Ville Harkke

Knowledge Freedom for Medical Professionals – An Evaluation Study of a Mobile Information System for Physicians in Finland

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Åbo Akademi University
Turku Centre for Computer Science/
Institute for Advanced Management Systems Research
Lemminkäinengatan 14 B, FIN-20420 Åbo
Finland

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Supervised by

Prof. Dr. Christer Carlsson
Department for Information Systems
Åbo Akademi University
Åbo, Finland

Prof. Dr. Pirkko Walden
Department for Information Systems
Åbo Akademi University
Åbo, Finland

Reviewed by

Prof. Dr. Urban Nulden
Viktoria Institute
Göteborg University
Gothenburg, Sweden

Prof. Dr. Matti Rossi
Department of Management
Information Systems Science
Helsinki School of Economics
Helsinki, Finland

Opponent

Dr. George M. Giaglis
Department of Management Science and Technology
Athens University of Economics and Business
Athens, Greece

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"The creation of wealth is certainly not to be despised, but in the long run the only human activities really worth while are the search for knowledge and the creation of beauty. This is beyond argument; the only point of debate is which comes first."
-Arthur C. Clarke, 1962

Abstract

The health care industry in the industrialised world is facing increasing pressures from changing demographics and scarce financing. As other businesses have been embracing the new information technologies, the health care sector has been somewhat lagging behind. One explanation to this is that fixed computer terminals are not perfectly suited to the work environments of the health care professionals. The emergence of mobile systems provides a potential remedy to this problem. Mobile systems could support health care work in ways that were impossible with the fixed terminals. There remains numerous problems connected to the information infrastructure and work processes that are not affected by mobilising information, but the potential of mobile systems is indisputable.

This thesis sets out to explore the possible effects of mobile technology in health care by presenting an evaluation of a mobile information system for physicians. The evaluation is intended to capture all of the effects the system under study has on physicians' work, thereby revealing some underlying mechanisms of mobile systems usage and potential for medical professionals. The system studied here, the Duodecim Mobile Package for the Nokia 9210 Communicator, consists of searchable databases containing general medical knowledge.

The impact of any new system or technology can be measured in its ability to change the structures of everyday life. The system evaluated here has a limited effect on these, mainly because of limitations in the contents and functionalities of the system and poor fit to the everyday routines of the users. Outside the routines the system performs remarkably well and definitely serves a purpose. As the system is mobile the usage contexts and usage patterns are numerous. The usage is concentrated to situations where the benefits of the system are most obvious, but the system is used even in unexpected surroundings. The main drivers for using the system are its usefulness in various situations and the quality of its contents.

Keywords:

Electronic healthcare, Information Systems Evaluation, Mobile Systems, Mobile Work, Technology Acceptance

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Part II The Original Research Publications

1: Harkke Ville and Landor Pär: Mobile E-Health - the Challenge of Eight Obstacles, *Proceedings of IFIP WG 8.3 Open Conference on Decision Making and Decision Support in the Internet Age (DSIage 2002), July 4-7, 2002*. Oak Tree Press, Cork, Ireland 2002, pp.625-634.

2: Harkke Ville and Collan Mikael: Structures Surrounding e- Health: Effects of Legal and Administrative Structures on Development of IT in Health Care Services - focus on Finland, a chapter in "*Human Organizational Dynamics in e-Health: A Global Perspective*", Editor(s)David Bangert, Robert Doktor, and Michael Valdez (Assistant Editor), Radcliffe Medical Press, 2004, pp.71-82

3: Han Shengnan, Harkke Ville, Mustonen Pekka, Seppänen Matti and Kallio Markku (2004): Physicians' perceptions of and intentions to a mobile medical information system: a descriptive analysis, *Innovations Through Information Technology: Proceedings of the 15th Information Resources Management Association International Conference* New Orleans, *USA, 23-26 May 2004,* Editor: Information Resources Management Association, USA 2004, pp. 954-957

4: Han Shengnan, Harkke Ville, Mustonen Pekka, Seppänen Matti and Kallio Markku (2004): Professional mobile tool: A survey of Physicians' perceptions of and attitude towards a mobile information system, *Proceedings of the 5th GITM conference*, San Diego, 13-15 June, 2004, Global Information Technology Management Association, Greensboro, U.S.A., pp. 120-123

5: Harkke Ville (2005): Physicians' Usage Experiences of a Mobile Information System, *Proceedings of the 38th Annual Hawaii International Conference on System Sciences(CD-Rom)* 03-06 Jan. 2005, Editor R.H. Spregue jr, Computer Society Press 2005, IEEE, los Alamitos 2005, 6 Pages

6: Harkke Ville: Impacts of Physician's Usage of a Mobile Information System, Submitted 19.12.2005 for publication in the *International Journal of Electronic Healthcare*

Part 1 The research summary

Chapter 1 Introduction

This work sets out to explore the use, possibilities and potential of a mobile information system in a health care setting in Finland. The study is done under the research paradigms of information systems research. The focus of the study is partly on the behaviour of professionals in professional organisations - especially medical professionals, and partly on mobile systems in general and a mobile information system for physicians in particular. The mobile systems are expected to create benefits in form of knowledge mobilisation or knowledge freedoms, and the emergence of these is the phenomenon of special interest here. The creation of knowledge freedoms is explained by means of a case-study of a mobile information system for physicians in Finland. The purpose of this study is to clarify the advantages and disadvantages provided by mobile information systems in a professional health care setting, help in conceptualising mobile systems for professionals and to clarify the factors affecting implementation, usage and impact of such systems.

1.1 Conceptual framework

When studying any phenomenon in the real world, the study is based on previous knowledge about the phenomenon in question or similar phenomena. This previous knowledge takes many forms, but the main need for previous knowledge lies in the conceptualisations of reality. This work is based on the following concepts:

- *information systems research paradigm* which defines the points of interest in this work,
- *organisations and professionals* as the key actors in the process described in this work,
- *knowledge work and medical information defining* for the work processes and information needs of the physicians under study,
- *information systems evaluation* which defines the types of information possible to extract in a study like this,
- *mobile information systems* which defines the nature of the artefact under study and
- *knowledge freedoms* that are the possible outcomes of implementing such systems.

The system and its implementation are scrutinised from the perspectives made possible and formed by these concepts. In the following sections 1.1.1-1.1.6 I will briefly introduce and explain the key concepts, which will form my conceptual framework.

1.1.1 The field of information systems

The emergence of a post-industrial society where information has replaced the former physical products, one of the most important social changes has been the movement towards an information society. As technological development has enabled tremendous changes in the ways people use and create information, the fields of information management and information systems (IS) gain in importance. However, the field of information systems is not clearly defined. Research in information systems has its roots in information technology research and organisations research (which is a subset of social sciences). The starting point for any research in IS is, naturally, an information system. An information system can be defined as "a collection of components that collects, processes, stores, analyses and disseminates information for a specific purpose" [Turban et al. 1996, p.7].

IS Research is not concerned solely about the systems themselves. "The core concern of the field can be taken to be the orderly provision of accessible information support for people acting purposefully, often, though not exclusively in an organisational context." [Checkland and Holwell 1998, p.218]. This definition directs the attention of a researcher towards the concepts "organisation" and "information", both of which are problematic. The cross-disciplinary nature of Information Systems Research has created a multiplicity of theoretical constructs that allow any phenomena to be studied from a number of distinctive perspectives [Benbasat and Zmud 1999]. The field has its roots partly in the traditional social sciences and partly in engineering and mathematics disciplines.

Ahituv and Neumann (1982) list a set of 18 separate fields that intersect in the field of Information Systems. These fields belong to three main disciplines; 1) "Exact" sciences comprising general system theory, control theory, mathematical economics, decision theory, management science and statistics, 2) Technology in the form of electrical engineering, computer science and information theory and 3) Social Behavioural sciences containing sociology, cognitive psychology, management theory, organisation theory, economics, political science, psycholinguistics, organisational behaviour and philosophy.

Organisations are studied partly as units with a coherent mind of their own, and partly as collections of individuals acting on various social and psychological issues. The behaviour of organisations can be understood on multiple levels. Since all organisations are organically developing at all times and differ significantly from each other, organisational studies are lacking in generalisability. There does, however, exist some general patterns of human

behaviour that can be predicted and projected from one situation to another. These general rules are not precise, and they cannot be studied in laboratory environments. Despite this there is a deeply felt relevance of such rules for information systems research. The core of the research discipline can be seen as instrumental, as the main goal for information systems research is to identify phenomena surrounding efficient use of information, aided by technology or not. This instrumental aim does not require extreme accuracy or generalisability of the theories, the main driving force being relevance in fast changing environments.

1.1.2 Organisations and professionals

An organisation, for the purposes of this study is an entity consisting of people and resources, structured and created to achieve a goal. Turban et al.(1996) defined organisations as "Human-designed and human-controlled systems made of people, equipment, inventory, and procedures arranged to interact to accomplish one or more objectives" [Turban et al. 1996 p.102]. A professional organisation is an organisation consisting of professionals and other supporting personnel.

Professions are occupations that have achieved professional status of special power because of their special competence in esoteric bodies of knowledge [Sharma 1997]. The people occupying these professions are coined professionals. Many privileges come with achieving professional status through the exclusive license to practice, among them, professional autonomy is the most important. With such autonomy, professionals are trusted to work conscientiously without supervision as well as to undertake the proper regulatory action on those rare occasions when an individual does not perform his work competently or ethically. As a result of professional autonomy, job performances of professionals are established through peer review processes. The medical profession enjoys more professional status than almost any other profession [Succi and Walter 1999]. A professional position cannot exist unless it is believed that the tasks they (professionals) perform are so different from those of most workers that self-control is essential [Freidson 2001].

Professionals, especially medical practitioners, may differ from the rest of the population even in their usage of and attitudes towards IS [Chau and Hu 2001].

A subset of professionals is the group of physicians. There are 17522 physicians in Finland (March 2003) of which 15 271 are in active work. 42% of those have at least one secondary occupation. The working physicians are divided into different workplaces a follows: 47% in hospitals, 22% in health care centres, 7% in research and education, 3% in open care offices etc, 5% in occupational health care, 10 % in private practices and 6% in other physician's occupations. [Suomen

Lääkäriliitto 2003]. The work structure of a typical physician consists of patient consultations (in average 76% of work time), administrative tasks (10%), teaching and research (8%) professional education (3%) and other tasks (3%) [Suomen Lääkäriliitto 1999].

In Finland health care is basically organised around publicly financed organisations and supported by private institutions in larger cities. The universal health insurance provided by the Social Insurance Institute of Finland (SIIF) covers use of the public health care services fully and a percentage of the privately produced services [Suomen terveyspolitiikasta 1999], for example 60% of the private physician's fees [SIIFinland 2002]. A certain level of health care is guaranteed by law for every Finnish citizen. Main responsibility for providing both primary and secondary care lies with municipalities. The primary health care services are provided by either independent municipalities or by joint health centres set up by a number of neighbouring municipalities. There are approximately 250 public health centres in Finland. They provide GP services, school healthcare, community nursing, long term care wards and free dental services [Mäntyranta et al. 2004]. The municipalities, 450 of them, have since the 1990's had the right to choose how the services demanded by law are produced, including buying the services from private service providers [Suomi and Tähkäpää 2002].

The private service providers act as a catalyst for restructuring even the public systems by showing in practice that the same services can be produced with a smaller use of resources.

Despite the existence of a universal health insurance, the citizens tend to be insured even in private insurance companies, either by themselves through home insurance healthcare packages (covering mainly accidents etc.) or by their employers. This complicates the administrative processes in cases of work-related illnesses, acute injuries and other situations where a patient is insured by several organisations.

Due to the independence of the municipalities the health systems in different parts of the country are very different from each other, all naturally providing the level of service required by law. In most districts there are organisations for everyday illnesses, for special care, in-patient wards etc. that have all been founded at different times and there is no generally applied organisational structure even within the municipalities or health districts. The existence of different organisational cultures within the bigger health care structures cause some administrative problems of their own, but even makes development of information systems difficult due to differences in work processes and information requirements.

Information systems compatibility is a major issue in developing functional health care systems [Harkke and Landor 2002]. In Finland the fragmentation of information systems has been a major obstacle on the road towards systems that would markedly alter the processes of the health care system, increasing efficiency and effectiveness. This situation has been noted by the governing authorities, and the Ministry of Social Affairs and Health has started a project for preparing a nation-wide electronic health record system. The project is organised as a work group and the main objective is to define the contents and criteria for a national electronic health record system and to maintain a co-operation network for implementing the system. The workgroup presented a strategy to the Minister of Social Affairs and Health in January 2004. This strategy contains standards for data structures, data communication protocols and data security that are to be implemented by all health centres and hospitals by 2007 [Ministry of Social Affairs and Health 2004]. This provides the public sector with not only a more secure environment for investing in information technology but even with a direct incentive to do so.

1.1.3 Knowledge work and medical information

A knowledge worker is anyone who works for a living at the tasks of developing or using knowledge. A term first used by Peter Drucker in his 1959 book, *Landmarks of Tomorrow*. Drucker defines knowledge work as comprising those jobs in which "…incumbents work more with their heads than with their hands." [Kelloway and Barling 2000]. There are views on knowledge work that would exclude the normally practicing physicians: "any creative systematic activity undertaken in order to increase the stock of knowledge of man, culture and society, and the use of this knowledge to devise new applications. It includes fundamental research … applied research … and experimental development work leading to new devices, products and processes" [Despres and Hiltrop 1995]. However, the knowledge component of medical practice is extensive. This is clearly indicated by the amount of training required for medical practice, and the need for physicians to continuously update their knowledge. The knowledge workers can even be defined as a group of people in certain professions that require professional knowledge: "knowledge workers are … a group that includes scientists, engineers, professors, attorneys, physicians and accountants" [Nomikos 1989, p.165]. Furthermore the physicians can be seen as knowledge workers as they are constantly applying their knowledge on curing people: "knowledge work is understood to comprise … the application of knowledge" [Kelloway and Barling 2000, p.287].

