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**Abstract**

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**Keywords:** Mobile medical information system, Smart phone, Military medicine, Field study

# Smart phone as a medium to access medical information: a field study of military physicians

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## Abstract

This paper aims to investigate the suitability of smart phones in the context of military medicine. Personal Digital Assistants (PDAs) have been adopted more often than smart phones in mobile medical care. In this paper, we aim to present results on the use of smart phones by military physicians. In the autumn 2005, thirty one physicians used a smart phone during their military service. We interviewed seven of these physicians during a training camp three months after they had received and used the smart phones in various field conditions. The study brings some light on the suitability of a given smart phone, the Nokia Communicator for field military operations. The importance of such a study resides in the fact that it uncovers critical shortcomings of the device and the software, which could result in the physicians' poor performance during the course of their core activities and duties. The study also gives valuable insights in the adoption potential of smart phones in military medicine.

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## 1. Introduction

Health information technology has been adopted by military medicine in different environments, and for different purposes. The adoption has, however, not been homogenous. We can see that the U.S. Military has been an early adopter, and can also be said to be in the forefront of the development in using information technology in military medicine. Smaller national defence forces (e.g., Finland) have generally had smaller resources to allocate in implementing health information technologies.

Due to the increasing availability and lowering costs of mobile devices and availability of suitable health information technology, it is not surprising that, in the recent years, also mobile technologies have started to penetrate military medicine. Mobile technologies may provide many benefits to military medicine, especially for managing health care in the line of battle. In order for military medicine to keep up with the building of more mobile and agile defence forces, using mobile technologies to support military medicine is becoming an increasing trend. When considering mobile devices, we can observe that two types of devices are available to deliver mobile health care solutions: (i) single-

purpose devices and (ii) multi-purpose devices. Single-purpose devices are designed and developed for the sole purpose of health care systems, and tailored to fit the needs of the users, and the demands of the environment in which these devices are operated. Multi-purpose devices are designed and developed to attract a wider customer base; they include many features and do not necessarily meet the demands of extreme environments such as military field operations, but yet provide a suitable platform for operating applications usable in military medicine. We can divide today's multi-purpose mobile devices into two categories: Personal digital assistants (PDA) and smart phones. In civilian and military medicine, PDAs have generally been adopted more often than smart phones, it is, however, a possibility that in the long run smart phones will include PDA capabilities and PDA's smart phone capabilities, which will make this division obsolete.

In this paper, we aim to present results on the use of smart phones and a standalone medical database software by military physicians. In the autumn 2005, thirty one physicians used a smart phone during their military service. We interviewed seven of these physicians during a training camp, three months after they had received and used the smart phones in various field conditions. The study brings some light on the suitability of a given smart phone, the Nokia Communicator (two different versions), for field military operations.

The importance of such a study resides in the fact that we can uncover critical shortcomings of the device and software under scrutiny. These shortcomings could result in the physicians' poor performance during the course of their core activities and duties.

The paper is structured as follows. In the next section, we briefly review the relevant literature. The research design, research method and the results are reported in Section 3. Section 4 includes a discussion of the results, concluding remarks, and present avenues for future research.

## 2. Background for this research

### 2.1 Physicians' information needs and use of supportive technologies to access information

The medical practice is very information-intensive by nature. The modern (electronic) ways of handling this information are, compared to other businesses, underused in the medical sector [Harris Interactive 2000]. The main user of different types of medicine-related information is a physician. The physicians' information needs can be classified as follows [Gorman 1995, Smith 1996]:
  o  Information on particular patients
  o  Data on health and illness within local population
  o  Medical knowledge (information about diseases, therapies, interpretation of lab tests etc.), which is potentially applicable to decisions about multiple patients and public health policies, unlike patient data [Wyatt and Liu 2002].
  o  Information on local health care system
  o  Information on local social influences and expectations

- o Information on scientific, political, legal, social, management and ethical changes that will affect medical practices

With the development of technology, especially computer and Internet technology, physicians can access medical information easily and efficiently.

