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Project Report:

Evaluation of a Mobile Medical Information System in the Finnish Defence Forces

Turku Centre *for* Computer Science

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Project Report: Evaluation of a Mobile Medical Information System in the Finnish Defence Forces

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Abstract

ENG

The goal of the project was to investigate the suitability of an existing mobile medical information system (created by Duodecim Publications Ltd.) for field use by the Finnish Defense Forces, when used with Nokia 9210 Communicator. Specific targets of this research were the usability, usefulness, and performance of the system; special interest was attached also to how the technology was adopted by the users, a group of medical doctors undergoing their military service, serving as military physicians. The project was carried out as a co-operation between IAMSR and Finnish Defence Forces during a period ranging from fall 2005 until the summer of 2006.

FIN

Projektin tarkoituksena oli selvittää (Duodecim Publications Ltd:n kehittämän) mobiilin lääketieteellisen tietokannan soveltuvuutta Puolustusvoimien kenttäkäytöön nykymuodossaan, Nokia 9210 Communicatorilla käytettynä. Tutkimuksen kohteena olivat erityisesti laitteiston käytettävyys, hyödyllisyys ja toimivuus. Lisäksi mielenkiinnon erityisenä kohteena oli miten hyvin käyttäjät (lääkintä RUK:n käyneet kokelaat) hyväksyvät laitteiston ja ottavat sen käyttöön. Projekti toteutettiin IAMSRn ja Puolustusvoimien yhteistyönä aikavälillä syksy 2005 – kesä 2006.

Keywords: Mobile medical information system, usability, usefulness, technology adoption

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1. Introduction

1.1. Project Overview

This project started in the late summer of 2005 from discussions between Mikael Collan,Ville Harkke, and Franck Tétard. Ville had recently finished a study of medical doctors' acceptance of mobile medical databases involving a number of Nokia 9210 Communicator devices that he had been able to get a hold of with the generous help from Prizer Finland Oy. The devices were packed with a medical database software developed by Duodecim Publishing Ltd. We decided to ask if we could do a follow-up investigation using the same setup, the Duodecim software suite on the Nokia 9210 Communicators, however, this time in real field conditions, in co-operation with the Finnish Defence Forces. We contacted the chief of the Finnish Defence Force medical staff and very fast we got a green light to start the co-operation, our contact in Lahti was Captain Sami Friberg.

Together with Capt. Friberg the team planned the research schedule according to the target group's, which by then had been identified to be the about 30 participants of the medical reserve officers course that had started earlier in 2005, schedule (called later on military physicians). The project started in the beginning of September 2005 with a short 2-hour crash course into how the system functions and the first questionnaires on the system were administered to the target group. By this time Shengnan Han had also joined the research team. Around October 2005 some mini-cassette recorders were distributed to the target-group with instructions to record on tape information about their use of the mobile medical information system. The recorders were collected after a two week period; the results were non-existent, and absolutely no information could be derived from this way of collecting data. The target group must have felt it to be totally useless to record anything on the tapes. Furthermore it was clear that the AA batteries that power the mini-cassette recorders are no match for the cold Finnish weather, and they rendered the recorders mostly unusable.

A field study was conducted at a training camp in Niinisalo in the beginning of December 2005, where seven users of the system were interviewed (video recorded interviews) and by using a semi-structured interview. During the interviews the military physicians were asked to also show to the camera how they actually use the device in the situations they describe. This allowed us to capture also contextual information about the system usage. A second survey questionnaire was administered in December 2005 after the visit to the training camp, it returned about 20 responses.

In April 2006 a third, and final, survey questionnaire on the same issues was done, this was at the end of the training period for the military physicians. About 20 answers to the questionnaire were received. All in all, the three sets of answers on the same topics allowed the research team to make a longitudinal analysis on the adoption and use of the

system. The surveys and the field study are described in detail below, in connection with the results. What is, however, not discussed there is the fact that we asked the military physicians about how they view the idea that the Finnish Defence Forces are testing mobile medical information systems; the answers were all (100%) positive and the sentiment was that they felt that such testing was meaningful and highly motivating for them. This trend followed throughout the research.

1.2. Research Objectives and Theoretical Framework for the research

The main research objective of the project has been to study the adoption and the suitability of an existing mobile medical information system (MMIS) in the Finnish Defence Forces. Suitability of the system is evaluated on the basis of usefulness, performance and usability.