1.1.4 IS evaluation

Smithson and Hirscheim (1998) argue that evaluation is endemic to human existence and hence an automatic response to a changing situation, especially in the case of IS, as there have been dramatic organisational changes associated with IS as well as layers of exaggerated benefits and hype encasing new information technologies.

Information systems evaluation has been one major part of IS research since the very beginning. The evaluation field is as cross-disciplinary as the overall field of IS research. A system can be evaluated from a purely technological perspective, from a management perspective, an economics perspective or a sociological perspective. For most decisions made about IS one does not necessarily need to apply all of the possible methods. Some aspects of a system and its usage are easily quantifiable, as the cost of hardware and installation, the level of usage among the users or the changes in productivity for some specific process after installing a system. Some aspects of a system are, however very elusive and cannot be quantified in a meaningful way. These are the hidden costs of learning to use a new system, immeasurable changes in service quality and the like.

The evaluation of any IS can take place on a number of different levels. The system and its effects can be evaluated on at least the following levels: macro, sector, firm, application and stakeholder [Smithson and Hirscheim 1998]. Apart from this, the basis on which the evaluation is performed defines IS evaluation. Grover et al. (1996) defined three evaluative referents: comparative, normative or improvement. The comparative judgement attempts to compare the effectiveness of a particular system with other "similar systems" The normative judgement compares the system against a theoretical ideal system - or in essence against "best practice". The improvement judgement assesses how much the capabilities of a system have improved over time .

Cronholm and Goldkuhl (2003) make a similar distinction, dividing evaluations in goal-based, goal-free and criteria-based. The goal-based evaluations use goals from the organisational context to measure the IT system, goal-free evaluation is an inductive and situational strategy, and the criteria-based evaluation uses some explicit general criteria as a yardstick. Furthermore, evaluation can be of at least three possible types: process evaluation, response evaluation and impact evaluation. The *process* approach evaluates the efficient use of resources, the *response* evaluation assesses the reaction of the individual or the organisation to the IS and the *impact* evaluation assesses the direct effects of IS implementation on individual and organisational performance. Of these three the impact

evaluation is the most comprehensive and the most difficult to assess [Grover et al. 1996].

1.1.5 Mobile information systems

The emergence of wireless electronic communications along with miniaturisation of electronic devices has led to development of electronic information systems that can be accessed with a variety of portable terminals. The terms mobile, wireless, portable and even ubiquitous have all been used to describe a type of devices and systems [Basole 2004].

A good working definition of a mobile information system has been coined by Upkar Varshney (2003). According to him, mobile wireless information systems can be described as "systems involving mobile devices, users, wireless and mobile networks, mobile applications, databases and middleware" [Varshney 2003, p.155]. The use of mobile systems in any business is an extension of electronic business (E-business or e-commerce). "Mobile commerce is the term for the extension of electronic commerce (ecommerce) from wired to wireless computers and telecommunications and from fixed locations to anytime, anywhere and anyone" [Keen and Mackintosh 2001, p.3].

1.1.6 Knowledge freedoms

According to Keen and Mackintosh (2001) mobilising information by the new technologies is naturally not a goal in itself. The new systems are expected to create value in the context they are used. The value imperatives for organisational development provided by the mobilised systems can be realised in three different levels: customer relationships where exploiting the new communication systems can create *relationship freedoms* and thus add value to the customer relationship, logistics and supply chain management where mobilising as many people, information items and communications can create *process freedoms* needed for effective process redesign, and finally the knowledge mobilisation, where bringing the information, communication and collaboration to the workers where and when they need them, instead of their having to go to the sources themselves, creates *knowledge freedoms* capable of adding value to the organisation and its workers.

1.2 Motivation

Health care is a very important sector of our society. The sector has been fast in adopting state-of-the art technologies in the clinical and research fields but the information management side of the processes has been automated very slowly compared with most other major sectors of the post-industrial society [Wickramasinghe and Mills 2001b]. The reasons for this are not perfectly clear, but as the healthcare systems in industrialised countries will face huge challenges from the changing demographic structure of the population and rising health care costs [OECD 2004] the efficiency of health care systems and organisations must be improved. One possible way to achieve this is to change the work processes in health care and to take full advantage of the already- existing technologies that could markedly decrease the costs of information-handling in health care. The technologies themselves are not, however, enough. Some new systems are designed to follow the old work processes and therefore have an impact on the efficiency (the speed and effort use on different tasks) of the organisations but very little effect on the effectiveness (the purposefulness and choice of the tasks and processes themselves) of the same. Furthermore, introducing new electronic systems does not automatically lead to usage of them, and even if the systems are widely used, their impact may be limited due to organisational reasons.

There are a number of non-technological barriers to changes in work processes and these are very distinctly visible in the health care sector. The intended users of the systems will go through stages of accepting change and the human side of the equation is equally important as the technological [Lorenzi 2004]. Even as the main objective for introducing new technologies in any field is to enable change and increase efficiency or reduce costs, the new systems must fit into the environment and the mentality of the users. The desktop computer-based systems in health care have faced difficulties that are only slowly being overcome, issues ranging from a lack of computer literacy among the practitioners to the computer terminals causing the physicians to focus their attention away from the patients. The emergence of mobile systems and tools has provided yet a new way to introduce electronic systems to health care settings - the progress seems to move from e-health (electronic health systems) to mobile e-health.

This work sets out to gain insight into how and why mobile information systems are actually used by Finnish physicians. The potential of these systems to change the processes of health care is currently unclear. By studying the usage of a system and its impacts it is possible to identify the areas of medical work where the impacts of mobile systems are beneficial.

The work processes of individual physicians could probably be arranged more efficiently, and the whole organisation of health care is continuously seeking new ways to provide the services needed by an aging population. By exploring the possibilities of mobile information systems and knowledge mobilisation in general and evaluating a pilot system and its impacts on the work of physicians I hope to give the IS community and the health care organisations new knowledge on how mobile information systems in health care settings are actually used and which factors are important for the design of new systems.

1.3 The research questions and focus of the research

The purpose of this study is to clarify the advantages or disadvantages provided by mobile information systems in a professional health care setting. The advantages (or disadvantages) of such systems should be recognisable as the value the system in question provides. This value can be measured either as individual - as the value a single user perceives the system to have - or general, in terms of the advantages for the larger context- the health care organisation or the society as a whole. One possibility is to study the relation of the costs of implementing the new methods and the benefits of it, measured in monetary savings or other quantitative parameters [Severens 2003]. The advantages may be direct or indirect and only some of the aspects of value can be captured by a cost-benefit calculation. Furthermore, a simple cost-benefit calculation provides little knowledge about the underlying mechanics of value creation in a given context.

Value as such is an evasive phenomenon. There may be intrinsic values that avoid being recognised. When trying to assess the value created by a mobile system one has to be able to distinguish between the value created by the contents of the system and the value created by the mobility of the system. A case study of a mobile information system developed for physicians by Duodecim Publishing Ltd is used in this study to clarify the essence of mobile IS. Because the contents of the case system are available in other forms (including printed books, CD-ROM based searchable databases and Internet content), this case offers a unique opportunity to distinguish the characteristics of the mobile application from those of similar applications available in a desktop environment.

When assessing aspects of technology that are not directly quantifiable one has to rely on research methods that have their origins in the social sciences. The value of mobility in case of medical information is by its nature rather diffuse and hard to quantify. The health care setting makes the mobile system a tool for reaching some goals that may differ from individual to individual. The value of such a tool for a single physician may be quantifiable in saving time or gaining easier access to information. The value of the mobility is not constant even for a single individual: the context and the environment where the individual is working have a profound impact on the preferred (and even available) tool for fulfilling a task. Furthermore, the task itself affects the way in which information is accessed.

The main point of interest in this work is:

What kind of benefits (or drawbacks) arise from bringing medical information to mobile devices in a medical professional setting?

This is evaluated by means of the following sub-questions:

- What kind of impact can a mobile information system have on a medical professional's work?
- How is such a system used by practising physicians?
- What are the reasons for physicians to use the system ?
- How will the work processes of a physician be affected by using a mobile information system?
- In which specific settings and contexts in physicians' work does a mobile information system have most impact in their everyday routines?
- Which factors contribute to the system's usage and impact in specific contexts or what would be the determinants of contextual fit between the system and medical practice in Finland?

1.4 Plan of the thesis

This thesis is constructed as follows:
In chapter 2, the information systems field and the relevant methodological questions for this work are revised and explained. Chapter 3 discusses the field of medical information and the information needs of practising physicians. This field is related to the state-of-the art of electronic information systems and mobile systems in medicine. Chapter 4 introduces the perspectives on information systems success and impact that are currently used and revisits the mobile systems. An evaluation framework used to conceptualise the system and its usage and impacts is presented. The empirical studies of the Finnish health care environment as well as the usage and impacts of a pilot system are presented in chapter 5. The chapter also presents the key findings of the original research papers and discusses the usefulness of the evaluation framework presented in chapter 4. The final chapter 6 presents answers to the research questions depicted above and links this work to interesting future research topics. The original research papers are presented unabridged in part 2 of the thesis.

Chapter 2 Methodology

2.1 The field of information systems and a state of the art of IS research

As discussed in the introduction, the field of IS is ill-defined and heterogenic. Despite this, the basic paradigmatic beliefs that constitute the basis for IS research are identifiable. A paradigm is a construct that specifies a general set of philosophical assumptions covering for example: ontology or the nature of what is assumed to exist, epistemology or the nature of valid knowledge and methodology or the set of methods or techniques to assist people in undertaking research or intervention [Mingers 2003, p.559].

Introducing information technology in any environment is not a goal as such but the technology is expected to have an impact on the environment. The impacts may have different scopes and magnitudes but there is always a need or hope for improvement driving the choice of IT as a tool for doing things. One important aspect of information technology deployment is that IT enables fundamental changes in the way work is done [Scott Morton 1991, pp.11-12]. The projects aiming at organisational transformation through IT do, though, have a surprisingly low success rate [Ranganathan et al. 2004]. This makes it imperative to evaluate the systems in their contexts.

The aim of information systems evaluation research is to produce ever more detailed answers to the question of why an IS initiative works (better), for whom and in what circumstances [Carlsson 2003]. In this study the aim is exactly this: to find answers to why and how a mobile IS in a medical setting provides benefits or drawbacks and in which exact contexts.

2.1.1 Ontology

Iivari et al. (1998) suggest that the information systems research realm studies a world that consists of the following: information and data, information systems, human beings in their different roles of IS development and IS use, technology, and human organisations and society at large.

Burrell and Morgan (1979) define the two main ontological bases for research and knowledge creation as being nominalism and realism.

Nominalism assumes that social reality is relative, and the social world is mainly names, concepts, and labels that help the individual structure reality. These labels are artificial creations.

Realism assumes that the real world has hard, intangible structures that exist irrespective of our labels. The social world exists separate from the individuals' perception of it. The social world exists as strongly as the physical world.

When following the construct of Iivari et al. (1998) above, one notices that some of the concepts are social structures and some are closer to the natural sciences. In order to maintain a solid ontological ground this research follows the philosophy of critical realism, which establishes the existence of a reality independent of observation even in social sciences, while accepting the relativism of knowledge as socially and historically conditioned in the epistemological domain [Mingers 2004]. A more thorough discussion on critical realism in IS research can be found in Mingers (2004), Carlsson (2003) and Monod (2004). In this study the existence of the systems and the structures of reality are accepted as such but the attitudes and perceptions of the systems users are considered to be relative and subject to influence from their social environment.

2.1.2 Epistemology

Another apparent dichotomy in the research strategies lies on the epistemological level between the positivist and anti-positivist approaches.

Positivists believe that one can seek to explain and predict what happens in the social world by searching for patterns and relationships between people. They believe one can develop hypotheses and test them, and that knowledge is a cumulative process.

Anti-positivists reject that observing behaviour can help one understand it. One must experience it directly. They reject that social science can create true objective knowledge of any kind.

Early IS research was dominated by positivist, or more generally empirist epistemology, which sees science as explaining events that can be empirically observed. In the 80's and 90's another strata of research appeared beside the "hard" positivist approaches. The main one of these competing approaches is interpretivism [Mingers 2004, pp.87-89]. The debate between the representatives of the competing research traditions has been based on the idea of two or more research paradigms being incompatible. However, each paradigm has strengths and weaknesses and these can be combined meaningfully, creating a research

strategy called pluralism. This would allow for different paradigms to be applied in a research situation [Fitzgerald and Howcroft 1998, p.162]. This pluralist approach is consistent with the critical realist paradigm that does not reject either of the epistemological standpoints. This work follows the pluralist approach due to the context and aims of the study- some aspects of the system such as actual usage and usage situations are clearly demonstrable in a positivist sense, but the reasons of the users for their actions demand a more interpretive approach.

2.1.3 Methodology

The final dichotomy presented by Burrell and Morgan (1979) is the division between ideographic and nomothetic theory.

Ideographic inquiry focuses on "getting inside" a subject and exploring their detailed background and life history. Ideographic researchers involve themselves with people's normal lives, and look at diaries, biographies and observations.

Nomothetic method relies more on the scientific method and hypothesis testing. It uses quantitative tests like surveys, personality tests, and standardized research tools.