When the desktop computers were first introduced to general practices the doctors and patients found using these systems stressful [Brownbridge et al. 1985]. The desktop system tends to move the consulting physicians' attention away from the patient, [Ridsdale and Hudd 1994, Greatbach et al. 1995] and may even increase the duration of consultations [Richards et al. 1998]. Some but not all of these problems are created by the desktop computer – keyboard setting, and some by the contents of the system the physician is using. The quality of the information available on the desktop systems is an area that has not been studied extensively and the overall effect of computerization of medical work on the information available for physicians is unclear [Ellis and May 1999]. The shortcomings of the fixed location and the attention-demanding desktop computer can potentially be helped by using handheld devices. Clinical computer systems are often underused in hospitals, because power and transmission cables either decrease their mobility, or make them a hazard [Norris 2002].

The effects of certain specific systems have, however, been studied. Several information technologies, such as computerized physician order entry and computerised physician decision support, have been shown to improve the safety of drugs [Bates 2000].

In their review of research on computer-based patient record systems (CBPRs) Delpierre et al. (2004) found that CBPRs did increase patient and user satisfaction, but the results on patient impact and quality of care were inconclusive. At the point-of-care computerized information resources are as effective as other resources, but they are more time-efficient [D'alessandro et al. 2004].

In their systematic review of 68 controlled trials of computer-based clinical decision support systems Hunt et al. (1998) showed that the systems in general are beneficial: the CDSSs can enhance clinical performance for drug dosing, preventive care, and other aspects of medical care, but not convincingly for diagnosis.

All computerized systems are not successes despite their usage: in a cluster randomized trial Eccles et al. (2002) found that implementing an evidence-based guidelines system for management of asthma had no significant effect on consultation rates, process or care measures or any patient reported outcomes.

The case for computerized systems in health care in general seems clear. There are undoubtedly benefits in some contexts, and as the systems develop their effects can be expected to be more positive. The obstacles caused by fixed terminals and wired systems can be overcome by mobile technologies- leading the development towards mobile e-health systems. The fit between the usage context and the characteristics of the system- including the chosen terminal device, is crucial for developing useful and beneficial systems.

## 2.2 Mobile devices for mobile e-health services

Ever since the introduction of the Apple Newton (The original MessagePad was launched at Macworld Boston in August 1993 [MacNeill 1998]) there have been medical applications for mobile computers. In fact, there is such a variety of applications that one would expect practically every physician to use some of them. Even if this may not actually be the case, the usage of mobile tools is spreading rapidly [Harris interactive 2001].

There are four main types of mobile devices or terminals available on the market: The pen-based Personal Digital Assistants (PDAs) either with a Palm ™ or Windows CE ™ operating systems, smart phones which integrate the functionalities of a PDA and a mobile phone, and Blackberry devices that differ from PDAs in that theses are always connected to a wireless network [Lu et al.2005].

The mobile terminals have some characteristics that reduce their usefulness in professional settings. Firstly, the screens of mobile terminals are (inevitably) smaller than the desktop, or laptop versions, thus limiting the types of information that are practical to view. Secondly, the input systems are either miniaturized keyboards or pen-based handwriting systems, neither of which is suitable for inputting large amounts of free text. The pen-based touch screen devices have proven to be ideal for structured data input such as selecting items from lists [Young et al. 2001], but a full-sized keyboard would have its downsides for point of care use, too: need for space or support since devices the size of laptop computers cannot be held in one hand and used by the other. Another aspect is the battery life. Most PDA type devices have a typical battery life of 2.5 to 4 hours of continuous use [Horne 2004]. This will not necessarily be enough for a full workday. Another aspect is the communication with other networks. The handheld terminals obtain data either by downloading over wireless networks, or by connecting the devices periodically to sync stations and downloading larger amounts of data at once [Afrin and Daniels 2001].

When studying actual usage of handheld computers (Palm OS, Handspring visor de luxe) in the Geneva University hospital in 2001, Tschopp et al. (2002) found that usage of the devices declined after the initial discovery phase and evened out at a level of 2.14 usage sessions per day. This would suggest that the mobile system does have a degree of usefulness since the usage never neared zero, and that compared with usage levels of other reference tools there is a strong case for further development of mobile systems.