Usefulness and usability are two interrelated concepts: it is usually said that usable products are such that are useful to the user; it is also said that useful products usually display good usability. Both dimensions have been used in the context of technology adoption. Several models of technology adoption have been developed; these models attempt to prescribe how various factors affect technology adoption behaviour. For example, the Technology Adoption Model (TAM) identifies two determinants that influence users' intention to use and adoption behaviour as a result [1]. *Perceived usefulness* and *perceived ease of use* are the two determinants of technology adoption according to the TAM model: (i) perceived usefulness is defined as "*the degree to which a person believes that using a particular system would enhance his or her performance*", (ii) perceived ease of use is defined as "*the degree to which a person believes that using a particular system would be free of effort*". The instrument used to measure perceived usefulness and perceived ease of use was adapted from the TAM model (see Appendix 1 – Questionnaire on perceived usefulness and perceived ease of use). Further information about how the instrument was used during the longitudinal study and how the data was analyzed can be found in section 2.1

Chang and King [2] developed an instrument to measure information systems impact on organizational performance using the following dimensions: systems performance, information effectiveness, and service performance. The research instrument proposed by Chang and King was adapted to analyze system usefulness/performance. Our instrument includes two constructs (system performance and information effectiveness) and changes in wording to make the constructs appropriate for the system and the context of use. Appendix 2 includes the elements of the two constructs used in the instrument. The constructs and sub-constructs were measured using a five-point Likert-type scale, ranging from (1) "hardly at all", to (5) "to a great extent", with (0) indicating "not applicable". Demographic data were also collected. Further information about how the instrument was used during the longitudinal study and how the data was analyzed can be found in section 3.2.

Usability of the system was investigated on the basis of semi-structured interviews. The ISO standard 9241-11 [3] defines usability as "*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"*. This set of goals has been extended by [4] to include learnability (easy to learn, easy to remember how to use), safety, and usefulness.

When preparing the script for the interviews, special attention was paid to identifying themes and questions which would cover the usability goals mentioned above. The interviews were articulated around five themes: (i) learnability of the system, (ii) frequency of use of the system, (ii) context and situations of use of the system, (iv) characteristics of the device, (v) characteristics of the system interface (see Appendix 3 for a complete list of interview questions). Further information about how the interviews were conducted and how the data was analyzed can be found in section 3.3.

It has been the objective of this study to research the usefulness, performance, usability, and technology adoption of the studied mobile medical information system by using the aforementioned research constructs and by reflecting on the previous results obtained with the same constructs. It has also been of interest to make explorative research into the use of the MMIS to learn new things outside the scope of the abovementioned research constructs.

This report continues by giving a short description of the mobile medical information system (MMIS) in question. Then the results for the longitudinal studies on system usefulness and system performance are shortly presented, followed by a brief presentation of the results from the usability evaluation of the system. Findings and improvement recommendations are indicated (Appendix 4) and the paper closes with acknowledgements and a list of the publications from the project and the list of references.

2. System Description

The mobile medical information system (MMIS) that was used in the project, is based on a software designed by Duodecim Publication Ltd. and it is a collection 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 centers), for Finland. The databases have been updated to include a drug interaction database originally developed by the Karolinska Institute, Sweden.

The content of the system is generated by an XML (eXtensible Mark-up Language) database. The database functions in most mobile devices, using different operating systems, e.g., Symbian, Palm OS, and Windows CE. 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.

Figure 1. The Mobile Medical Information System

The device that has been most commonly used as a platform, in Finland, is the Nokia 9210 Communicator (was also used in this study), but newer devices are constantly entering the markets.

3. Research Results

3.1. Longitudinal Study of System Usefulness

3.1.1. Method

A longitudinal study was carried out from the autumn 2005 to the spring 2006. On September 6, 2005, with support from Pfizer Finland Ltd. and Duodecim Publishing Ltd, thirty one physicians, later in this paper called military physicians, (including some medical students) undergoing their military service in the Finnish Defense Forces, were given a Nokia Communicator 9210 equipped with the mobile medical information system. After the first user training of the system[1] (on the same day they got the system), we distributed our first, semi-structured, questionnaire to collect their demographic information and to investigate their initial perceptions of perceived

[1] The military physicians were given a two-hour introduction to the mobile device and the mobile medical information system.

usefulness and ease of use of the system. In December 2005, after the military physicians had used the mobile medical system for a time of approximately three months, we conducted the second survey, which was made to study the use of the system and the opinions regarding the system being used for military purposes in the field conditions. Nineteen valuable answers were returned. In the spring 2006, these physicians were relocated to different garrisons to continue their military service. In April 2006, the third survey that had a similar structure and questions with the previous surveys was distributed. Twenty-one physicians responded the survey.