Because of the cross-disciplinary nature of the IS research it is common to use a combination of the basic methodologies. “Multimethodology is considered desirable for four main reasons: (i) the real world appears to be multidimensional and in each intervention consideration needs to be given to the material, social, and personal aspects; (ii) interventions themselves have distinct phases— appreciation, analysis, assessment, and action— that need different methods; (iii) the use of several methods can improve the reliability of results through triangulation; and (iv) using several methods improves the richness and variety of possible results” [Mingers 2003, p.560]. The research questions presented in 1.3 do require a certain richness of the results.

The philosophical foundations of IS research are sound and there is a choice of research approaches on multiple levels. The approaches are not mutually exclusive. It is possible and even desirable to use a set of methodologies anchored in different research paradigms.

2.2 Choice of research strategy

There are a number of possible approaches in IS research. The taxonomy suggested by Järvinen (2004) presented in figure 1 gives a good overview of these. The phenomenon under study as well as the context of the study place this study in the category of research stressing utility of artefacts, in the subset of artefacts-evaluating approaches. According to Järvinen, evaluation of instantiations, such as the mobile information system under scrutiny here, concerns "The efficiency and effectiveness of the artefact and its impacts on the environment and the users" [Järvinen 2004, p.116]. This does not only include the planned changes in efficiency and effectiveness, but also the emergent unanticipated outcomes that accompany the changes.

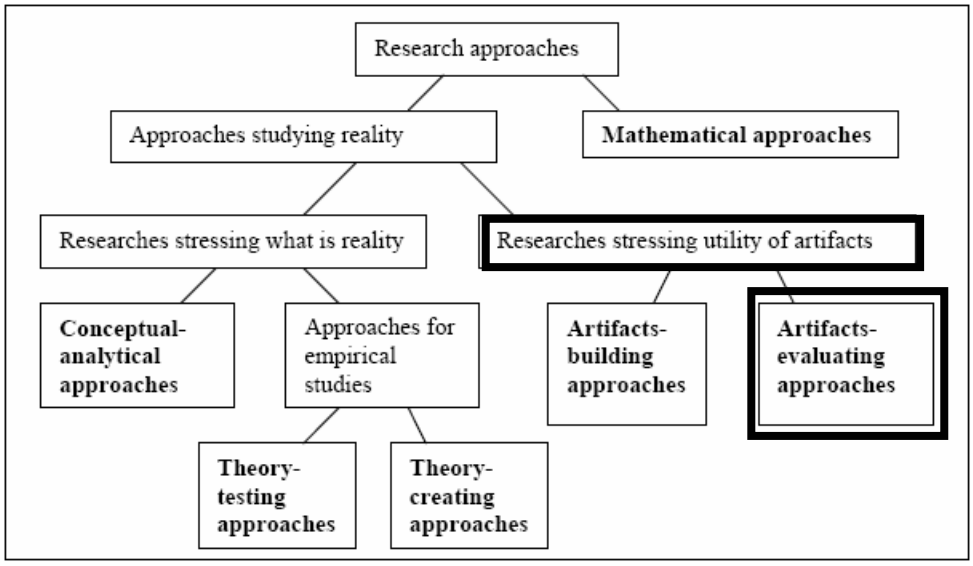

Figure 1

Järvinen's taxonomy of research approaches (Järvinen, 2004)

2.2.1 Evaluation methods

Evaluation methods can be classified in many ways but there are two distinctly different approaches, coined objectivist and subjectivist. The main difference lies in the philosophical orientation of the approach. The objectivist approaches follow the logical-positivist philosophy and the subjectivists follow the anti-positivist notion of importance of the observer. A typology developed by Ernest House (1980) describes four objectivist and four subjectivist approaches. The objectivist approaches include:

- Comparison-based evaluation where the resource in question is compared to a control condition,
- objectives-based approach which checks whether the resource meets it's designer's objectives,
- decision-facilitation approach which seeks to resolve issues important for developers for making decisions about the future of the resource, and
- goal-free approach where the evaluator pursues whatever evidence they can gather to enable them to identify all the effects of the resource, regardless whether intended or not.

The subjectivist approaches include:

- Quasi-legal approach where testimonies for and against the resource are evaluated,
- art critic approach where an experienced critic evaluates the resource, professional review, and
- responsive/illuminative approach which seeks to represent the viewpoints of the actual users and other key people in the environment of the resource [Friedmann and Wyatt 1997 pp. 25-29].

All of the possible approaches have their advantages, but some of them were ruled out for this study by the situation: comparison was practically impossible since there are no similar mobile information systems (however, comparisons to traditional means of information search were conducted). The design objectives as such would not give the researcher any idea of the impact of the system, the main point of this study. The system, although under constant development was as such not in a decision-critical situation even as the results of this study can naturally be used as a basis for future decisions. The subjectivist approaches would require resources in the form of experts and/or experienced critics and their suitability for answering my research questions is limited. A part of the study does border on the illuminative approach as the main source of information is the users of the system. In general this study falls under the description of goal-free evaluation as the impacts of the studied system were undefined in the beginning of the research.

The goal-free evaluation calls for a rich data content since the unexpected effects would go unnoticed if very strict criteria were used.

2.2.2 Case studies

A case study can be technically defined as an ”Empirical inquiry that:

- Investigates a contemporary phenomenon in it’s real-life context, especially when
- The boundaries between the phenomenon and context are not clearly evident
- Copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
- Relies on multiple sources of evidence with data needing to converge in a triangulating fashion, and as another result
- Benefits from the prior development of theoretical propositions to guide data collection and analysis” [Yin 2003, pp13-14].

A case-study has the advantage of giving the researcher an opportunity for a holistic view of a process [Gummeson 2000]. A holistic view considers the whole as more than its parts, claiming that reducing a phenomenon to small, well-defined parts does not create a complete picture. Consequently, the whole can be understood only by treating it as the central object of study.

Case study research has been widely criticised as inferior to methods based on random statistical samples of a large number of observations. The heaviest critique is on the possibility to generalise from case studies to larger populations. Instead of relying on mathematical approximations the possibilities to generalise from one single case are founded in the comprehensiveness of the measurements which makes it possible to reach a fundamental understanding of the structure, process and driving forces rather than a superficial establishment of correlation or cause-effect relationships [Normann 1970].

Given the goals of this work, the strategies it uses should take into account the need for comprehensive information and a holistic perspective suggested by Gummeson. An evaluation of a single mobile system does make a perfectly suited situation for a case-study, with multiple data gathering and analysis

methodologies used. Järvinen's notion about being able to capture even the unanticipated, emergent effects does require a flexible research strategy.

2.3 This study

The phenomena investigated in this study is clearly contemporary and the boundaries of the phenomena, especially on the industry-level, are not quite clear- as the mobile information system usage is expected to cause changes in the structures of the whole field of health care and the structure of the environment affects the usages of mobile systems. The number of variables of interest is large and there are multiple sources of information used in the analysis. The analysis and data gathering have relied on existing theoretical propositions and the results reflect this.

In this study I use only one case instead of attempting to gather information from several similar cases. Yin (2003) suggests that single-case studies are appropriate among other situations when the case is revelatory, i.e. it is a situation previously inaccessible to scientific investigation or when the situation is unique. The situation under study here falls clearly under this category: the system studied here is new and has not existed before and the study situation with a large number of actual users of the system is even unique in the world so far.

Any study is bound to have a unit of analysis. In order to create a rich holistic picture of the mobile information system and its usage and impacts, there are multiple units of analysis in this study: firstly the users or the physicians using and potentially using the systems, secondly the organisations in which the system is used and thirdly the system itself. The attributes of these three units interact and intertwine in a fashion that makes it necessary to take them all into account in order to explain the advantages of using a mobile information system. The users are studied in their work routines, behaviour, attitude towards the system, usage of the system and the changes in their routines the system has caused. The organisations are analysed in terms of potential for efficiency gains and as environments for systems development and usage. The system is described in terms of technology, purpose and usefulness in different situations as well as usability and functionality attributes.

Under the general strategy of case-study research, I have used a number of data collection and analysis methods. According to Järvinen (2004), the most typical data gathering techniques are interview, observation, questionnaire (survey) and written material.

Interviews (a conversation between interviewer and respondent with the purpose of eliciting certain information form the respondent) are further divided into formalised (structured) and informalised (semi-structured). The formalised interviews, where the interview structure and questions are predetermined and

rigid, are most suited for theory-testing research. The informalised interviews, which are not free discussions but not very formalised questionnaires either, are suited for theory-creating and constructive approaches. In evaluation studies the formalised interview is useful when the evaluation criteria are known and predetermined, otherwise an informalised method is recommended [Järvinen 2004].

Observations include visual and aural following of an object. Observations may be more reliable than what people say, particularly when people behave differently than they claim. Observation data is, however, time-consuming and difficult to interpret.

Questionnaires in paper or electronic form contain many structured or unstructured questions intended to be answered by a selected group of people. A questionnaire is the mostly used data gathering technique in survey studies, a theory-testing approach, but a questionnaire with open-end questions can be used in theory-creating and constructive research. The differences between structured and open-end questions in questionnaires are similar to the differences of formalised and informalised interviews above.

Written documents can be divided into primary and secondary sources. The primary are those which came into existence in the period under study, and secondary are interpretations of events of that period based on primary sources [Järvinen 2004]. Secondary material about the development of our society and technology is readily available. This material can be used as a background and a basis for IS development and evaluation.

The description of the Finnish health care sector and the infrastructure surrounding the mobile systems, which is presented in chapters 5.5. and 5.6, was obtainable by a literature study of written documents. Articles, statistics and other publications were used for creating a picture of the external environment for the development of mobile information systems in the Finnish Health care sector. A small survey was further used in order to clarify the views on electronic (e-health) systems of the industry actors.

Data about the pilot system usage and its impacts were gathered by :

1) Unstructured discussions with the developers of the system and its contents.
2) Secondary data gathered by the developers of the system in form of structured questionnaires.
3) Secondary data gathered by the sponsor of the pilot by telephone interviews.
4) Semi-structured field interviews of users of the system

5) A structured Internet survey of the users.

The analysis methods used are mainly qualitative. The basic goal of qualitative data analysis is understanding, i.e. the search for coherence and order [Järvinen, 2004, p.75]. This has been applied by searching in the data for:

1) Indications of coherence with the theoretical models and constructs used as a basis of understanding
2) Coherence between different implications of the same sub- phenomena
3) Indications of causal relationships in the data

Some quantitative measures are also used to measure the measurable qualities of the phenomena, such as usage levels, attitudes towards the system, impacts of system usage to time and effort used at work. Evaluating methodologies, i.e. comparisons of a desired state and an actual state were even employed.

Triangulation in social sciences means the application of two or more methods to the same research problems. If the results corroborate, the reliability of the results is likely to have increased [Jick 1979]. In the available material a search for similar patterns in data gathered with different methodologies was conducted, as well as search for patterns that are inconsistent with each other. Possible explanations for the inconsistencies are naturally considered.

According to Benbasat et al. (1987), the contextual and data richness of the study should be presented as fully as possible and a clear chain of evidence should be established. "The researcher's reasoning in establishing causes and effects should be clearly stated and defended" [Benbasat et al. 1987, p.374]. This richness is to be preserved both on the level of the whole case and the analysis of the sub-units within the case. Within-case analysis typically involves detailed case study write-ups for each site. These write-ups are often simply pure descriptions but they are central to the generation of insight [Eisenhardt 1989].

2.4 The research process

This work is the result of a process that has spanned a period of time and an evolution of perspectives. The original perspective was to find the advantages of mobility in a specific professional setting. This, however, called for an analysis of the underlying structures of the setting under study. The organisations in which medical work is conducted are very much connected to the rest of our society, and the rules and regulations governing the organisations and individuals are rigid. The health care sector is a special case when defined as an industry: the flows of finance and support for investments are subject to decision processes very unlike the processes in any other industry. Even the products of the industry are complicated: in a broader view the most effective health care system has made itself completely obsolete by removing all forms of illness and even discomfort from the population.

Apart from the organisations and the individuals in the health care sector even the computer systems are subject to strict regulations and the fragmented nature of the industry has created compatibility problems on top of the regulation-based problems. In order to clarify the level of readiness for new systems in Finland today I conducted a literature- interview-and observation study on the healthcare environment in Finland with the objective of clarifying the extent of possibility and feasibility of implementing mobile information systems. After this I set out to study an existing system that is in use by physicians in Finland. The system has interesting technological features but here I set out to define the system in terms of the impacts created by the mobility aspect of the system.

This process follows the realist evaluation approach. This evaluation strategy is based on a scientific approach to the construction of models of intervention described by Rom Harre in his 1984 book "The philosophies of science" [Kazi Mansoor and Spurling 2000]. When applied to IS evaluation research the critical realist approach attends to how and why an IS initiative has the potential to cause (desired) changes and seeks to understand for whom and in what circumstances (contexts) an IS initiative works through the study of contextual conditioning. The process begins with theory. Theory includes propositions on how the mechanisms introduced by an IS invention into pre-existing contexts can generate outcomes. After this a theoretical analysis of the context, mechanisms and expected outcomes is used to create a set of hypotheses about the outcomes, their contexts and the mechanisms enabling or inhibiting these changes. A multi-method data collection and interpretation then will possibly provide evidence of the IS intervention's ability to change the reality. Next, the theory is developed or the hypotheses refined. This process can run in multiple directions and the steps may

be repeated until satisfactory explanations are found [Carlsson 2003]. The single-case study strategy described above gains depth and validity through this iterative research process.