## 2.3 A mobile medical information system

In Finland, the first computerized medical information database was launched in 1989, and disseminated on diskettes. It mainly contained 20 Finnish guidelines dealing with common and important primary healthcare problems. In 1991, a CD-ROM was published with a guidelines database, as well as, additional databases, e.g., Finnish medical journals, laboratory databases, and pictures. Throughout the 1990's, Duodecim

Publication Ltd., owned by Duodecim, the Finnish Medical Society, put more effort into improving evidence-based medical guidelines (EBMG) to make them more comprehensive and reliable. With the development of Internet technology, an Internet-based version was introduced in October 2000 (www.ebm-guidelines.com). Translation of these to English was completed in the year 2000, and to Swedish in 2001. Use of the computerized EBMG's by Finnish physicians was found to be very encouraging. They could usually find the information they were looking for and their searches were usually completed within 5 minutes (Jousimaa, 2001). EBMG has become an important source of information for Finnish physicians. Currently, EBMG as well as other databases, e.g. drug, diagnosis, etc… can be accessed through various channels. These channels include, e.g., printed books (published annually), Intranets within health care centres, or hospitals, or the national Internet portal Terveysportti (www.terveysportti.fi), which also contains links to many domestic and international providers of healthcare information. In 2002, a mobile version of those databases was developed and ready for use.

The mobile medical information system, used also in this research, is designed by Duodecim Publication Ltd. It is a set of medical information and knowledge databases. It contains the EBMG (available in both, English and Finnish) with Cochrane abstracts, a pharmacology database, Pharmaca Fennica, with a wireless update service for a complete medicine price list, the international diagnosis code guide (ICD-10) in Finnish, a laboratory guide by the Helsinki University Hospital, an emergency care guide issued by the Meilahti Hospital, a medical dictionary of over 57,000 terms, and a comprehensive database over health-care related addresses and contact information (pharmacies, hospitals, health centres). The content of the system is generated by an XML (eXtensible Mark-up Language) database. The system functions in most mobile devices operated by different systems, e.g., Symbian, Palm OS, and Windows CE. The device most commonly used as a platform in Finland is the Nokia 9210 Communicator, this is also the device that is used in this research. There are more recent versions of Nokia Communicator telephones available on the market; this fact is acknowledged by the authors. We feel that the findings from this research are, to a large extent, relevant also to the newer, more sophisticated communicator models.

The Nokia 9210 Communicator is an advanced mobile phone. It is not only a handheld computer, or a Personal Digital Assistant; but rather a mobile solution combining a mobile phone and high connectivity features (for example, access to Internet, communication by email, SMS, and fax). The phone includes a high-resolution color display (4096-color screen), enabling to use diverse applications, such as Web applications, word processor, spreadsheet, mobile e-mail, and multimedia. The phone also includes more common features such as calendar, notes, and contacts. The Nokia 9210 Communicator enables access to locally stored or remote databases. The phone operates on the Symbian platform, and uses the EGSM 900/1800 operating frequencies.

The mobile medical system is delivered on a 128 MB (now 256 MB) memory card, and is self-installing, containing the search engine, user interface programs, and core databases. Currently, an update of the system is available and is delivered on memory cards. In the near future, the system will be able to update itself partly, or completely,

through the GPRS (General Packet Radio Services), or UMTS (Universal Mobile Telecommunications System) wireless networks. In the autumn of 2003, the price list, part of the Pharmaca Fennica (the pharmacopoeia) was made able to update itself through the GSM (Global System for Mobile Communications) data link provided by the device – Nokia 9210 Communicator. The databases have been updated to include a drug interaction database originally developed by the Karolinska Institute, Sweden. It is important to point out that even if the most commonly used platform is an advanced mobile telephone, the system (medical databases) does not require connection capabilities to be fully operational: the system is stand-alone.

## 3. The research and the results

### 3.1 Research design and methods

The study presented here is part of a larger study aiming at investigating the suitability of a mobile medical information system for military physicians in the Finnish Defence Forces. The purpose of the study is to investigate the advantages and disadvantages of using "off-the-shelf" technology in providing medical professionals in armed forces support in their daily tasks in different field conditions, including time spent in training and in active duty in peace time armed forces bases. The aspects of interest to this research are the usability of the selected device (Nokia Communicator) in delivering the medical application (the mobile medical database) and the benefits for military doctors of having the device and the application at hand at all times.