The data analysis was primarily descriptive in nature. Frequencies and some central tendencies were calculated to illustrate physicians in the military service, their usage, and assessments towards the mobile medical information system. Potential differences in their behaviour over the three points in time were tested by ANOVA (Sig. < 0.05). The Scheffé test was used for *post hoc* tests.

3.1.2. Results

Demographics

Of the thirty one participants, twenty-three have graduated and have become qualified physicians, eight are still medical students. Among the 31 participants, one has earned a doctoral degree in medicine, and two have, or will, become qualified pharmacists. The gender distribution was 30 male and one female. The mean age of the group was 25.19 years, the youngest being 20 and the oldest 28. Among the participants, twenty-two have never used a Nokia Communicator (any models), eight indicated prior usage. Seven have used the mobile medical information system before; among them, two have used it for 1 year (one of the two was the female physician in the group), two have used it for some months, and 3 have tried for a few hours.

In order to know, whether the participants were familiar with the contents of the databases in the mobile medical information system, we also collected information regarding the usage of Terveysportti, the Finnish health care portal in the Internet in the first survey. Excluding 6 missing answers, all have used it ranging from 7 months to 5 years. They have used it for education/learning purpose (n=30), for patient consultation (n=21), and for completing their specialisation knowledge (n=8). In general, this group was young, male–dominated, and familiar with the contents of the mobile medical system. The participants were mostly naive users of it when the study started.

Perceived usefulness of the mobile medical information system

The military physicians' perceived usefulness of the system was studied from four aspects: (i) using the system improves my medical knowledge; (ii) using the system enhances my effectiveness to do clinical work in the field conditions; (iii) using the system improves my ability to make good decisions; and (iv) I find the system useful for me.

The perceived usefulness of the system, after a period of actual usage, was still positive in general (mean value > 3), but with a clearly declining trend (Table 1) across the study period. The *F*-ratios for the analysis of variance on the aspects of effectiveness and usefulness were significant at the 5% level ($F_{\text{effectiveness}} = 7.29$, df =2, 65, $p<0.05$; F_{useful}

= 14.25, df=2, 68, $p<0.05$). Consequently, the Scheffé Test was used to compare pairs of the means in order to assess where the differences lie. It was found that at the 5% level of significance, the assessment of effectiveness of the system in April 2006 (M=3.38) was significantly lower than those in September 2005 (M=4.34), but the means of that in September and in December 2005 did not differ from each other. The evaluation of the usefulness of the system in April 2006 (M=3.38) was also significantly lower than those in September (M= 4.58) and in December (M= 4.32), but that the means of those of the two times in 2005 did not differ from each other.

Perceived Usefulness	Mean			F	Sig. (p<0.05)
	Sep./05 (n=31)	Dec./06 (n=19)	Apr./06 (n=21)		
Improves medical knowledge	3.97	3.68	3.62	1.18	0.313
Enhance effectiveness in field conditions	4.34	3.94 (n=18)	3.38	7.29	0.001
Improves my ability to make good decisions	3.83	3.74	3.33	2.25	0.114
Useful	4.58	4.32	3.38	14.25	0.000

Table 1 Usefulness of the mobile medical information system

A very important insight we get from the results is that military physicians have gradually found that the system is not very useful in their military training. As they have obtained more experience from their actual usage in the different working environments, they have evaluated the usefulness of the system quite differently from their initiative hype of the system. There are several reasons. Firstly, it might be due to the differences between the civilian and military medicine. The mobile medical system is designed for civilian physicians, therefore the contents of the system lacks of a focus on military medicine. The longer time they worked in the field conditions, the more the demand for the contents specifically suited for military medicine would raise, and the more limitations of the current contents would be shown. The second reason may due to the fact that military physicians used the system in the tough field conditions. The weather was cold and humid during the study period. The natural environment gave rise to the high requirements on the physical robustness of the mobile device. The Nokia communicator is not very suitable to be used in such conditions. The drawbacks of the physical device may shed a shadow on the usefulness of the system. The third reason goes to the limitation of the mobile medical system itself. As a standalone system, it contains only the medical knowledge and information, but lacks of integration with other important systems which contain some crucial information, e.g. soldiers' health records. The last reason may be the possible effect of the changing working environment from the field conditions to the garrisons. In the different garrisons these physicians can't access to the Internet, but they have other traditional databases which are accessible, i.e. books, CDs. The possible increasing usage of the traditional databases may also lead to less use of the mobile medical system in their daily work, thus, decreased positive perceptions of it in terms of effectiveness and usefulness.

