthcare environment?

3. Research Methodology[1]

In order to extract opinions about technology in a specific domain such as healthcare, the choice of sample is crucial. This is because the opinions expressed by healthcare professionals should be unbiased and should pertain only to the technology and not the effects of the technology on their current workflow.

In this study, a mixed-mode methodology is adopted to address the above research question. A qualitative approach is adopted to understand the rich, complex, and idiosyncratic nature of human phenomena [17]. This method of research can include interviews, focus groups, and observations [17]. This research adopts the interview approach to collect initial data about the use of PDAs by nurses. Furthermore, the participants chosen are working in clinical wards. People in administrative roles are eliminated from this stage to avoid any unforeseen bias. While information systems

---

[1] Literature and methodology in the paper is similar to associated with the previous publications by the both authors in this domain.

research identifies a range of sampling techniques such as random and clustering, the sampling technique used for this study is 'purposive' sampling. As healthcare staff with special knowledge of technology is needed, this sampling technique is employed in this study. The samples are chosen through the local medical district on their advice as their opinions on wireless technology are extracted based on their knowledge. Therefore, the samples need to exhibit certain attributes that are related to technology adoption.

A quantitative approach can be used to measure the phenomena under investigation and the use of statistics to analyse the raw data to measure the effectiveness of PDAs in the healthcare environment [17]. This method of research uses questionnaires and laboratory experiments, and also statistical data gathered by organisations such as the ABS [17]. In this research study, a survey instrument is developed from the initial interview stage. The participants who participate in the trial are requested to fill in the survey instrument. The main reason for this approach is that previously tested instruments are found to be inadequate in the healthcare settings. The data from the interviews is used to develop a specific range of questions to gather a more detailed view from the wider population, such as the usefulness of wireless handheld devices in healthcare, participants' knowledge of wireless handheld technology, their views about error reduction and cost reduction, and the clinical efficiency as well as performance factors. This survey instrument (containing a 5 point Likert Scale) is pilot tested to capture the information reflecting the perceptions and practice of those adopting the wireless technology in the healthcare system, particularly focuses on what internal and external environmental factors shape the adoption of wireless and the extent of influence. This survey is then randomly distributed to healthcare professionals from the three different locations of the trial of the healthcare facilities. A cover letter explains the objectives and goals of the research. In order to improve the response rate, a telephone reminder is sent

two weeks after the initial date of survey distribution.

4. Discussions and Data Analysis

In this research study, the authors incorporate PDA's from more than one manufacturer, such as Nokia, HP, Samsung, Palm, i-mate, BlackBerry, HTC, and Motorola, to study the effects of physical characteristics of the PDA's in healthcare environment. Furthermore, all the hardware come with different operating systems as well, such as Windows CE, Android, Palm OS, and Symbian. This strategy is adopted to find the suitability of various operating systems in the healthcare environment. Numbers of applications trial in this research are limited to few software applications to reduce the complexity, as this is one of the finding from the earlier research. Researcher developed in-house specifically for this research projects a "Main Manu" application to facilitate the overall operation of the handheld devices in the healthcare environment. Other applications trial in this project includes local protocols, MIMS, medical calculator, medical dictionary, lab reference, and drug guide.

Qualitative data is collected through interview process during the trial period and revealed the following issues associated with the actual use of PDAs by nursing staff. Seventeen nurses and two Nursing Unit Managers (NUMs) participate in the study. These 17 nurses use the PDAs continuously for over 6 months. In addition to these, a post graduate student is also involved in the interview. The trial involves a total of 60 nursing staff but many of them use the PDAs on a trial basis and staff that do not use the PDAs continuously is excluded from data collection. Small test sample tests are performed on quantitative data.

In spite of all these drivers and inhibitors of the wireless handheld technology aspects mentioned in Table 1, the overall feedback and the motivation of the nursing staff towards the use of PDAs in the wards are positive. For example, they are keen to have the trial extended, and at one location, the trial is extended twice.