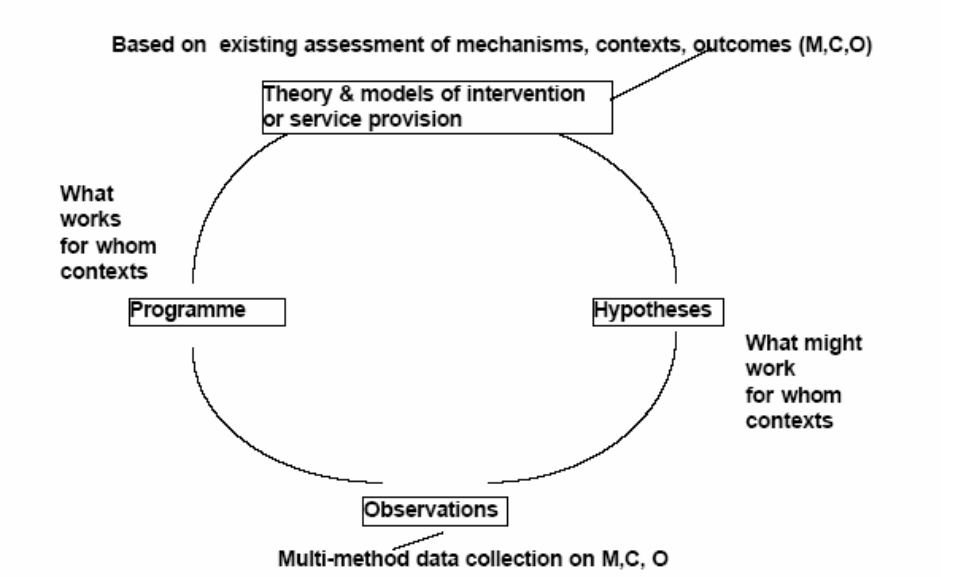

Figure 2 The realist effectiveness cycle (Kazi Mansoor et al. 2000)

In this work the starting point is the notion of mobile systems ability to change the real-world routines of physicians. The first set of observations, described in the research papers 1 and 2, define the environment in which mobile systems are developed in Finland - this set of data defines the limits of possible mobile solutions and the scope of impact that is to be expected. The second round of observations, described in the research papers 3 and 4, consists of surveys about the expectations of the potential users and highlights some aspects of the system and physician work that are to be taken into account during consequent steps of research. These findings are compared with the explanations provided by technology acceptance theories and IS success models, checking the fit between the models and reality, helping in developing loose hypotheses about the impacts of the system defined as a knowledge freedom- creating artefact. The third set of observations collects data about the actual usage of the system at hand, the usage situations and contexts as well as the needs and special expectations of different user groups in different situations. These observations are used to create a rich picture about the system and its impact potential, together with explanations of possible causal relations behind the impacts. These observations, as well as an

evaluation framework used to conceptualise the findings, are presented in the original research papers 5 and 6.

2.5 Relevance

This study is aiming at having a high relevance for the users and developers of mobile information systems and health care decision-makers. Benbasat and Zmud (1999) summarise relevant research as being focused on the concerns of practice, providing real value to IS professionals and applying a pragmatic rather than academic tone [Benbasat and Zmud, 1999, p.5]. The most relevant points for development of more efficient health care systems are the descriptions of the usage contexts for mobile tools for physicians and the explanations of the factors contributing to the impacts a mobile information system has on the work structure of a physician. For information systems research this work attempts to clarify the mechanisms contributing to systems usage and impact in professional settings by dissecting the usage situations and the needs that arise in different work contexts. An exploration of contextual fit between a system's attributes and the possible as well as actual usage environments and situations reveals several points of importance for future development of mobile information systems. The further relevance of this study is linked to the changes in our society the health care sector as a whole is faced with. Insight into how changes in tools and methods may affect physician's work may open new possibilities for reorganising medical work.

2.6 Validity and generalisability

Validity in essence means that a theory, model, concept or category describes reality with a good fit [Gummeson 2000, p.93]. In that sense a rich description of the processes in information systems usage does hold as much validity as a formalised, quantitative measurement of some aspects of the processes. The aim of this work is to provide a descriptive/explanative view of a social/technical phenomenon, and the measure of validity here should be the accuracy and extent to which this description and the proposed explanations of the mechanisms behind the described phenomenon reflect the nature of the phenomena in question. As case-studies are used as theory-generating rather than theory-testing research methods, this work does not attempt to validate the findings in a strict positivistic manner. The findings take the form of verified observations and a set of possible explanations that do call for further research in order to validate the general understanding of the phenomena at hand.

Chapter 3 The problem field

3.1 Medical information

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]:

- Information on particular patients
- Data on health and illness within local population
- 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].
- Information on local health care system
- Information on local social influences and expectations
- Information on scientific, political, legal, social, management and ethical changes that will affect medical practices

These types of information are needed in different settings. Some types of information can be considered time-critical in acute situations, and other types are more of a supportive nature, not needed in everyday practice. The use contexts and sources of information are depicted in table 1.

Information type	Use context	Main source
Patient-specific information	Point of care, Back-office	Patients themselves, patients' families, referring doctors, rest of care team, patient record, laboratory data
Population-specific information	Planning and administrative contexts	Public health departments
Medical knowledge	Point of care, education, back-office	Textbooks, journals, electronic databases
Information on local health care system	Point of care, administrative contexts	Local sources
Information on social and legal structures and changes in the environment	Education, administrative contexts, even free time	Diverse sources, local, national and international

Table 1 Types of medical information (adapted from Smith, 1996)

In a review of literature Jousimaa (2001) found that information needs frequently arise when physicians see patients. The questions that arise are most likely to be about treatment and drugs [Jousimaa 2001]. A large portion of the questions do, however, remain unanswered [Ebell 1999, Ely et al. 1999]. A possible solution to this problem is a tool that is easy to use, fast, portable and requires no excessive training or great technical skill [Fontelo and Ackerman 2004].

In a survey of perceived information needs of inpatient physicians and nurses McKnight et al. (2001) found that the physicians cited a majority of information needs related to patient-specific data. The surveyed physicians often pointed out that the information sources should be accessible on-line or on hand-held devices, whereas the nurses expressed concerns about web-based materials because some health care workers might not be able to access these materials. The comments imply that the required information in general is available but due to time constraints it is too difficult to obtain [McKnight et al. 2001].

On ward rounds a very large percentage of arising information needs are unmet. In an observation study Kubose et al. (2001) found that on teaching rounds the information needs were 34% patient information and 57% medical information. On teaching rounds the main source of information was naturally the other team members. As much as 80% of the attempts to find information from medical resources remained unsatisfied at the end of their observation, calling for better accessibility of information [Kubose et al. 2001].

Having access to up-to date- medical information can have a direct effect on the operational decisions made by physicians even in an operating room [Finegan 2004].

The emergence of electronic information sources has helped the situation slightly, but the electronic information retrieval tools have problems of their own. Apart from the behavioural obstacles such as difficulty in modifying the original question and uncertainty about whether all the relevant information has been accessed, Ely et al. (2002) found in their observation study of 103 family doctors in Iowa that there were two salient obstacles that have a direct effect on information systems development: the excessive time required to search for information and failure of a seemingly appropriate resource to address the topic.

The information needs of physicians, especially at the point-of-care are clearly not met by today's information retrieval tools. Development of future systems should place more emphasis on the specific requirements of clinical work both in the form of information content and in retrieval methods. The healthcare professionals are reported to be highly mobile in their work in a hospital setting, which suggests that supporting this mobility by wireless technologies might be beneficial [Coiera and Tombs 1998].

3.2 Electronic information systems in medicine

The first computerised systems in medicine were introduced on the hospital management side of the organisations. In the 1960´s and 70´s the first Hospital Information Systems (HIS) were developed. The early systems were focused on communicating orders for acute care and reporting results from ancillary departments such as pharmacy and laboratory. However, the functions of an HIS varied from institution to institution. Despite the success of the early systems, support for clinical care was limited in the 70´s and the 80´s. The survival factor of this era (in the U.S.) was in the fee-for-service reimbursement; therefore executives often implemented computerised billing first [Staggers et al. 2001]. In the late 1980´s the clinical side of information systems got into focus.

The current Clinical Information Systems (CIS) comprise a lot of functionalities of the early systems, but the backbone of a CIS today is the electronic patient record (EPR). The current EPR models, organized by time, by information source or by problem, offer an overview of patients' information [Weed 1997].

Besides keeping an electronic record of the patient's clinical information, the EPR also serves a number of functions in the administrative and financial management of a practice. It frequently offers the ability to generate diagnoses according to the International Classification of Diseases (ICD-10) [Wechsler et al. 2003]. A

properly designed and implemented CIS can facilitate many aspects of clinical management, clinical administration and general management, making a paperless system possible [Simpson and Gordon 1998].

Another stratum of information systems development is the Decision Support Systems for medical practice. Computerised decision support systems for medication ordering and provision of preventive care guidelines are the most common to have a positive effect on clinician performance [Kaplan 2001]. These applications are numerous and most of them are very specialty-specific.

The core of the present systems is a clinical information system, a multipurpose system for maintaining and accessing relevant information about the patients, processes, subsystems (i.e. laboratory, radiology etc.), and financial information. In Finland the market is dominated by VM-Data's Pegasos and Tietoenator's Effica. The solutions provided by these systems are very similar, for example the Effica system family offers the following components for hospitals:

- Patient Information System for hospitals
- Electronic Patient Records
- Operational Planning System
- Laboratory Information System
- Radiology Information System
- Picture Archiving System
- Administrative Systems

The different systems are intertwined and do function as decision-support systems when used properly.

3.2.1 Physicians' interaction with patients and technology

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 even increase the duration of the consultations themselves [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 computerisation 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 computerised 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 computerised 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 computerised systems are not successes despite their usage: in a cluster randomised 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 computerised 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.

3.3 Knowledge freedom for medical professionals

As presented in chapter 3.1 the medical professionals do have vast needs of information and knowledge in their work. Handling this information has become a large part of the medical professionals work. As the field of medical work is very knowledge-intensive there should be possibilities for creating knowledge freedoms with modern technologies in medical settings.

3.3.1 Data and information support

Physicians need clinical information during most consultations with patients and much of this need could be satisfied by online sources. However, selecting the pieces of information likely to be useful in a particular clinical situation is a major problem [Gardner 1997]. Data and information are available in various forms, ranging from textbooks and articles in professional publications to computerised systems and indexed bibliographies such as Medline, but using them and turning them to knowledge is time-consuming. Apart from the medical information needs the physicians need vast amounts of patient-related data. The most common form of computerised data support systems in hospitals are electronic patient records. "Computer-based patient record systems are designed to allow physicians to directly enter patient data, findings, and notes into a computer system that may be linked to hospital-wide databases and decision-support systems" [Patel et al. 2000]. The objectives of implementing such systems are found in replacing paper documents and improving access to information.

3.3.2 Knowledge support

The knowledge required is very context-specific. The information needs of a clinician are vastly different from those of an academic researcher. The clinicians require a wider range of material and they need a small representative sample of the information useful for decision making in a rapidly browsable manner [Gardner 1997]. Even the existence of primary care guidelines in concise form, either printed or electronic, does not necessarily mean that the physicians will explicitly use them. In their study Gabbay and LeMay (2004) found that the practitioners in primary care mainly rely on their knowledge in practice, a set of their own internalised "guidelines" constantly evolving by sharing information among their peers [Gabbay and LeMay 2004]. Creating and presenting knowledge in a usable way is one of the greatest challenges of knowledge support.

3.3.3 Decision support

Any decision a physician makes is based on knowledge. Earlier this knowledge was expected to be completely internalised and a medical doctor was to be able to recall a vast amount of knowledge acquired during education and previous practice in order to make well-informed decisions. As the cumulative body of medical knowledge increased the capacity of the human brain was no longer adequate for handling all of this knowledge. The first step to rationalise knowledge support was naturally printed material containing up-to date information about medical conditions. As the amount of information is growing rapidly and changing all the time, finding relevant information on paper-based systems has become increasingly time-consuming. Healthcare organisations are increasingly using computer-based clinical decision-support systems (CDSS) which provide physicians with patient-specific assessments or recommendations. Some systems are built in order-entry systems or prescriptions systems and these have proven to improve prescribing practices and inherence to recommended care standards [Kaplan 2001].

In a broad definition a medical computer-assisted decision support system is any computer system that deals with clinical data or medical knowledge and is intended to provide decision support. There are four main types of these systems:

1. Computerised guidelines and bibliographic retrieval systems containing general medical knowledge.
2. Information systems containing patient data.
3. Tools for focusing attention, such as laboratory systems that flag for abnormal values.
4. Tools for patient-specific consultation- computer programs that provide customised assessments or advice based on patient-specific data [Jousimaa 2001, p. 47].

In their systematic review study of CDSS articles published in Medline, CINAHL and Cochrane Controlled Trials Register, Kawamoto et al. (2005) found that in 68% of the trials CDSS improved clinical practice significantly. The successful systems minimised the effort required by the clinicians to receive and act on systems recommendations. This study concentrated on the systems of the fourth type, but any system minimising the clinician's effort could reasonably be seen as an improvement.

Decision-support depends on high-quality, evidence-based medical knowledge. Ideally, this knowledge must be integrated into the process of care and delivered at the point of need in a patient-specific manner [Greenes 2003]. The quality of the knowledge is very critical when making decisions with direct effect on human

life. This sets the requirements for knowledge very high. The delivery method has even an effect on the support system's usefulness: the knowledge provided must be in a form readily understandable and usable in the context of need, and preferably validated by some authority.