Figure 2. Military physician using the Nokia 9210 Communicator

Perceived ease of use of the mobile medical information system
The military physicians were asked to indicate their perceived ease of use of the system. Questions about four aspects were asked: (1) learning to operate the system is easy for me; (2) I find it easy to get the mobile medical system to do what I need to do; (3) It is easy for me to become skilful in using the system; and (iv) I find the system easy to use.

The military physicians' perceived ease of use of the mobile medical system was positive in general with most of the mean value> 4 at the three points of time (Table 2). It is interesting to notice that the evaluation with an increased trend from September to December 2005, but declined afterwards, especially the aspect "easy doing what I need to do". The *F*-ratio for the analysis of variance was significant at the 5% level ($F = 5.45$, df = 2, 68, $p < 0.05$). The post hoc Scheffé test showed that the difference lied between the evaluations of December 2005 with that of April 2006. The changing working environment may be one of the reasons to explain the differences. In a comparison with the accessibility of the traditional databases (books, CDs), it might be not easy enough to use the mobile medical system.

Perceived Ease of Use	Mean			F	Sig. ($p<0.05$)
	Sep./05 (n=31)	Dec./06 (n=19)	Apr./06 (n=21)		
Easy learning to use	4.65	4.84	4.52	1.85	0.165
Easy doing what I need to do	4.19	4.47	3.57	5.45	0.006
Easy to become skilful	4.42	4.53	4.19	1.16	0.320
Easy to use	4.32	4.42	4.05	1.38	0.258

Table 2. Ease of use of the mobile medical information system

Usage intention

In the first survey in September 2005, the military physicians' behavioural intention towards the system was also measured by asking, if they think they will use it in the future. There was one negative answer that indicated that the person would not use the system, several neutral responses (n=7) that indicated insecurity about the future use. Twenty-three (74.2%, n=31) military physicians expressed clear interest in using the system in the future.

Self-reported actual usage

In the second and third survey we carried out in December 2005 and April 2006, we investigated the real usage of the mobile medical information system, in terms of usage frequency (Table 3), and volume of use during a period of one week (Table 4). The possible differences of the usage frequency and volume over the study period were performed by paired T-tests; neither of the results was statistically significant. Table 3 has shown that majority of the group have used the system on weekly basis. Two physicians have reported that they did not use it at all from the dataset in April 2006. A declined trend of usage volume was also found.

	Usage Frequency	
	Dec. 2005 (n=19)	Apr. 2006 (n=20)
I don't use it at all	0	2
About once a month	4	3
About once a week	4	4
Several times a week	7	8
About once a day	3	2
Several times a day	1	1

Table 3. Usage Frequency

	Usage Volume	
	Dec.2005 (n=19)	Apri.2006 (n=20)
< 0.5 hours	10	14
0.5-0.9 hours	6	5
1.0-1.9 hours	2	1
2.0-2.9 hours	1	0
3.0 or more hours	0	0

Table 4. Usage Volume

As showed in Table 4, 14 physicians in April 2006, compared to 10 in December 2005 have used it less than half an hour per week. Possible reason may go to the fact that as their hand-on experience of using the system grows, they increased their speed to find information, thus, spend less time on using it. Another explanation is the possible negative effect from their declining perceptions of usefulness of the system. The third explanation may also go to the changing working environment across the study period.

The increasing use of other databases would decrease the usage of the mobile medical system in terms of usage frequency and usage volume.

3.2. Longitudinal Study of System Performance

3.2.1. Method

We carried out two surveys to investigate the physicians' assessments of the system performance, in terms of system performance and information effectiveness. The first survey was conducted in December 2005, after the military physicians had used the mobile medical system for a time of approximately three months in field conditions. Nineteen answers were collected. In the spring 2006, these physicians were relocated to different garrisons to continue their military service. In April 2006, the second similar survey was distributed. Twenty-one responses were received.

We followed the Chang and King (p104) [2] recommendation to implement the data analysis, which is "*the average score for each sub construct or dimension are the indicators of the specific sub area or dimension.*" Therefore, the analysis was primarily descriptive in nature. Frequencies and some central tendencies were calculated to illustrate military physicians' assessments of the performance of the mobile medical system from the perspectives of system performance and information effectiveness. Potential differences in physicians' assessments over the two points in time were tested by the T-Test (Sig.< 0.05).