Table 1   Summary of drivers and inhibitors for PDA's use in healthcare environment by nurses.

	Drivers	Inhibitors
1	Time saving	Culture
2	Error reduction	Interpretations
3	Efficiently	Implementation
4	Quality of care	Existing infrastructure
5	Real time information	Physical features of the ICT devices
6	Client perception	Integration with existing processes
7	User perception	Security of data and information
8	Information on the move	Processing capacity
9	Better decision making	Flexibility and scalability
10	Ability to learn quickly	Integration of existing data
11	Better drug administration	Ability to adopt
12	Improved communication abilities	Lesser need for training
13	Patient management	
14	Ability to follow complex procedures	
15	Ability to follow healthcare policies and procedures	
16	Quick access to data and applications	

Nursing staff are very motivated and keen to see that the use of PDA's becomes part of their everyday work. The drivers and inhibitors identified by the staff at the healthcare facility is summarised in Table 1. This table clearly indicates that PDAs in healthcare for nurses have great potential and provide benefit into their daily workflow and routine activities.

Researcher also collects limited quantitative data from the nurses who are involved in the trial of the PDAs. The reliability of the instrument is measured through Cronbach's alpha and the value of 0.97 is achieved for all the 41 items in the instrument. However, the Cronbach's alpha based on standardised items is 0.962. According to Ref. [18], this value corresponds to high reliability of the instrument [19]. Once the reliability is ascertained, the survey items are further analysed to understand the usability and types of resources available on the PDAs that can be beneficial for the nurses. Fig. 1 shows that decision making by nurses is a critical part of day to day activities and the availability of accurate and timely information can help to improve the decision making
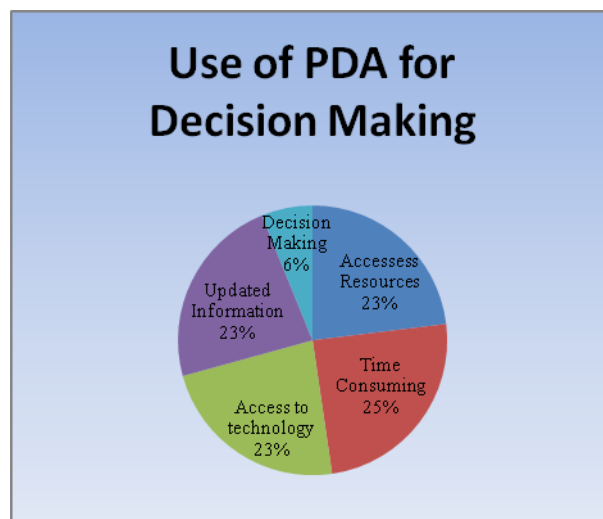
Fig. 1   Summary of decision making and associated contributors.

process. It appears that nurses rely on credible sources of information instead of relying on the experiences of colleagues for critical decision-making. It can be seen that the direct help in decision making is less than 6% of the overall processes. However, the processes of taking concrete decision is heavily contributed through availability of updated information (23%), access to technology (23%), ability to save time (25%), and accesses to various resources in a timely manner help to improve the overall decision making processes of providing care in a healthcare environment.

In any healthcare environment, the overall procedure of providing healthcare services to patients can be improved through the use of wireless handheld technology. For example, Fig. 2 shows that primary care could be improved (18%), ability to facilitate the training processes (22%), knowledge about various drugs (23%), ability to facilitate policies and procedures (23%), and ability to facilitate updating of procedures (14%) can be materialized about the procedures through the wireless handheld technology in a healthcare environment.