The intention is to explore the benefits of the system for both, the military physicians using the system and for the Finnish Defence force. In rather small defence forces, like the Finnish Defence Force, the resources that can be allocated for specialized mobile devices are limited and hence cheaper and highly available "off-the-shelf" technology that can easily be customized is a viable alternative to investing in optimized technologies (especially when the technologies must be updated often). The medical profession is information intensive and it was considered likely that military physicians would benefit from a mobile database application. Similarily, information intensive tasks can also be found elsewhere in the military services, hence this study also acts as a pilot for a larger investigation of using "off-the-shelf" mobile technologies in delivering intelligence on the field and in field conditions, e.g., in the form of databases.

On September 6, 2005, with support from Pfizer Finland Ltd. and Duodecim Publications Ltd, thirty one (military) physicians (including some medical students), undergoing their military service in the Finnish Defence Forces, were given a Nokia Communicator 9210 equipped with a mobile medical information system. On December10, 2005, after the military physicians had used the mobile medical system for a time of approximately three months, we conducted a field study. In this study, two researchers visited a training camp to interview the military physicians and to observe them in their daily routines and their operating environment. The researchers had the opportunity to visit two different attachments of military doctors during a military exercise, one at the battalion level medical station and one on the front line.

Seven semi-structured interviews were conducted during the field study: the interviews included questions regarding (i) how they learned to use the system, (ii) the frequency of use of the mobile medical information system, (iii) the situations of use encountered the most frequently and the benefits associated to the use of the system, (iv) the characteristics and the features of the medical database, and (v) the properties and the features of the device. Questions regarding the properties and features of the study, which are the concern of the study presented in this paper, dealt with:

- screen properties: lighting, size, readability of the information (text size, font), and use in different weather and daylight conditions
- keyboard properties: size, layout (easiness to input text, use with gloves), and use in different weather and daylight conditions
- phone cover: robustness and durability
- phone storage and portability: how is the phone handled? Is the phone easy to carry with? Where and how is it kept?
- battery life

Interviewees were asked to report problems they had with the device in different field situations, and also to propose improvements they would like to see in the device for their use in the field. The interviews were video-taped as a means to capture contextual information, and to let the interviewees show how they use the device in various situations.

## 3.2 Data analysis

The data collected during the interviews was transcribed, and the physicians' opinions about the features of the device were categorized according to a set of questions determined before the interviews. Additional comments were added to specific categories when appropriate, whereas uncategorized comments were added to the category "other comments". In section 3.4, extracts of the data are reported in the form of quotes; these quotes have been translated from Finnish to English by the authors.

## 3.3 Evaluation Background

Of the seven interviewees, six were male and one was female. The Nokia 9210 Communicator was a new device to most of them, although they had seen or heard about the device; one interviewee had used the Nokia 9210 Communicator before and was actually using her own new Nokia 9300 Communicator during the field study. All of the interviewees were familiar with the national Internet portal Terveysportti; this can be assumed to have facilitated the uptake of the mobile medical information system.

**Fig. 1:** Military physicians using the Nokia 9210 Communicator on the training camp

## 3.4 Military physicians' evaluation of the mobile medical information system

In this study, we are especially concerned with the interviewees' learning patterns of the device, and their evaluation of the device's properties.

### 3.4.1 Learning to use the device

The physicians reported that they were trained to use the device on the day they received the devices. The training session lasted a couple of hours; and it included training about the basic features of the phone and the mobile medical database. All physicians reported that they learned to use the device and the database within the first week, but some expressed that some more training about the device's advanced features could have been useful; the core concept of the database was known from earlier experience of the Internet portal, Terveysportti, although one interviewee mentioned that the mobile database did not feel like the same than on the Internet *"... but I have not experienced that the database is quite the same as the one on the Internet"*. A reason to this could be that the mobile interface looks much simpler than the Internet database and, therefore, requires from the user to "know" exactly what to look for. Another user mentioned that it took more time to learn how to use the database *"...it took a few moments to learn the basics, but learning to use Pharmaca Fennica1 did not happen as fast... maybe a week"*.

Learning to use the device did not seem to be a problem, according to the respondents. One factor, that was mentioned often, is that the Nokia user interface was known from the use of previous phones. This certainly facilitated the uptake of basic functionalities. *"… it took about the first week, I have used a Nokia phone before, so I knew more or less. It took a few moments to learn the basics"*. One user expressed that the use of the device did not differ from the use of a normal computer, *"This does not actually differ from a normal computer... works according to the same principles ...of course later I have found new features, but basic information search ... (I learned) instantaneously"*.