3.2.2. Results

Measures of system performance assess the quality aspects of the mobile medical information system (mobile package), and the various impacts that the system has on the military physicians' work in general, and their military training in particular. The results showed that the military physicians' perceptions of the performance of the mobile medical system was slightly positive (construct average score >3), but with a decreasing trend over the study period (construct average score went down from 3.28 in December 2005 to 3.19 in April, 2006) (Table 5). Such a decrease was contributed by the declined assessments of the sub-constructs, i.e., impact on job, impact on external constituencies, impact on knowledge and learning, and specifically, systems usage characteristics, which declined statically significantly at the 5% level. A further analysis was performed by comparing the scores of the 9 dimensions included in the "systems usage characteristics" sub-construct (Table 6). There were 5 dimensions, which significantly declined from December 2005 to April 2006, i.e., the responsive time, reliability, accessibility, expectation, and flexibility.

The declining trend of the military physicians' assessments of system performance, has risen a bit, but not significantly, via the system's increasing performance, in terms of its impact on internal processes (mean= 2.55 -> 2.97) and in terms of intrinsic systems quality (mean = 3.78 -> 4.13).

Systems performance	Dec./ 2005 (n=19) Mean (S.D)	April/2006 (n=21) Mean (S.D)	Sig. (2-tailed) df=18 (p<0.05)
Impact on job	3.27 (0.56)	3.21 (0.74)	0.978
Impact on external constituencies	3.16 (0.71)	2.95 (0.97)	0.525
Impact on internal processes	2.55 (1.04)	2.97 (1.00)	0.202
Impact on knowledge and learning	2.96 (0.97)	2.83 (0.89)	0.706
Systems Usage characteristics	3.83 (0.49)	2.92 (0.60)	0.000
Intrinsic systems quality	3.78 (0.49)	4.13 (0.75)	0.263
Construct average score	3.28 (0.42)	3.19 (0.55)	0.624

Table 5. System Performance

Systems Usage Characteristics	Dec./ 2005 (n=19) Mean (S.D)	April/2006 (n=21) Mean (S.D)	Sig. (2-tailed) df=18 (p<0.05)
The mobile package has fast response time.	3.89 (0.74)	3.21 (0.92)	0.019
The mobile package downtime is minimal.	3.11 (1.44)	2.79 (1.32)	0.500
The mobile package is well integrated.	3.74(0.65)	2.95 (1.51)	0.056
The mobile package is reliable.	3.95 (0.62)	2.74(1.37)	0.003
The mobile package is accessible.	4.05 (0.41)	3.15 (1.54)	0.031
The mobile package meets your expectation.	3.95(0.62)	3.21 (1.08)	0.015
The mobile package is cost-effective.	2.16(1.64)	2.32(1.49)	0.674
The mobile package is responsive to meet your changing needs.	3.53 (0.61)	3.16(0.69)	0.130
The mobile package is flexible.	3.74(0.65)	2.89(1.24)	0.016
Average score	3.83 (0.49)	2.92 (0.60)	0.000

Table 6. Systems Usage Characteristics

Information effectiveness

Measures of information effectiveness assess the quality of the medical information and knowledge, as well as, the effects of the information and knowledge on the military physicians' work. The results of the information effectiveness of the mobile medical system were shown in Table 7. Statistical analysis indicated a rather good performance of the system in term of information effectiveness, but also with a declining trend; especially the assessments on the sub-constructs of accessibility and flexibility of information have decreased significantly at the 5% level, from December 2005 to April 2006. The results of a T-test have shown that the declination of the sub-construct of accessibility of information mainly came from the dimension of "accessible" (df =18, Sig. = 0.013), and that of the flexibility of information were contributed by the aspects of "can be easily changed" (df=18, Sig. = 0.033) and "can be easily updated (df =18,

Sig. = 0.011). The presentational quality of information was increased slightly from the mean value 3.50 to 3.64; however the change was not statistically significant.