This research also helps to identify the some critical areas where wireless handheld technology can be effective in a healthcare environment. Fig. 3 shows that wireless handheld technology can be effective in the area of understanding the drugs compositions (25%),
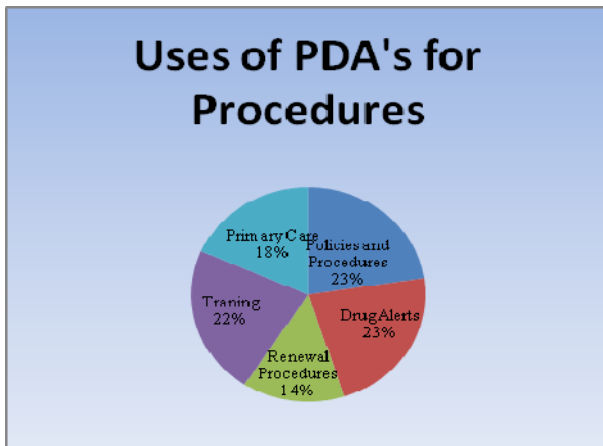
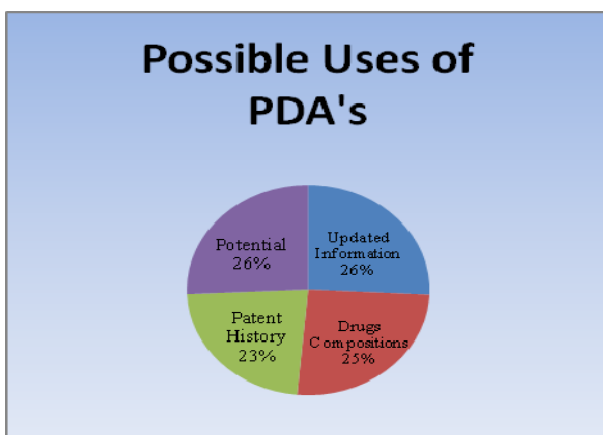**Fig. 2   Summary of procedures in healthcare and associated contributors.**

Fig. 3   Summary of possible uses and associated contributors.

ability to have updated live information on the move (26%), future scope of the wireless handheld technology in healthcare environment (26%), and ability to carry and interoperate patient historical history (23%).

The above shows that nurses are able to see the

benefits and potential uses of PDAs in healthcare facilities. For example, nurses are confident that PDAs can make a positive difference to the quality of care. Nurses are reluctant to use the PDAs for some specialised activities, as evidenced by the fact that PDAs can be useful for "Resuscitation Procedures". Almost all the nurses also agree that PDAs can provide evidence that technology is mature enough to provide benefit to the healthcare industry. Furthermore, correlation analysis is conducted among the PDAs' ability to facilitate decision-making, the resources and applications available on the PDAs, and the training required to use the PDAs, to investigate whether there is any underlying relationship among these variables (Table 2).

Correlation analysis between the variable Decision Making (DM) ability by nurses, PDA Resources (R), Training (T), and PDA Healthcare Applications (HA) shows there is a strong relationship between nurses' ability to make better decisions and the availability of healthcare applications through the PDAs. The correlation is statistically significant ($r = 0.8$, $p < 0.05$). The training seems not to be a big concern for the nurses in their ability to use PDAs for decision-making ($r = 0.24$, $p > 0.05$). Regression analysis also confirms this ($R2 = 0.513$, $t = 2.15$, $p = < 0.05$) [20]. However the coefficient of determination for the relationship of availability of appropriate live resources on the move through the use of wireless handheld technology in healthcare environment is 0.511. This means that 51.1% of the decision making variance is explained

Table 2   Correlation analysis among decision-making, PDAs' resources, training required, and PDAs' application.