3.3.4 Administrative and research support

Health care professional workstations provide, apart from information and decision-support, even a vast amount of functionality (such as order entry, workflow management, report writing) for professionals in inpatient and outpatient units [Ammenwerth et al. 2003]. These functionalities are not limited for clinical use. The data gathered by different CIS can be used even outside the actual clinical work setting: A Medical Automated Record System at Kaiser Permanente, Ohio, gathers data and generates reports of different activities and enables the management to follow the processes in the hospital [Wickramasinghe and Mills 2001a]. CIS data can be used for research purposes by using different data mining techniques or other methods of organising the vast masses of information within the systems. The data collected for immediate clinical use will, however, be very context-specific and as such may not be well suited for secondary purposes [Berg and Goorman 1999]. The clinical information systems are, though, a relatively new phenomenon. The systems supporting billing and report creation were the first to evolve in medical settings since those were similar to systems used in other industries, and these not-integrated systems would need to be integrated into clinical systems to give true benefits and freedoms to the administrative tasks.

3.4 Knowledge freedom: Possibilities of IS technology

Given the nature of the information and knowledge needs of a physician there remains a lot to do. Traditional knowledge management can improve the health care significantly but knowledge mobilisation, as defined by Keen and Mackintosh (2001), could go a step further. The aim of knowledge mobilisation is to:

- Provide mobile portals to the people who do the work,
- Put the person in the centre of the information and communication and
- Provide on-demand knowledge to meet needs at the moment of relevance [Keen and Mackintosh 2001, p.163]

Clinicians practice in a wide variety of environments (patients' homes and workplaces, wards, clinics, treatment rooms, etc), where standard desktop computers may not be available but information is still required [Gorman, 1995]. Bringing relevant information to the point of care could profoundly change the practice of medicine, bringing the evidence-based medicine closer to the patients. The possibilities do not limit themselves only to the physicians. Other health care personnel are often responsible for collecting and using the data related to a patient, as well as the patient herself. The knowledge freedom-creating ability of new IS technology in forms of smarter applications providing the relevant data to where it is needed, by mobile channels or other appropriate methods, will probably change the way our health care is handled. The technology itself is not enough - it merely provides potential for freedoms, and these need to be realised by real people in interaction with real social structures. If the systems are rigid, impractical and require the user to come to the knowledge resource, the users will rely on easier methods of obtaining knowledge, like asking colleagues.

3.5 Mobile e-health systems

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 the mobile computers. In fact, there is such a variety of applications that one would expect practically every physician to use some of them. The usage of mobile tools is spreading rapidly [Harris interactive 2001].

The mobile commercially available tools for individual physicians can be roughly divided into the following groups: medical calculators, reference guides, financial aides and monitoring systems [Freiherr 1998].

The usefulness of the mobile tools in health care settings is widely recognised. The mobile or handheld devices have proven their usefulness in the following situations:

- Data entry in the point of care [Ault 1998], removing the problems associated with handwriting and separate data entry and enhancing the timeliness, accuracy, richness and confidentiality of the patient data [Lanway and Graham 2003, Carroll et al. 2002]. The early documenting systems were, though, reported to take more time to use than the paper-based systems [Shiffman et al. 1999].

- In medication decisions in the form of reference guides [Rotschild et al. 2002] or linked systems with some decision support capabilities [Nightingale et al. 2000, Grasso and Genest 2001]. These systems have stopped potential medication errors and streamlined the routines by enabling medication decisions by the bedside.

- In an emergency care setting in the form of a cart containing a wirelessly networked computer [Bullard et al. 2004].

- In coding and managing billing and insurance claims [Morrison 2002].

- In specialist care situations and decisions [Shiffman et al. 2005].

- In providing contacts to library resources and online information [Shipman and Morton 2001].

- In ambulatory settings in emergency care in the form of easily accessible guides and drug references [Shah 2003], decision support systems

[Karlsten and Sjöqvist 2000] and telemonitoring systems [Pavlopoulos et al. 1998].

- In telemonitoring and remote diagnosing by specialists in locations other than the patients [Reponen et al. 2000].

- In critical care surroundings in the form of reference guides, drug calculators and connection to patient records [Lapinsky et al. 2001].

- Bringing the possibility of using evidence-based medicine (the conscientious, explicit and judicious use of current best medical evidence (from systematic research) in making clinical decisions about the care of individual patients [Sackett et al. 1996]) to the point of care [Vogel et al. 2003].

- Providing the patients with useful information and educational material [Magos et al. 2004].

- In a number of general and versatile uses [Chasin 2001, Chin 2001, Connor 2001, Ebell and Rovner 2000, Fischer et al. 2003, Blackman et al. 1999, Volsko 2004, Martyn 2003, Tapellini 2000, Stammer 2001].

Even a link to a fully-fledged CIS has been implemented in the New York Presbyterian hospital. The system links a Palm-based PDA to selected parts of the hospital's web base CIS. The system has been received well, the information content was deemed appropriate. The main problem with the system was the slow connection speed, among with cumbersomeness of the login procedure [Chen et al. 2004].

In a study among medical residents in Charlottesville, VA, Barrett et al. (2004) found that more than 75% of the residents were using a PDA daily. The most used applications were medical references (84%), built-in organisers and calendars (83%) and medical calculators (59%). The main advantages stated were speed of information access and help in being organised. The main limitations of the current devices/systems were the bulkiness of the devices and possibility of catastrophic data loss and slow manual data entry.

Mobile information systems in general can be used to provide the time-and place-critical types of information to the point of care or in unexpected situations to the physician facing the unexpected situation. Another potential advantage of handheld technology is that it is less obtrusive than desktop computers. Studies about this aspect are somewhat limited but Houston et al. (2003) found in a study in a university-based clinic for low- income patients that the patients in general

have very positive attitudes about their physicians using a handheld terminal. This trend was even stronger among patients who had actually witnessed their physician using a handheld (Palm). Only 10% of the patients did not like the idea of their physician using a handheld. Contrastingly 23% of the physicians in the same setting expressed reservations to the use of handheld computers in the exam room.

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 miniaturised 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 / 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.

Handheld technology use is by no means limited to the physicians, although a majority of the systems are developed for their use. Nurses using a handheld-based care planning system were shown to improve the consistence of nursing care with patient preferences and the patients' preference achievement [Ruland 2002].

From these reported uses a taxonomy of possible uses for handheld technology in medicine can be created. The taxonomy is depicted in table 2.

Usage setting	Type of information	Input/access of information	Main user	Possible or verified benefits
Point of care	Medical, Patient-specific, medication, billing and other administrative	Both	Doctors and nurses	Time-saving, error-reduction, easy access to EBM, unobtrusivity
Emergency care	Medical, patient-specific,	Access	Doctors and nurses	Timesaving, error reduction
Ambulatory care	Medical, patient-specific, resource information	Access	Doctors and nurses	Time-saving, error reduction, control over available resources
Communication with patients	Medical, condition-specific, medication	Access	Doctors and patients	Added information content
Distance work	Images, other patient-specific material	Both	Specialists	Time-saving, better use of resources

Table 2 Different uses of mobile systems in healthcare

The taxonomy above highlights the contextual nature of mobile systems usage in healthcare. Different systems are needed in different settings and by different users – and the benefits differ between the usage contexts. The Duodecim system under study here is not intended to be used in any specific situation, but the benefits of the system should be visible in a number of settings.

Chapter 4 IS success and impact

Any health care innovation may influence three aspects of the health care system: the structure of the health care system, the processes and the outcomes [Friedman and Wyatt 1997, p.5]. Introducing mobile systems in healthcare does not differ from other innovations in this matter. The mobile systems are introduced primarily to help the health care personnel carry out their tasks and thus increase the overall efficiency of the health care system. Mobilising information and freeing the healthcare professionals from the desktop systems or even from paper-based information systems should have an effect at least indirectly on the whole health care system through streamlining the work processes of individual professionals. This effect or impact is one of the main success factors of a mobile system. The ability of a system to affect its users and the organisation around them can be studied from different perspectives.

4.1 User evaluations

One widely used measure of IS success is the user evaluation, meaning the assessment made by a user along some continuum from positive to negative, about certain qualities of information systems [Goodhue 1995]. Goodhue (1995) argued that these user evaluations are directly affected by the system's task-technology fit (TTF) or the extent to which the system meets their needs and abilities. The level of TTF is determined by the characteristics of the *task*, the *used technology* and the *individual user*. The model of TTF was tested and found valid in a survey of 259 users of quantitative information in managerial tasks [Goodhue 1995]. The TTF posits that a system will be used and have an impact if, and only if, the functions available to the user support (fit) the activities of the user [Dishaw and Strong 1999]. The TTF concept would provide valuable insight about the system under study here, but as the concept requires clearly defined tasks it is not very suitable for a goal-free evaluation. The underlying assumptions of different user evaluations' dependence of the task at hand is, however, taken into account in the analysis of the findings.

4.2 Diffusion, acceptance and usage of information systems

System usage, the utilisation of information technology by individuals, groups or organisations, is a core variable in IS research. The usage is even seen as the primary variable through which IT affects white collar performance [Straub et al. 1995]. The determinants of usage have been subject to large amounts of IS research. One important line of studies has employed intention-based models

which use behavioural intention to predict usage and focus on identification of the determinants of intention such as attitudes, social influences, and facilitating conditions [Taylor and Todd 1995]. This work is based on models in social psychology such as the Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB) [Ajzen 1991] and has led to the emergence of the Technology Acceptance Model (TAM). The model presents the antecedents of system usage as beliefs about two factors: perceived ease of use and perceived usefulness of the system [Davis 1989].

Another stream of usage research has examined the adoption and usage of information technology as diffusion of innovations [Rogers 1983]. This type of research examines a variety of factors thought to be the determinants of innovation adoption and usage. Some factors examined are: Characteristics of the individual users, information sources and communication channels and characteristics of the innovations.

Moore and Benbasat (1991) have integrated the intention- and diffusion-based approaches and developed a comprehensive mode for measuring user acceptance of IS.

The TAM model has been used in a variety of organisational contexts and has proven to be a reliable model of behavioural intent. The model has been extended by introducing more variables and validated by empirical tests [Venkatesh and Davis 2000].

Understanding the determinants of usage has naturally implications for evaluating the value and impact of an information system. Usage is a necessary albeit insufficient requisite for deriving the benefits of IT [Straub et al. 1995]. The models describing usage are not intended to be used in evaluating a system's impact on its users per se, but the concepts used in the acceptance and adoption models are intertwined with the concepts used in evaluating impacts of a system. The basic component of the TAM- model, perceived usefulness, is of course a measure of potential individual impact – a tool or a system can hardly be perceived useful unless its usage has a positive impact on the productivity or satisfaction of the user.

One problem with the TAM and similar models is that they measure *intention* as a dependent variable, and intent does not necessarily reflect actual usage. Even when the models are used with self-reported measures of actual usage, there may be a gap between actual usage and the self-reported one. This weakens the explanative power of the TAM constructs on actual usage and its impacts [Straub et al. 1995]. However, most sociological research stresses the point that the world is as it is perceived and there is no distinction for the individual between perceived usage and actual as there is no difference between actual and perceived

impact. The perceived impacts in their part have an ability to change the behaviour of the individuals, thus causing factual changes in the performances of the individuals and organisations.

The TAM model has been successfully integrated with Task-technology fit models, enhancing the predictive power of the model [Dishaw and Strong 1999, Klopping and McKinney 2004]. Nevertheless the models aiming to explain adoption and usage of information systems are not sufficient to evaluate the value of a system or the actual benefits stemming from its usage. And in the case of this research, the constructs do not directly capture the change-enabling potential of mobility, the main goal of this work.

4.3 Impact of IS

The returns on investments in information technology have been evaluated ever since the first mainframe systems were taken into use. The small evidence of IT investments contribution to overall productivity has led to coining the term "Productivity paradox", meaning the situation where the IT investments show no significant increase in productivity on the macro level. Brynjolfsson and Hitt (1998) argue that the reason for the paradox is not in the systems but in the fact that the full potential of the new technologies are not used due to old organisational structures and work practices. Advocating changes in these are even more time-consuming and expensive than the systems hardware but combined they create long-term advantages. These benefits were recognised by Scott Morton (1991) as an important part of IS development. New systems can themselves act as catalysts for organisational change. Orlikowski (2000) argues that when people use an artefact (technology) they enact structures that shape their future use of technology, in accordance to their social practices. The users are even always able to find new uses for existing technology, thus developing new structures. It is important to note, however, that the technology only enables changes when interacting with existing social structures. The impacts of systems are usually studied either from a macro perspective or case by case using methods borrowed from social sciences. One possible measure of impact is system effectiveness that can be studied with the evaluation methods described above. Formal methods may provide objective measurements and informal approaches to gaining perceptions of system effectiveness are necessary and helpful for calibrating the credibility of the information [Hamilton and Chervany 1981].

4.4 Comprehensive models

IS success is inevitably a very complex phenomenon. In a framework attempting to capture all the factors effecting IS implementation success Larsen (2001) listed seven categories of variables: *individual* variables describing the users of the system, *task* variables concerning the work processes, *structural* variables focusing on the characteristics of the organisation, *technology* variables explaining the characteristics of the implemented technology or innovation, *process* variables which emphasise the effects of different stakeholder groups and the organisation of the IS department, *interorganisational* variables concerning linkages to other organisations and environmental variables concerning the organisational and social environment of the process. The set of variables is more comprehensive than the one suggested by Kwon and Zmud (1987) which lacked the process and interorganisational variable categories [Larsen 2001]. The set of variables presented by Larsen does, however, only explain the success of the implementation of a system. The effects of the same should not to be forgotten either.

When conceptualising the complex phenomenon of IS success DeLone and McLean (1992) created a construct of information system success, finding six interrelated measures of success. These were:

- system quality,
- information quality,
- use,
- user satisfaction,
- individual impact and
- organisational impact.