Information effectiveness	Dec/2005 (n=19) Mean (S.D)	April/2006 (n=21) Mean (S.D)	Sig. (2-tailed) df=18 ($p<0.05$)
Intrinsic quality of information	3.80 (0.38)	3.75 (0.67)	0.793
Contextual quality of information	4.07 (0.48)	4.00 (0.69)	0.809
Presentational quality of information	3.50 (0.71)	3.64 (0.57)	0.407
Accessibility of information	4.23 (0.39)	3.56 (0.75)	0.005
Reliability of information	3.92 (0.69)	3.76 (0.84)	0.963
Flexibility of information	3.62 (0.43)	3.26 (0.62)	0.028
Usefulness of information	3.49 (0.36)	3.35 (0.61)	0.309
Construct average score	3.80 (0.29)	3.68 (0.47)	0.300

Table 7. Information Effectiveness

By comparing the construct scores of the system performance (Table 5) and of information effectiveness (Table 7), it is easy to find that the mobile medical information system performed better in the domain of information effectiveness, than in the domain of system performance. The system can provide high quality medical information and knowledge for military physicians during their military service, and has various positive influences on their work in practice (Table 7). However, the military physicians have changed their assessments after they relocated to different garrisons, which the working environment was more stable. In addition to using the mobile medical system as a support for retrieving medical knowledge and information, they were able to access other traditional medical databases, e.g., books or CDs in spite of without a connection to the Internet. The changes of the working environment (space), the availability and accessibility of the other databases can have some impact on the physicians' assessments of the performance of the system. This is further discussed in the next section.

3.3. System Usability Evaluation

3.3.1. Method

On December 10, 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 actual users were interviewed during the study (video recorded interviews): other users were unavailable, as they were either dispatched to other battalions, or unavailable

for an interview at that time. The age of our interviewees ranged from 20- to 30-years old. Six physicians were male, one of the interviewee was female.

Semi-structured interviews were conducted during the field study. Interviewees were asked to report problems they had had with the system in different field situations, and to propose improvements they would like to see in the device/system for its' use in the field. Interviewees were also asked to show how they would use the device in situations encountered in the exercise of their military duties. The interviews were video-taped as a means to capture contextual information, and to let the interviewees show how they use the system in various situations.

3.3.2. Results

In this study, we learned more about field operations requirements in military medicine, along with mobility, device and database properties and features. learnability and safety requirements. This field study was also a good opportunity to gather improvement suggestions for use of the phone in field operations. Along the questions that were asked, the physicians underlined critical features and properties of the system that would fit their needs.

The findings suggest that military physicians welcome the mobile system as way to access medical knowledge and information in very specific situations - (i) check information during patient treatment, (ii) review of physicians' own knowledge and (iii) training situations - whereas the system shows its limitations in other situations - (iv) support for diagnostic, and (v) crisis situations; in such situations physicians will use their own knowledge and the system will eventually be used as a last resort.

Special attention should be paid to increasing the phone's robustness and durability, and the battery life. Also, a protection case is needed so that the device is more suitable for military field conditions. The device size proved to be optimal, but the use of an alternative device, such as a PDA, could be considered.

The results show that there is a need to fine-tune the usability of medical databases, by adding functionality and support to bookmark frequently or recently needed information. In our study, previous use of similar systems and databases was a factor enhancing the learnability of the system.

4. Findings & Recommendations

All in all it must be said that military physicians received the mobile medical information systems very positively. All investigated aspects of usefulness and ease of use received high scores in all of the three surveys. The scores seem to have a tendency to go down with time – however, they remain consistently high during the whole 7-month period of study. This indicates a high degree of usefulness and ease of use. The amount and frequency of use declined somewhat during the period of study, indicating

that in the beginning of the study there was perhaps more "getting to know" use of the system, whereas, by the end of the study the use was more "professional". The longitudinal study on system performance revealed that the results after three months of use (Dec. 05) were higher than the results after about 7 months of use (Apr. 06). This indicates that after more use the system was perceived to be less functioning, perhaps more "bugs" and other inflexibilities had come to light. Even with this negative overall trend in system performance the scores remained high or average, and on some occasions, even got higher. This was true for issues of quality, which can be interpreted as the system having given the military physicians a sense of security by giving them a possibility to refresh their memory on different issues, and this possibility having become a habit (a process). The results on the quality of the information remained quite stable, which is a very reassuring sign of trust in the capabilities of a mobile medical IS and the quality of information that can be stored in such systems.

The complete list of findings and recommendations derived from the usability study can be found in Appendix 4.

5. Acknowledgements & Publications

The project staff would like to acknowledge the support and co-operation that it received Prizer Finland Oy in the form of covering travel expenses and most importantly in giving the Nokia 9210 Communicator devices to be used in the project. Equally important has been the co-operation of Duodecim Publishing Ltd. that gave the project the right to use, free-of-charge, the mobile medical database software.