Descriptions		Decision making	PDA resources	PDA training	PDA HC applications
Decision making	Pearson correlation	1	0.715**	0.244	0.593*
	Sig. (2-tailed)		0.001	0.345	0.012
PDA resources	Pearson correlation	0.715**	1	0.389	0.800**
	Sig. (2-tailed)	0.001		0.123	0.000
PDA training	Pearson correlation	0.244	0.389	1	0.682**
	Sig. (2-tailed)	0.345	0.123		0.003
PDA HC applications	Pearson correlation	0.593*	0.800**	0.682**	1
	Sig. (2-tailed)	0.012	0.000	0.003	

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

availability of the resources. Whereas the variance explained by training factor in the context of decision making is not significant and that is why variance explained is only 5.9%. On the other hand, availability of appropriate application is also significant, but the variances explain by this (35.1%) for the decision making through the wireless handheld technology in a healthcare environment.

This relationship is further explored through regression analysis conducted to the relationship between the decision making and the PDA resources, PDA training, and PDA applications identified through the analysis. Regression analysis is conducted by having Decision Making (DM) as dependent variable and Resources (R), Training (T), and Applications (A).

The liner regression analysis shows that a decision making process is supported by availability of resources, training needs, and availability of application. The correlation coefficient ($r = 0.72$) is significantly different from zero, $F(3, 13) = 4.68$, $P < 0.5$, and 40.1% of the variation in the decision making processing is explained by training, resources, and applications variables ($r2 = 0.52$ adjusted $r2 = 0.41$) [20-21].

The study indicates that nurse's feel that they are comfortable in using PDAs, and that PDAs will contribute to the quality of services offered by them to patients, especially in the processes of decision making while providing quality of care to patients. However, this depends on the availability of PDAs and access to other infrastructure, such as appropriate applications, resources through PDA's. In addition to this, the surveyed participants feel that relevant applications loaded onto the PDAs will help them to conduct their activities better in a ward.

During the qualitative stages, it is also learnt that nurses could save about 30 minutes of walking time per day by using PDAs in the ward. This saving is realised by referring to various reference manuals loaded onto the PDAs. Assuming that nurses walk about 5 miles per shift, this is a great saving. This saving can also be converted into other productive activities.

A main aspect that has been highlighted in this study through the data analysis is that data properly accessed by the nurses through the PDAs would help to offer better services and yet show productivity gains. Another aspect stated is the need to develop home-grown applications that are suitable for Australian healthcare. Nurses surveyed and interviewed believe that applications developed in foreign countries may not comply with the Australian regulations and hence may not be suitable for their work place. This is an important lesson because making investments in procuring applications that may not be suitable to nurses in their wards would prove to be a waste.

5. Conclusions

This study is a preliminary attempt to understand Australian healthcare professionals and their views about the use of wireless handheld devices in a healthcare environment. A mixed-mode methodology is adopted, and a qualitative study provided an insight into understanding the views and opinions of Queensland nurses. A quantitative study is developed from the findings of the qualitative study. In this research, qualitative and quantitative techniques adopted to collect data compliment each other. This study clearly identifies the added value provided by wireless handheld technology for Queensland nurses, such as saving time, improved quality of care, help in decision making, and the availability of up to date information. Another finding of this study is that healthcare professionals have been concerned about the instigations of the existing infrastructure and the specific policies and procedures adopted by the Australian healthcare regulatory bodies and their implications.

6. Future Study and Limitations

It is understood that this is the first study of this kind, and that it is limited to a few hospitals with limited use of PDAs by nurses, but the study provides valuable

information on the potential and actual uses of PDAs in the healthcare environment. The findings of this study cannot be generalised due to the limited scope of the study. Large-scale research study is required to generalise the findings of this research and to understand the adoption of wireless handheld technology in a healthcare environment, specifically in the context of the Australian healthcare setting.

References

[1] R. Gururajan, A. Hafeez-Baig, V. Gururjan, Clinical factors and technological barriers as determinants for the intention to use wireless handheld technology in healthcare environment: An indian case study, in: 16th European Conference on Information Systems, National University of Ireland, Galway, 2008.

[2] A. Hafeez-Baig, R. Gururajan, Key common determinants for adoption of wireless technology in healthcare for India and Pakistan: Development of a conceptual model, in: 13th World Congress on Medical and Health Informatics (MEDINFO 2010), Cape Town, South Africa, 2010.