The model, depicted in figure 3, has been subsequently validated and extended [DeLone and McLean 2003].

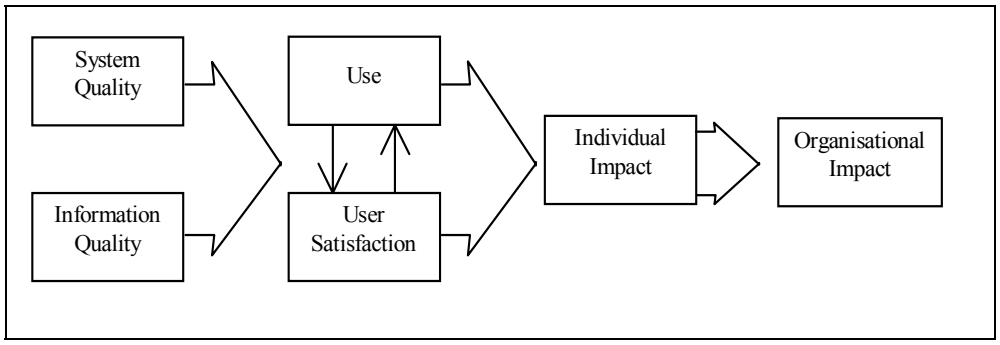

Figure 3 Information System Success Model (DeLone and McLean 1992)

But how should the success of a mobile information system in healthcare be measured? The purpose of the system under study here is relatively clear: to provide physicians with up-to date medical knowledge anytime, anywhere. This naturally calls for a scrutiny of the success criteria. The problems the healthcare industry is facing are of a universal nature - and any change or improvement in the technologies should help to solve these problems. Therefore, from a holistic perspective the organisational impact would be the most important measure of success in any system development. In the case of mobile systems, the picture is somewhat blurred: the mobile systems provide functionalities previously impossible and have potential for changing the whole structures of almost any industry or work process. Nevertheless, as the mobile instruments are very personal and have a direct effect on behaviour on a personal level the organisational and interorganisational changes are necessarily indirect effects of the usage of the systems. Even the scope of the system in question will have a distinct effect on the success of the system. Seddon and Kiew (1996) added a seventh dimension to their refinement of the DeLone and McLean model: *Importance of the system*. This dimension captures the rather obvious notion that a system can have an individual and an organisational impact - and even wider usage only if the system provides each user with something important. This is a crucial dimension of usefulness - that the use of a system has a purpose. The DeLone and McLean model provides a good starting point for analysing the possible effects of a mobile system. It describes the connections between the different characteristics of the system, the users and the organisation but it simultaneously provides enough room to encompass even the unanticipated effects of system usage, laying a solid ground for finding answers to my research questions.

4.5 Characteristics of mobile systems

Mobility as a word is derived from Latin word “Mobilis” which generally refers to “move” the current English definition of “mobile“ is: capable of movement, movable, not fixed or stationary. [Webster’s] The new information systems characterised as mobile differ from the traditional systems in a number of ways. The most striking difference is naturally the mobile system’s ability to function in different geographical locations as well as in different contexts. The mobile telephones and short message services have had a profound impact on the communications patterns in our everyday life [Ling 2000].

The emergence of mobile systems has tremendous potential for changing the way we do things. The mobile revolution can change the world by delivering a set of freedoms:

Relationship freedoms: by mobility, personalisation and convergence of telephony and the Internet. These will profoundly change the way people communicate and work. Sharing documents during telephone conversations was unimaginable just a few years ago.

Process freedoms: adding value along the entire supply chain by making fully mobile as many of the steps, people, information items and documents needed for effective process design. The process participants, like truck drivers, gain certain control over the process they are involved in, adding flexibility and efficiency.

Knowledge freedoms: adding value to the organisation and its workers through knowledge mobilisation [Keen and Macintosh 2001, p.20]. Having the knowledge available for the user when needed and where needed instead of the person having to find the information may streamline most of the information-intensive processes in most types of organisations.

The promise of mobile systems will not, however, necessarily be fulfilled if the systems developed do not fulfil a purpose. A construct by Keen and Mackintosh distinguishes three types of mobile services, according to their potential impact on everyday life: A *freedom* is changing the limits of the possible in everyday life-that is: firstly, the context in question is common - everyday, secondly, the mobile enables the user to do things that would be impossible or very inconvenient with other means of information retrieval. A *convenience* offers saving time and effort in doing what is already possible within the daily routines. A *feature* offers some new options in those routines [Keen and Macintosh 2001, p. 4]. This distinction enables a researcher to evaluate a mobile system by its potential impact: systems

that create freedoms are most likely to have an impact on the users and the society as a whole.

Mobility as a field for changing the society by mobile information systems is not exclusively a question of overcoming geographical constraints. Kakihara and Sørensen (2002) introduced three different aspects of mobility; the *spatial* mobility that refers to the global flux of people, objects, symbols and space itself, *temporal* mobility that considers the detachment of human activities from linear clock time, and *contextual* mobility that encompasses the flexibility of interaction between different contexts.

Spatial mobility is not limited to human movement. Interconnectedness of different systems has led to information mobility where signals and sounds and data move freely over different information and communication networks, and the Internet has changed the space itself, creating virtual environments and communities [Basole 2004].

The spatial mobility itself is not a heterogeneous concept. Bellotti and Bly (1996) found in their study of design professionals that there are two types of mobility that need different support from information systems: *Remote* mobility where the user of a system is outside the normal working environment, using means of transport or public spaces, and *local* mobility- simply walking between rooms in a local site.

Bardram et al. (2003) studied the support of local mobility in a health care setting and found that systems supporting local mobility should i) integrate into the existing infrastructure, ii) support the use of various heterogeneous devices and iii) enable seamless application roaming between these devices. They even found a typical action range of clinicians in hospitals. The distinction of local and remote mobility does have a crucial importance in evaluating mobile systems and especially their fit to the work structures of people.

The nature of mobile systems poses challenges even in evaluating the usability of the systems. Normally computer systems can be tested in laboratory settings but the use of mobile devices is very context-sensitive and the evaluation methods should take this into account. Kjeldskov and Stage (2004) have developed some techniques to overcome this problem.

The freedoms or other changes in human behaviour can have beneficial effects on our society. Mobile systems usage in enterprise settings has been suggested to have the following benefits: improved productivity, lowered operational cost, increased customer satisfaction and improved decision-making [Varshney et al. 2004]. These impacts are naturally intertwined with other changes in organisations and processes. The mobile systems themselves are initially only

enablers of change- and given the possibilities of mobilising information in all of the dimensions of Kakihara and Sørensen these changes can be significant. However, when evaluating the success and impact of mobile systems one has to take into account the context-sensitive nature of mobile systems. A system that would clearly provide a freedom in some contexts, for example in the realm of remote mobility -travelling or otherwise outside the office- having access to information normally only available in the office can be crucial if one is contacted by a customer. In the office in a different context the mobile aspect has less impact since the knowledge is available by other means and the system provides a mere convenience or feature.

4.6 The evaluation framework

The framework used to conceptualise the data in this evaluation is built on two constructs: the DeLone and McLean Information Systems Success model and the Keen and Mackintosh Classification of mobile systems according to their ability to create freedoms. The model here is not intended to be an exact causal or process model but merely a conceptualisation of the phenomenon at hand.

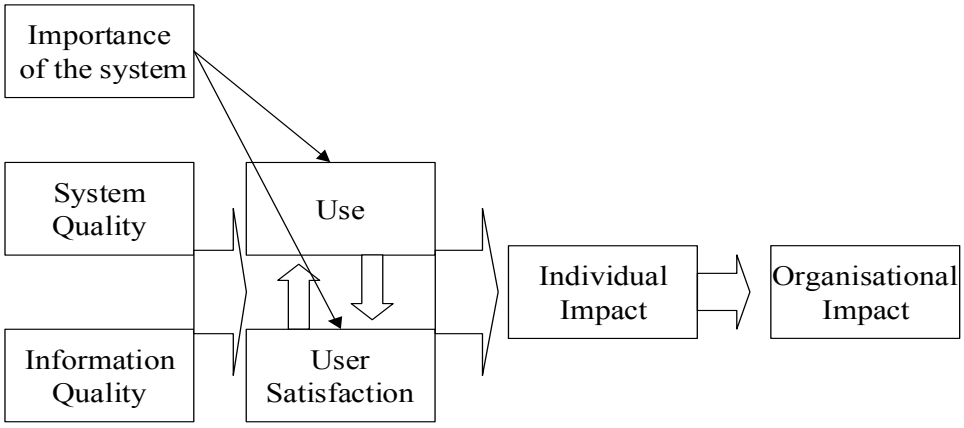

Figure 4 The success model with extension of Seddon and Kiew (Seddon and Kiew 1996)

The IS success model, as introduced in chapter 4.4, with the Seddon and Kiew (1996) extension, depicted in figure 4, gives a good overall picture of the types of phenomena connected with the success of an IS. For a system to have an impact

on individual users and furthermore on organisations the system must perform in a satisfactory manner in each of the precedent categories on the left side:

The *quality of the system* (system quality) - technological functionality, usability, and logical operation- must enable use of the contents or the information.

The content or *information quality* must satisfy the information needs of the user in such a way that the user is able to transform the information into knowledge. In case of medical information the information quality is crucial- not only the validity of the information but even the form of presentation must be on a level high enough to support decisions of life and death.

Usage (use) of the system is partially self-explanatory. When using a system is not mandatory, using it reflects the level of benefits the users perceive- creating user satisfaction and vice versa. A system that is not used will not have an impact, however good the system or information quality. *User satisfaction* on the other hand depends on the usage of the system- one must try a system at least once before there can be any satisfaction, and a satisfied user is likely to use the system again. The model has been validated by among others Rai et al. (2002) and Seddon and Kiew (1996) who added the component of importance of system after considering the concept of usefulness. The *importance of the system* affects the usage and user satisfaction components. If a system is not really needed the usage will be sporadic at best and nonexistent at worst. These five interdependent dimensions of information systems success work towards an impact on the user and the organisation around her.

The right-hand side of the model depicts the *impacts* a system can have. These impacts can take numerous forms and vary in importance. One of the concepts introduced by Keen and Mackintosh (2001) is the Braudel rule, named after a historian who identified the changes in the limits of the possible as the core of progress in civilisation. The rule states that "freedom becomes value when it changes the limits of the possible in the structures of everyday life" [Keen and Mackintosh 2001 p. 31].

The Braudel rule emphasises the system's ability to change the structures of everyday life. In fact, it encompasses the whole left side of the model presented above. The four variables presented by DeLone and McLean and the system importance addition by Seddon and Kiew capture most of the necessary characteristics of a system and user essence of the Braudel rule but not everything. The Importance concept is vital but not necessarily sufficient to explain the effect of a system to everyday work of an individual. The Braudel rule emphasises the ability of a mobile system to create freedoms or other levels (conveniences, features) of advantage. The freedoms can manifest themselves in any of the three dimensions of mobility: *spatial, temporal and contextual*.

Therefore a system must, in addition to the extended success model's dimensions, be analysed even in its ability to change the limits of the possible- i.e. to remove spatial, temporal or contextual constraints to fulfilling the tasks the system is intended to ease. This freedom-creating ability of a system is an important measure of the impact on individual behaviour of the user, as well as the wider organisational impacts caused directly or indirectly by the individual changes. The position of freedoms in the success model is depicted in figure 5.

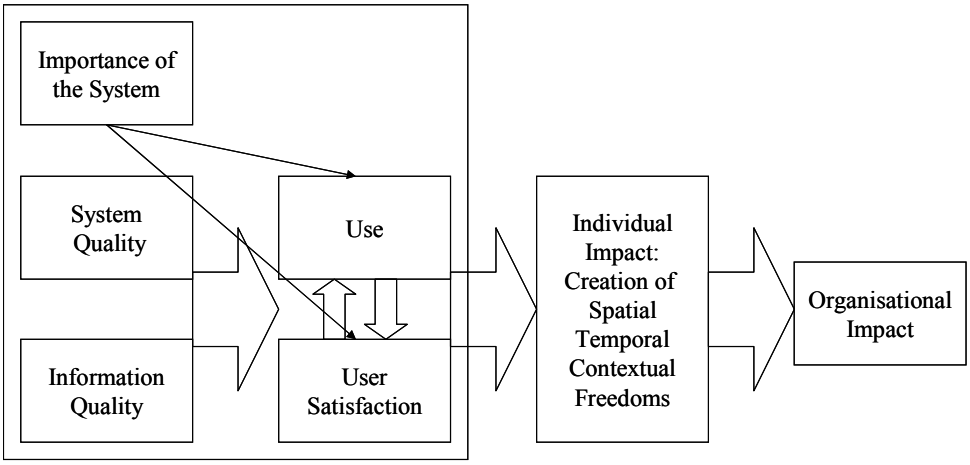

Figure 5 The position of freedoms in the success model

In a professional setting a mobile service provides value when it delivers a freedom, a convenience or a feature. A *freedom* changes the limits of the possible in professional routines of everyday life; a *convenience* offers saving time and effort in doing what is already possible within the daily routines and a *feature* offers some new options in those routines.

The model presented in figure 5 provides a basis for answering the research questions from the following angles:

The importance of the system defines the kinds of impact the system can possibly have, i.e. the parts of processes and organisations that are potentially affected by using the system.

The system and information qualities are important determinants of the reasons for using the system- these define the usefulness and usability of the system.

The use and user satisfaction are evaluated within contexts, providing answers to the questions about how the system is used.

The freedom-creating capability of the system defines the possible impacts the system can have in different situations and contexts.