The project would not have been possible without the co-operation and help of Captain Sami Friberg from the Finnish Defence Forces; he acted as the host of the researchers in many occasions and organized the interviews in field conditions. We also thank the medical doctors undergoing their military training for accepting to be a part of this study. We want to extend thanks to Joanna Carlsson for her great help on getting the data from paper to a digital format.

The results of the project have so far been reported in six published or pending papers:

Han S., Harkke V., Tetard F., Collan M. (2007): *The performance of a mobile medical information syste: assessments from physicians in military service*, Journal on Information Technology in Healthcare, 5(3), pp. 171-181

Han, S., Harkke,V., Collan, M., and Tetard, F. (2006): *The performance of a mobile medical information system: a preliminary assessment from physicians in military service*, Proceedings of the 6th Nordic Conference on eHealth and Telemedicine. 31 August-1 September, 2006 Helsinki, Finland

Han, S., Harkke,V., Collan, M., and Tetard, F. (2006): *Usage of a mobile medical information system: an investigation of physicians in military service*, Proceedings of Bled2006, June 5-7, Bled, Slovenia

Tetard, F, Han, S., Collan, M., and Harkke,V. (2006): *Smart phone as a medium to access medical information: a field study of military physicians*, Proceedings of Helsinki Mobility Roundtable 2006, June 1-2, Helsinki, Finland

Han S., Tétard F., Harkke V., & Collan M. (2007): *Usability evaluation of a mobile medical information systems for military physicians*, Proceedings of the 40th Hawaii International Conference on Systems Sciences.

Tetard F., Collan M., Han S., Harkke V., *Usability Evaluation of a Mobile Medical Information System for Military Physicians: a Field Study*, Journal of Usability Studies, (under review)

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Appendix 1 – Questionnaire on perceived usefulness and perceived ease of use

Please circle your response to the items measured by using the 5-point Likert scale. 1=Strongly disagree; 2= somewhat disagree; 3= Neutral (neither disagree nor agree); 4= Somewhat agree; 5= Strongly agree.

1. Using the mobile package improves my medial knowledge.

1 2 3 4 5

2. Using the mobile package enhances my effectiveness to do clinical work in the field conditions.

1 2 3 4 5

3. Using the mobile package improves my ability to make good decisions.

1 2 3 4 5

4. I find the mobile package useful for me.

1 2 3 4 5

5. Learning to operate the mobile package is easy for me.

1 2 3 4 5

6. I find it easy to get the mobile package to do what I need to do.

1 2 3 4 5

7. It is easy for me to become skilful in using the mobile package.

1 2 3 4 5

8. I find the mobile package easy to use.

1 2 3 4 5

9. On the average, I use the mobile package:

1. I don't use it at all. 2. About once a month. 3. About once a week.

4. Several times a week. 5. About once a day. 6. Several times a day.

10. Please specify (estimate) how many hours each WEEK you normally spend using the mobile package?

___. <0, 5 hours;___. 0, 5-0, 9 hours; ____ 1, 0-1, 9 hours;
____. 2, 0-2, 9 hours; _____. 3, 0 or more hours

Appendix 2 – Constructs and sub-constructs used in the questionnaire on system performance

Information Effectiveness	**System Performance**
1. Intrinsic quality of information	*1. Impact on job*
Interpretable	Makes it easier to do your job.
Understandable	Improves your job performance.
Complete	Improves your decisions.
Clear	Gives you confidence to accomplish your job.
Concise	Increases your productivity.
Accurate	Increases your participation in decisions.
Secure	Increases your awareness of job-related
2. Contextual quality of information	Improves the quality of your work.
Important	Enhances your problem-solving ability.
Relevant	*2. Impact on external constituencies*
Usable	Improves the patient's satisfaction.
3. Presentational quality of information	Improves patient care.
Well organized	*3. Impact on internal processes*
Well defined	Speeds treatment delivery.
4. Accessibility of information	Streamlines work processes.
Available	*4. Impact on knowledge and learning*
Accessible	Facilitates collaborative problem solving.
Up-to-date	Facilitates collective group decision-making.
5. Reliability of Information	Facilitates your learning.
Reliable	Facilitates collective group learning.
Verifiable	Facilitates knowledge transfer.
Believable	Facilitates knowledge utilization.
Unbiased	*5. System usage characteristics*
6. Flexibility of information	The mobile package has fast response time.
Can be easily compared to past	The mobile package downtime is minimal.
Can be easily maintained	The mobile package is well integrated.
Can be easily changed	The mobile package is reliable.
Can be easily integrated.	The mobile package is accessible.
Can be easily updated.	The mobile package meets your expectation.
Can be used for multiple purposes.	The mobile package is cost-effective.
Meets all your requirements	The mobile package is responsive to meet your
7. Usefulness of information	The mobile package is flexible.
The amount of information is adequate.	6 *Intrinsic system quality*
It is easy to identify errors in information.	The mobile package is easy to use.
It helps you discover new opportunities to serve patients	The mobile package is easy to learn.
It is useful for defining problems.	It is easy to become skilful in using the mobile
It is useful for making decisions.	
It improves your efficiency.	
It improves your effectiveness.	
It is useful for identifying problems.	