[3] R. Luanrattana, K.T. Win, J. Fulcher, Data security and information privacy for PDA accessible clinical-log for medical education in problem-based learning (PBL) approach, in: 2010 IEEE 24th International Conference on Advanced Information Networking and Applications Workshops, 2010, pp. 979-984.

[4] I.-L. Wua, J.-Y. Lib, C.-Y. Fuc, The adoption of mobile healthcare by hospital's professionals: An integrative perspective, Decision Support Systems 51 (2011) 587-595.

[5] A. Anogeianaki, G. Ilonidis, G. Anogeianaki, J. Lianguris, K. Katsaros, D. Pseftogianni, A. Klisarova, N. Negrev, A training network for introducing telemedicine, telecare and hospital informatics in the Adriatic-Danube-Black Sea region, Journal of Telemedicine and Telecare 10 (2004) 1-3.

[6] M. Bensink, N. Armfield, T. Russel, H. Irving, R. Wotton, Paediatrick palliative home care with internet based videophones: Lessons learnt, Journal of Telemedicine and Telecare 10 (2004) 10-13.

[7] M. Hamalainen, P. Pirinen, Z. Shelby, Advanced wireless ICT healthcare research, in: 16th IST Mobile and Wireless Communications Summit, 2007.

[8] R. Gururajan, Factors influencing the intention to use wireless technology in healthcare: An Indian study—Embargoed until December 2008, Journal of Telemedicine and Telecare 13 (2007) 40-41.

[9] L. Kohn, M. Corrigan, M. Donaldson, To Err Is Human: Building a Safer Health Systems, National Academy Press, Washington, 1999.

[10] P.J. Hu, P.Y.K. Chau, S.O.R. Liu, Adoption of telemedicine technology by health care organisations: An exploratory study, Journal of Organisational Computing and Electronic Commerce 12 (2002) 197-222.

[11] O. Boric-Lubecke, V. Lubecke, Wireless house calls: Using communications technology for health care and monitoring, IEEE Microwave Magazine 3 (2002) 43-48.

[12] D.G. Cramp, E.R. Carson, A model-based framework for assessing the value of ICT-driven healthcare delivery, Health Informatics Journal 7 (2001) 90-95.

[13] H.J. Wisnicki, Wireless networking transforms healthcare: Physician's practices better able to handle workflow, increase productivity (The human connection), Ophthalmology Times 27 (2002) 38-41.

[14] T. Yampel, S. Eskenazi, New GUI tools reduce time to migrate healthcare applications to wireless, Healthcare Review 14 (2001) 15-16.

[15] F. Turisco, Mobile computing is next technology frontier for health providers, Healthcare Financial Management 54 (2000) 78-82.

[16] I. Alexander, The impact of future trends in electronic data collection on musculoskeletal research and evidence-based orthopaedic care, The Journal of Arthroscopic and Related Surgery 19 (2003) 1007-1011.

[17] R. Cavana, B.L. Delahaye, U. Sekaran, Applied Business Research: Qualitative and Quantitative Methods, John Wiley & Sons, Milton, Australia, 2001.

[18] J.F. Hair, W.C. Black, B.J. Babin, R.E. Anderson, R.L. Tatham, Multivariate Data Analysis, 6th ed., Pearson Education Inc., Upper Saddle River, NJ, 2006.

[19] R.A. Paterson, Meta-analysis of Cronbach's alpha, Journal of Consumer Research 21 (1994) 381-391.

[20] J. Stevens, Applied Mutlivariate Statistics for the Social Sciences, Lawrence Erlbaum Associates Publishers, Hillsdale, New Jersy, 1986.

[21] B.C. Tabachnick, L.S. Fidell, Using Multivariate Statistics, 3rd ed., Harper Collins, Northbridge, California, 1996.