The individual impact is one of the goal concepts of this study. This is studied in relation to the work processes and contexts, trying to find the contexts of most visible impact.

The organisational impact is the aggregation of individual impacts and the changes the system causes in the organisation of work.

The factors contributing to the system's use and impact in specific contexts are found in every concept in the model. One of the main purposes of the model is even to create a holistic picture of the mobile system usage with some possible explanations of the observed phenomena.

The Duodecim mobile package can be seen as a provider of freedoms-conveniences-features: The mobile package serves a predetermined purpose: to provide medical practitioners with medical knowledge wherever they are. The need for this type of information in a work context determines whether the mobile can be seen to create freedoms or whether it is merely a convenience or a feature. The needs for this type of information are not homogenous but very context-sensitive- as are the users' other means of obtaining the information. The services (databases) must therefore be analysed within a context. The possible usage situations are numerous and the impact of the mobile system in these varies greatly. The analysis here follows the framework and attempts to capture the essential characteristics of the system in every aspect in the logic model. The logic model states that the basic structures - system quality, information quality, usage and user satisfaction determine the success of the system- all of these must fit the context of usage and provide some level of benefit to the user: a benefit that can be classified as a *freedom, a convenience or a feature*.

A mobile medical system does not exist in a vacuum. The framework so far only defines components of system success. The components are partly defined by factors outside the framework in figure 5. As the medical information field is heavily regulated and controlled, the surrounding society has a profound effect on what kinds of systems are possible and legal to build and use. The level and cost of available technology are other limiting factors for the possible system and information quality. Another set of factors interacting with the success factors included in the framework is the characteristics of the users. The effects of user characteristics for technology adoption have been proven and analysed by a number of studies, mostly relying on the TAM- model. (See e.g. Croteau and

Vieru 2002) Even though the main interest here is the freedom-creating impact of the system under scrutiny, it would be foolish to ignore the effects of the users themselves. The complete evaluation framework is depicted in figure 6.

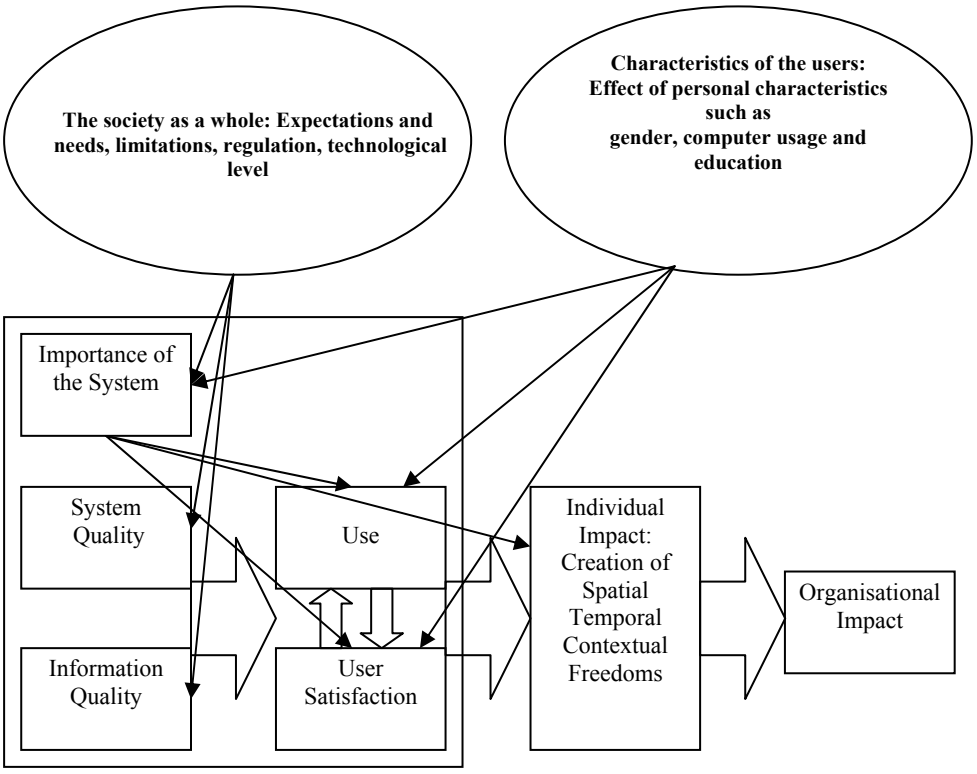

Figure 6 The evaluation framework in a broader context

The societal variables such as legislation and the level of technology, by defining the level of what is possible, provide a background for evaluating a specific system: the impacts can only reach levels that are possible in the surrounding society.

The user characteristics are shown to have an effect on technology acceptance; that is use and user satisfaction of a system. These factors were included here for two reasons: firstly, they may cause misinterpretation of the results from the empirical data on the usage of a system and secondly they provide additional information about the usage of mobile systems in general.

4.6.1 Hypotheses about the nature of the system

When describing the Duodecim mobile system in terms of the Keen and Mackintosh there are some interesting concepts:

1) The system is potentially able to create *freedoms* in situations where other means of information search are limited. These situations in a physician's life range from working outside the primary workplace, when travelling and on free time, at home or elsewhere. The freedoms manifested are spatial: the process of information search is detached from the desktop computer or other fixed means of information access. These freedoms are however dependent on the fit of the system's quality, information quality and usability of the system to the usage situation as well as the importance of the information needed. In certain situations the system should provide benefits unobtainable without it.

2) On regular working conditions, i.e. working in the physician's own office the system does not change the limits of the possible but merely offers some time - and effort - savings by being simpler to use and less obtrusive than a desktop system or a paper book. In these conditions the system may not even provide time-and effort saving but merely a novel way to handle some of the daily routines. In this setting the system provides the user with a mere *convenience*. Here again the importance of the system's output and the fit of the system usage to the work habits of the user will effect the outcome - these must be filtered out of the equation in order to unravel the conveniences the system provides.

3) During patient consultations the system provides some unique advantages- but no extension to the limits of the possible- hence the system is even in this setting a *feature*, which is appreciated more or less depending on the user.

4) Given the relative importance of the system - the need for the available type of information arises in average four to five times a day - the system is not able to make radical changes in the working habits of the users.

The usage patterns and stated reasons for these in the empirical studies should reflect these concepts in the following way:

1. The majority of the users should be using the system explicitly in situations described above. Variation in the usage patterns can be explained by individual characteristics, but the main benefits of the system should be recognisable for every user.

2. The system should be used even in normal office conditions when there are tangible benefits over the other means of information search, such as saving time and effort or offering a simpler user interface.
3. During patient consultations the advantages of the system should be recognised by some number of users, depending on their work habits in general.
4. The changes in the work habits and structures of the users will be negligible. The recognised changes will, however give a clear indication about the potential of mobile systems in the future.

4.6 Summary

Information systems can be evaluated from a number of perspectives and with a number of methods. Most perspectives and methods are somewhat narrow and do not provide a holistic picture of a system's characteristics and fit to the situations and contexts where these systems are used. Comprehensive models for illustrating the success of a system do exist and these models can even be used for evaluating mobile systems. Since the impacts of mobile systems are secondary effects caused by changes in human behaviour enabled by the mobile systems, the evaluations should be able to identify these changes. Only some of the changes are predictable and the evaluation should be able to capture even the unexpected ones. This calls for checking the data against several possible explanations and using several data gathering methods.

Chapter 5 Empirical studies

5.1 The system

The Finnish Medical society Duodecim's fully owned publishing company Duodecim Publishing Ltd. (later the publisher) has been publishing medical literature in paper form for years and started experimenting with electronic formats in the late 1980's. The first commercial electronic product called "Lääkärin CD" (Physician's CD), was launched 1991. It was (and is) a PC-CDROM containing the EBMG (Evidence-based Medicine Guidelines or EBM Guidelines or Doctor's handbook), the Pharmaca Fennica drug database and other highly relevant medical books in searchable database format. In 1999 the contents of the CD were made available through the Internet in the form of the Terveysportti.fi (www.terveysportti.fi) portal. In year 1999 the next step towards ubiquity of information provision was taken when the publisher launched a mobile version of their databases, running on a Symbian platform tailored to be used on a Nokia 9210 Communicator. A picture of the device running the system is found in figure 7. (Versions for Palm OS and Pocket PC were developed later). The initial product consisted of a set of searchable databases containing the same material as the printed and electronic versions of Duodecim's books: the Doctor's Handbook , Pharmaca Fennica (a complete guide to all drugs available in Finland), ICD-10 diagnosis code database, Abstracts from the Cochrane library, a contact information database for all the health care related organisations, including pharmacies in Finland, acute care guide by Meilahti hospital and a medical dictionary of over 57000 terms. The texts are generated from an XML-based database. This mobile package is delivered on a 128 MB memory card and is self-installing, containing the search engine, user interface programs and the core databases. So far the updates are delivered as physical memory cards, the users returning the older cards. The system is continually upgraded. The latest versions since fall 2003 incorporate an automatic updating feature of the drug price lists in the Pharmaca Fennica database through the GSM data connection provided by the device itself. (Later versions of the Communicator have a faster GPRS (General Packet Radio Service)data link).

Figure 7 A screenshot of the Duodecim mobile EBMG

In terms of medicine-related knowledge the system provides only *medical or clinical knowledge* and some *information on the local health care system* (namely the contact information database).

5.2 The setting

In order to test the mobile package and promote its usage among the practising physicians the publisher, with support of Pfizer Finland Oy, provided a set of physicians (870 in all) with a Nokia 9210 Communicator and the Duodecim Mobile Package for a period of two years. The pilot users received their devices during a training session where they were instructed about how to use the system. The pilot users agreed on providing the publisher with information about their usage of the system. What makes the setting unique on the perspective of a mobile systems researcher is that the participating physicians do have access to the contents of the mobile system even on their desktop computers (through the Terveysportti.fi portal by the publisher or by the databases running on a local intranet) or printed books. This makes the pilot population optimal for studying the mobile form of the system, highlighting only the effects of the mobile format instead of the content and information quality of the system. The pilot group's usage and acceptance of the system provide valuable information about mobile systems in healthcare.

The research questions presented in chapter 1.3 can be answered in this setting in the following way:

1) What kind of impact can a mobile information system have on a medical professional's work?

The possible impacts of the system used here are mirrored in the usage and expectations of the pilot users. The extent of possible impacts is determined by the nature of the system and the surrounding environment.

2) How is such a system used by practicing physicians?

The actual usage patterns and contexts can be identified after some time of pilot system usage.

3) What are the reasons for physicians to use the system?

The initial reasons for accepting the pilot system and the consequent usage patterns answer this question.

4) How will the work processes of a physician be affected by using a mobile information system?

The changes in the behaviour of the pilot group are visible after pilot use. Changes can occur in the spatial or temporal planes or be visible just as slight alterations of routines.

5) In which specific settings and contexts in physicians' work does a mobile information system have most impact on their everyday routines?

The settings of preferred usage and most actual usage are naturally expected to be the settings with most impact. The usage and impact do have to be measured separately.

6) Which factors contribute to the system's usage and impact in specific contexts or what would be the determinants of contextual fit between the system and medical practice in Finland?

The possible factors are numerous and identifying them requires using some sort of conceptualisation of the factors. Here this conceptualisation is done by creating an evaluation framework, presented in chapter 4.6.

5.3 Data collection

Within the case study I used two main methods of gathering primary data, namely field interviews and surveys. The interviews were to provide information about the surroundings of the user, the usage patterns which could not directly be predicted by any other method, and opinions about the system. The surveys were to measure certain aspects of the system usage in different settings. In addition to these I had access to the publisher's set of questionnaire data gathered from the users during the semi-annual system update and training sessions and the data gathered in two telephone interviews conducted by the project sponsor.

Data used in this research was collected in five different sets:

Expert survey: The surrounding society and the hindering/ supporting factors for mobile technology in the environment were evaluated by an expert survey of a group of five occupational health care professionals (doctors and nurses) in a private hospital and by unstructured interviews of four health care network experts from Sonera, a Finnish telecommunications operator during fall 2001.These studies were conducted by the author in cooperation with Pär Landor.

Company survey: Preparedness for using electronic systems by health-care related companies was studied by the author and Mikael Collan with a survey to approximately one hundred companies providing healthcare services, ranging from pharmacies and individual private doctors to large health care centres in 2002. Answers were received from 25 companies, usually from managers responsible for IT investments in the company.

Pilot User survey 1: The pilot users of the mobile system were surveyed with a questionnaire by the publisher when they had just received their devices in April, 2003. The first survey concentrated on the expectations and intentions of the users. The number of questionnaires handed out was 500 and the number of responses 379, giving a response rate of 75.8%. Of the respondents 152 were from the capital Helsinki area, including the cities of Helsinki, Espoo and Vantaa, 51 were from the North, city of Oulu, and 15 respective 47 from the cities of Turku and Tampere. The youngest respondent was 23 years old, the oldest 67. The data from this set is later referred to as user survey 1.

User survey 2: A follow-up telephone survey of 42 physicians was conducted by Pfizer Finland Oy after 2 months of usage in June 2003. This data set is referred to as the User Telephone Survey. The data from the user surveys were analysed in cooperation with Shegnan Han, Pekka Mustonen, Matti Seppänen and Markku Kallio.

Interview study: Further and deeper data about the actual usage and its impacts was collected by structured interviews of 30 medical practitioners in the Turku area during winter 2003-2004. This data set is referred to as the Interview Study. The interview structure is attached as Appendix 1.

Internet survey: From March to October 2004 a web questionnaire was distributed via email to the pilot users. Of the 578 physician contacted, 242 completed the survey, giving a response rate of 41.9%. This survey was conducted by Shegnan Han, Pekka Mustonen, Matti Seppänen and Markku Kallio.