Appendix 3 - Questions for the field interviews

(i) How physicians learned to use the system

(ii) The frequency of use of the mobile medical information system:
- How often is phone used? How many times per day, per week …?
- How often are the mobile databases used?
- Are there such features that have never been used? Why?

(iii) The situations of use encountered most frequently and the benefits associated to the use of the system:
- What are the situations when the mobile databases are used most often?
- Describe the situations in their context (what, where, when, how, and why)
- Is the phone intrusive with respect to other medical activities?
- In what situations are the mobile databases the most useful?

(iv) The characteristics and the features of the medical databases:
- Navigation issues in the databases
- Are the most important functions easily available?
- Is there a need for additional functions?
- The use of colors in the interface
- Easiness in finding information – Failed searches
- Missing information
- Quality of the information: accuracy, completeness, up-to-datedness
- Usability of the system in crisis situations

(v) The properties and the features of the device:
- 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? Where and how is it kept?
- Battery life

Requirements	Findings	Recommendations for improvement
1. Situations of use / Context		
1.1. Check information about drugs	Physicians use the system as their last resort, if they really need to be sure about a prescription.	Access to drug information should be fast, as this situation would occur during the treatment of a patient
1.2. Review of physicians' own knowledge	Situation encountered frequently. Situation occurs when a physician has some time off in the course of his daily activities.	
1.3. Training situations	Situation encountered seldom, but proved to be beneficial	Add content that would promote training and learning situations (e.g. first-aid procedures, checklists…)
1.4. Search for contact information	Useful to find and locate health care resources	
1.5. Support for diagnostic	Physicians use primarily their own knowledge, but the system can be useful when a case is not clear-cut (e.g., disease diagnostic, treatment procedure,…)	In its current version, the system does not provide support for diagnosis, the addition of this functionality to a new version should be investigated.
2. Field operations requirements		
2.1. Humid, dry, or dusty environments	Device is vulnerable to humidity, even when protected by a standard phone cover	The phone or the cover should be designed to protect against humidity.
2.2. Use in dark	The device is difficult to use, especially input is clumsy.	A backlit keyboard is needed.
2.3. Cold weather conditions	Cold weather reduces battery life significantly.	Improved battery power management
3. Mobility requirements		
3.1. Battery life	Charging possibilities are scarce in the field; battery should last at least a week in the field	Improved battery power management
3.2. Portability	Device size is optimal; it could be somewhat smaller but at the expense of the keyboard.	If device is to be smaller, then it should offer alternative input mechanisms.
3.3. Connectivity	Connectivity features were not used in the current version of the system	Explore how connectivity could enhance physicians work
4. Device properties and features		
4.1. Screen properties	Users expressed the need for a larger screen or for a screen oriented vertically.	Screen can be made larger but not at the expense of the overall device size. A vertically-oriented screen might improve readability, but would set new constraints in respect with input mechanisms.
4.2. Keyboard properties	Keyboard size was good and could be even smaller.	
4.3. Robustness / Durability	Physicians feared that the device would easily break down in field conditions	The device should be made of more robust materials
5. Database properties and features		
5.1. Navigation	Users, who are familiar with Terveysportti, did not experience any problems. Users have a mental map of what information is available and where to locate it.	A number of shortcuts and a record of earlier searches would enhance navigation.
5.2. Functionality	Users thought that basic functionality is available	According to user requests: (i) search by active substance, (ii) bookmark frequent searches or pages
5.3. Quality of information	Users assessed that information is accurate and up-to-date; some bits of information were missing (pictures and tables)	Newer version should include all tables and pictures
6. Learnability	Users are familiar with the basic functionalities of the device; previous use of Terveysportti enhance learnability	
7. Safety	No loss of data was reported; wireless security was not tested as the system does not require the use of wireless communications in its current version	Future versions of the system, which might include wireless update as a feature, should be thoroughly tested in military field settings.

Appendix 4- Usability study - findings and improvement recommendations

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