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1 Pharmaca Fennica is one of the databases provided in the mobile medical information system

*3.4.2 Screen properties*

Physicians were asked to comment on the screen of the device, for example its size, the readability of the information presented, its use in various weather and light conditions.

All physicians expressed that the screen size was suitable to the types of situations they had to face. When asked if the screen could be larger, most users mentioned that it could be larger, but not at the expense of the overall size of the device; "*I don't really like a larger screen, this size of the device is quite maximal at this point*" However, when asked if the device could be smaller, mixed opinions were expressed: to some users, screen size could not be smaller as it would automatically mean a smaller device ("*I think that it (the screen) should not be smaller ... especially because it would mean a smaller keyboard, which would not be as handy*"), whereas some users expressed that they would like to have a smaller, less bulky device, but they would not be ready to compromise on the size of the screen ("*It could be a bit smaller, I mean that the new Communicator looks a bit more handy and is smaller*").

An interesting comment about the screen size touched upon the shape of the screen, especially the horizontally-oriented screen of the Communicator vs. the vertically-oriented screen of a PDA. According to one interviewee, a PDA screen would be more suitable to present the type of information included in the database; in the sense that less screen real estate would be used to line breaks between paragraphs and therefore decrease the amount of scrolling through the database: "*the screen should be so that more information should fit in one screen instead of scrolling back and forth*".

Interviewees reported unanimously that readability and font size did not pose any problem. Screen readability in various weather and light conditions was not blamed; however it was mentioned several times that, when trying to type in text in the dark, the screen had to be bended in order to bring light onto the keyboard. This could be assumed to affect readability and make the use of the device somehow unpractical ("*I have used (the phone) in the dark; it works if one bends the screen's light towards the keyboard...*").

*3.4.3 Keyboard properties*

Physicians were asked to comment the device's keyboards and its use in various weather and light conditions. The keyboard of the Nokia 9210 Communicator reminds a computer keyboard; the keyboard is rather large, with keys separated from each other, compared to the keyboard of the Nokia 9300 Communicator. Text input did not pose any major problem in most cases; input of special signs, which are not accessible directly through the keyboard, was felt to be tedious ("*text input is easy, well... actually I have had a few problems inserting special signs because I never quite remember how (to dot it)...*").

Use of the keyboard with gloves, for example in cold weather conditions, was said to be nearly impossible, even with the large keyboard of the Nokia 9210 Communicator ("*in winter with the gloves, it is not necessary possible to type ... the keyboard should be by no means made smaller...*").

The need for a backlit keyboard was expressed: using the keyboard in the dark is impossible unless the screen is bended towards the keyboard ("*well, it works if one bends the screen towards the keyboard... but a backlit keyboard would be a good idea*").

### 3.4.4 Phone robustness and durability

When asked to comment the phone's robustness and durability in field conditions, the physicians mentioned that the device seemed to be robust in stationary conditions, for example in a field hospital. However, when on the move in "extreme" conditions (in cold and humid circumstances, or when crawling in the field), the device would break down easily unless protected by a phone case; in winter conditions, the battery of the device would certainly run out very fast ("*actually here humidity comes into play, we have obviously humidity here on this camp, that's why one of the phone broke down*"), (Question: "*Has there been worse conditions?*" Answer: "*well, there have been a lot of things going on around the place... I could have watched after the phone much better*"). On the basis of the interviews, humidity seemed to be the factor that would influence the most the phone's robustness and durability: one phone actually broke down when being exposed to humidity.

### 3.4.5 Size of the device, phone storage and portability

The physicians expressed their opinions about the size of the device, and they reported how they store the device in their daily operations. When starting their training, the physicians were given a leather case to keep the device; this leather case can be easily attached to a belt, or used simply to protect the phone when carried in a pocket.
In the section on screen properties, we mentioned that the interviewees thought that the size of the device was maximal, though they saw that there is potential to increase the screen size. A smaller device would be welcome, but not at the expense of the size of the screen size, or the keyboard. Still, the original device (Nokia 9210 Communicator) can be considered to be bulky (although better than medical books), and it is not convenient to carry it along attached to a belt in a leather case; that leather case is in most cases insufficient against humidity.
Physicians reported that they carried the device in the front pocket of their uniform jackets.

### 3.4.6 Battery life

Battery life is a major concern for field operations, especially when battery charging possibilities are not available. Physicians have used the device during several training camps; they reported the situations where battery life was a problem. A few of the interviewees mentioned that they did not encounter any problem with the phone battery, the battery lasted several days (about 5 days) during a training camp ("*it lasts several days, if one does not phone a lot*". Others reported situations where battery was insufficient, for example:

- War-like situations, which last longer than a training camp, and where charging possibilities do not exist; in these situations, a spare battery was deemed to be necessary "*the battery has lasted, but if we think about a war-like situation with older equipment, there is not necessary any electricity nearby the first-aid point ... it is not possible, unless one has a better battery ... a spare battery is definitely needed, if the phone is used in a crisis situation*"

- Outdoor operations with cold weather conditions, where the battery runs out very fast "*difficult to say... if it is cold then the battery will discharge quickly.. charging possibility should be available*".

A recurrent problem in field operations is that the work pace can be very hectic, which means that the user can forget to charge the battery, or leave the phone running, therefore, consuming the battery.

## 4. Discussion and concluding remarks

This paper sets out to investigate military physicians' evaluation of a smart phone –Nokia 9210 Communicator - that supports their access to medical knowledge and information in field conditions. Six properties or features of the smart phone were investigated.

This field study was also the opportunity to gather suggestion improvements for use of the phone in field operations. Along the questions that were asked, the physicians added their own suggestions for improvement and underlined critical features and properties of the device that would fit their needs.

One point which was outlined very often is the size of the screen, and what would be optimal for physicians' purposes. This question needs to be addressed jointly with the size of the device and the keyboard, which influence design choices. The Nokia 9210 Communicator cannot be larger than in its current state, the keyboard is of suitable size, somehow usable with gloves; and its screen could be even larger without compromising the size of the device. On the other hand, the Nokia 9300 Communicator's size makes it even more mobile, the screen is the same size than its predecessor, but the keyboard is impractical in extreme field conditions.

A different screen layout was proposed. Military physicians use the device to retrieve medical information from a database: for them it is important to get the information they need quickly without scrolling back and forth in order to read information. The horizontally-oriented screen of the device under scrutiny does not optimally display all the needed information at once; this can be a serious drawback in situations where physicians work under time pressure. A vertically-oriented screen could accommodate much more information at once.

The field conditions encountered during our field study revealed that use of the device in the dark is not a rare occasion. The devices under scrutiny had no backlit keyboard: although the physicians coped with this problem by bending the screen onto the keyboard, this made the use of the device often impractical.

Physicians also mentioned that a special protecting case could be useful in field conditions: considering that one device actually broke down during the experiment because of humidity, there is reason to believe that a special protecting case would be necessary. Besides a special case, it is obvious that such a device should be designed and built in order to cope with humid and cold weather conditions.

Finally, special power saving settings could be in use for field operations: as battery life can be estimated to be reasonable for a training camp, it will not be sufficient for war-like situations and extreme weather conditions.

If a special device should be developed specifically for the needs of the Finnish Defence Forces, it should integrate the previously mentioned improvements. During the field study, physicians expressed their satisfaction to have the chance to use a mobile device in their field work, and they recognized its usefulness. The smart phone has provided physical accessibility to a mobile medical information system, where other media, (printed books, Internet) are not easily available in the field. This also means the phone can be viewed as a premier to access to information regardless of time and space. The freedom created is beneficial for military physicians to cope with their task in the field.

The study presented here has practical implications. The findings suggest that smart phone as a medium to access to medical knowledge and information is welcomed by the physicians in the military services. The developer might continue the endeavor to use this mobile device to deliver the mobile medical information system. Special attentions should be paid for increasing the phone's robustness and durability, and the battery life. Also, the protection case is needed so that the phone will be used in military field conditions.

Several other mobile devices, e.g. PDAs, pocket PC, Blackberry have been adopted to deliver different mobile e-health services. A few studies have been conducted to compare these device properties in their suitability of delivering mobile e-health services. Future research on this direction will give us more know-how to help healthcare providers to select a good mobile device to accomplish their tasks in mobile e-health. An "awkward" mobile device might undermine the usefulness and ease of access to a particular mobile product or service. It is very important to deliver the mobile system through a user-friendly and ease to use device, which in turn, would increase the quality of health care at the point of care.

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