The first two surveys were not directly connected to the Duodecim package but aimed to analyse the Finnish health care systems structure and need for mobile systems.

5.4 The research papers

Each of the original research papers sets out to explore some aspect of the mobile medical system. The positions of the papers in the evaluation framework are presented in Figure 8. Papers 1 and 2 clarify the expectations and limitations of the society in general and the health care industry in particular. These expectations and limitations (regulation, technology, and social influences) form the reality in which the mobile system is developed and used. These factors define the level of the possible in terms of technology, defining the possible (and available) levels of technology that has a direct effect on the system quality. Moreover, the expectations and especially the limitations of the society and the health care industry sets rather strict limits to the content (Information) presently possible to include in a general mobile system. The main contribution of the two first papers is that they clarify the limits of the possible impacts in the Finnish context, as well as provide basis for evaluating the possible effects of the system.

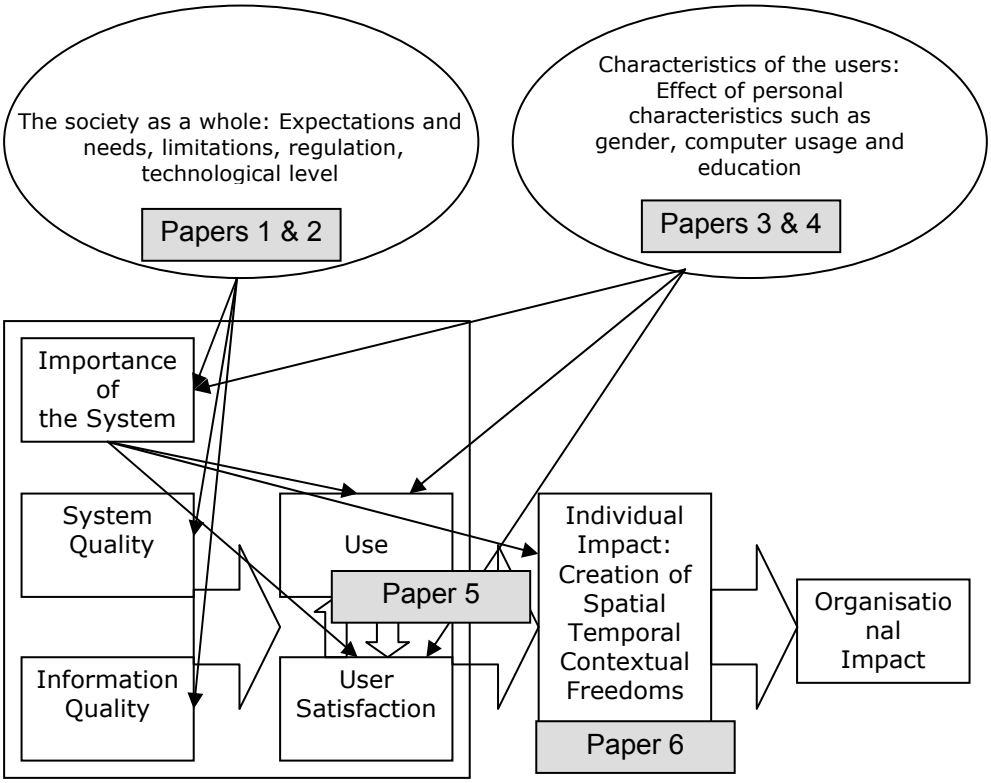

Figure 8 The positions of the research papers

Papers 3 and 4 are attempting to shed light on the attitudes and expectations of individual users as well as the impact of different user characteristics to these. Recognising these serves two purposes: First, it makes it possible to isolate the individual differences between different users in order to concentrate on the effects of the system itself. Second, these attributes themselves are a measure of system success and recognising the main motivational factors makes it possible to assess the system's performance in the aspects considered important by the users.

Papers 5 and 6 concentrate on the actual usage and the effects of it. Paper 5 offers a classification of the users and presents some typical usage patterns. Paper 6 presents a deeper analysis of the usage and the impacts of the system, validating the evaluation framework presented above.

The research papers are partly overlapping, namely papers 3 and 4 are presenting different findings from the same survey, and papers 5 and 6 are presenting different aspects found in the interview study. The following summarisations of the results are structured according to the data sets instead of individual research papers.

5.5 The surrounding infrastructure and society for mobile health services

The system under study here does exist as an integrated part of the surrounding society and the organisations in it. The surrounding society has a profound effect on the development and usage of any system. In order to clarify the readiness of the surrounding society to accept mobile systems and to identify the areas in which mobile technologies could help medical professionals we conducted a preliminary expert survey by having a group of five occupational health care professionals (doctors and nurses) in a private hospital and health care centre evaluate their work processes on basis of a questionnaire with open-end questions. The questions concerned the following topics: Their use of information systems in their work, their perceived need for mobile solutions, their visions of mobile solutions that would change their work and their perceptions of why such systems do not exist as yet. The insights were deepened by unstructured interviews of four health care network experts from Sonera, a Finnish telecommunications operator. The study design was very informal, being intended to give us a preliminary insight into the actual work of medical professionals and the social, organisational and technological systems in place at the time of the study. The findings suggest that there are a number of non-technological hindrances on the way to mobile e-health. The findings can be summarised as follows:

1: The existing technological infrastructure is not ready for large scale mobilising of knowledge.
2: The health information secrecy and data security legislation in Finland make some applications illegal.
3: There is not yet a market consolidation that would allow for recognising the most suitable platforms for mobile services.
4: At the time of the study wireless data transfers as well as terminals were relatively expensive.
5: Investment risks: The insecurity about the future standards of mobile communications was inhibiting fast adoption of mobile devices – and services.
6: The systems available in 2001 were generally too slow in data transfer to disseminate different types of data.
7: The procedures and work habits of the health care personnel seems to be very bound to the paper-based systems.
8: The public sector is, given the inflexibility of financial steering and constant under-funding, less eager to use new systems than the private actors. As the need for change is similar in both sectors, the gap in efficiency between the public and private sectors will probably widen.

In conclusion: the surrounding infrastructure in Finland is not yet on a level which would enable integration of all necessary systems to mobile systems- the medical information part is the only easily implemented part of the whole information field countrywide. Mobile extensions of the different clinical information systems are of course possible and even under construction. The organisational and structural constraints are discussed further in research paper 1 ": Mobile E-Health - the Challenge of Eight Obstacles", where we show that despite the enormous potential of mobile technologies the surrounding society and infrastructure are not very well adapted to switching to mobile systems. This is a direct answer to the research question 1, the possible impacts of mobile systems and an important basis for evaluating any specific system.

5.6 Political and legal environment - the need for change

In order to further deepen our (Harkke and Collan) understanding of the feelings and thoughts of the actual stakeholders in the field of health services production, an exploratory survey about the use of e-health was prepared in cooperation with students from the Turku School of Economics and Business Administration in 2002. A mailed survey was sent to approximately one hundred companies providing healthcare services, ranging from pharmacies and individual private doctors to large health care centres. Answers were received from 25 companies, usually from managers responsible for investments in IT in the company. The sample was not randomised and the response rate of 25 % leaves room for nonresponse bias. The results of this survey are therefore only explorative. The questions of the survey varied from basic questions about the readiness of the respondents to utilise different e-Health innovations (in connection with the Internet) and what their attitudes are towards e-Health as an addition to their business generally and specifically. One of the issues taken up in the questionnaire was the interest of parties to engage in using e-prescriptions. The reason for this was that the authors were aware of the difficulties in the development of systems regarding e-prescriptions and the administrative hindrances that are slowing the progress of using e-prescriptions.

The findings of the survey suggest the following:

- It seems that the stakeholders are positive about the use of IT and feel that it has potential for enhancing their productivity.
- In-house tasks are often already done with IT-solutions, and there are positive experiences.
- On a number of occasions it was mentioned that the administration by the Social Insurance Institution of Finland (SIIF) and the National Agency for Medicines (NAM) are hindering development.

- Most of the respondents specify that incorporating electronic drug prescriptions would be an important step. This is, however, not possible due to administrative hindrances.

Nearly 80% of the answers stated that the businesses would be interested in using electronic drug prescriptions. One answer stated that based on observations from a longer period of time it seems quite hard to expect any changes in the near future due to lack of cooperation from administrative bodies.

The Finnish administrative framework for health care services is complicated and service production is divided into the services provided by private companies and the public services. There is a gap between the productivity of private services and public services and we feel that one of the reasons for the existence of the gap can be more advanced use of IT. One factor hindering the development in the public sector - and indirectly even the private sector, as the systems will need to communicate with each other - is the existence of administrative and legal barriers that do not take into account the possibilities offered by the technologies available today. Legislation and administration have not been able to develop in pace with technical innovations. This has caused a bottleneck in areas such as production of health care services that have a strong focus on privacy and customer (patient) protection. The lack of up-to-date governance (laws and administration) of IT in health care is a major source of uncertainty and a serious hindrance for development in the sector. The obvious conclusion is that in order to work optimally from the point of view of all stakeholders, the legislation and administration of IT in health care service production should be brought up-to-date with the technological advances, otherwise we will most likely see stagnation in the development of such systems. Companies operating in the field of health services provision need proof of cooperation from the regulators to invest in and fully embrace new technology. Our survey found that companies would be interested in implementing new systems but are sometimes unable to do so, because of institutional constraints. The latest developments in legislation and the numerous government projects aiming at developing guidelines for IT in health care do manifest a commitment to change in the highest levels of administration, but the health care sector will probably nevertheless remain a few years behind the rest of our society in the field of information technology usage. The effects of the legal and organisational environment are discussed in research paper 2, “Structures Surrounding e- Health: Effects of Legal and Administrative Structures on Development of IT in Health Care Services - focus on Finland”, in which we show that there is a widespread interest in developing and using new technologies.

The legal and administrative barriers presented here provide more insight into how a mobile system could fit into the Finnish health care system and consequently a more detailed answer to research question 1.

Despite the rather difficult organisational environment the Duodecim Publishing Inc. has developed their mobile system and it is in use. Due to the restrictions presented above concerning patient-specific information and prescription information the system is in its contents limited to medical information of a general nature.

5.7 Initial expectations of the users: Pilot user survey 1

In order to understand the acceptance of the new mobile tool under study here, the Duodecim mobile package, the factors affecting the initial perceptions of such systems among the pilot user group and the perceived need for such a system, a survey was conducted during the training sessions where the physicians initially received their devices and databases.

There are a number of points clearly visible in the results:
First, physicians have positive perceptions and intentions regarding the mobile system. They are willing to use it in their work. Ease of use and usefulness of the system are main drivers for them to adopt it. Physicians showed, however, considerable interest in buying a Nokia Communicator if the mobile system was available in it. The lack of enough such devices is the biggest barrier to adoption.

Second, the contents of the mobile system are crucial for its acceptance. EBMG, Pharmaca and ICD-10 were valued as the three most important contents. Higher quality information - the service content - constitutes a positive value for users [Landor 2003].

Third, the system is generally used either on the move or at home. The possible explanation for this is that physicians in Finland generally acquire information and manage their patient care through computers and Internet connections at their place of work. At home, they are away from those channels; consequently, they easily turn to the mobile system for help. Mobile services are seen primarily as supplements to rather than as substitutes for the wired Internet and PC-based tools at the moment.

User adoption theories assert that intention is a proper proxy to examine and predict a user's behavior towards information systems [Davis 1989]. Our study convinced us that such a mobile system designed for healthcare is needed by physicians. There is a high potential for mass adoption in the future and physicians could be the early adopters of mobile technology.

IT can usually enhance users' productivity in their work. As mobility becomes a must in the modern world, professionals, such as physicians, have to seek support from mobile technologies [Kakihara and Sørensen 2002]. Most of the physicians in our surveys expected the mobile system to speed up their work. It might improve efficiency of work, an important aspect of productivity. Such "speeding up", could save physicians' time, especially when they are on the move or making a house call. They can access information immediately. The mobile system also provides a good alternative for physicians completing their information search

and helps them with patient care, which enhances effectiveness and productivity. These expectations suggest that the mobile system will have an impact on the everyday work of physicians in the contexts where the freedom-creating ability of the system is most obvious.

5.7.1 Individual differences

The examination of individual differences' impact on physicians' perceptions of usefulness and barriers to the mobile information system has provided us with some insights of the information needs in the practical health care work. The 6 tested factors, except for positions in hospitals, do make a difference on physicians' perceptions of and attitudes towards the system. *The working environments* influence physicians' preferences of information delivery channels and their perception of usefulness of mobile the databases. *Usage levels of a traditional Internet portal* do affect physicians' opinions on the usefulness of mobile EBMG and education calendar and their judgment of barriers to using a mobile system. *Age* has an impact on physicians' consideration of lacking usefulness being a barrier to usage. *Gender* influences the perception of usefulness of the mobile EBMG. *Practical education* differentiates attitudes towards the mobile Pharmaca compared to Internet-and paper-based versions.

5.7.2 Summary

Three of the initial research questions could be answered by the study presented here: "What kind of impact can a mobile system have?", this time in the exact context of the pilot group's work. "In which specific settings and contexts in physician's work does a mobile system have most impact in their everyday routines?", and "what are the reasons for physicians to use the system?".

The pilot group had rather clear expectations of how the system will perform in their work:
The kinds of impact expected by the users were generally positive. A majority of the respondents expected the two main databases (EBMG and Pharmaca) to speed up their work.

The expected usage was concentrated to two locations or contexts. The first one, at home follows the expected patterns of usage outside the realm of local mobility. The second one, on practice in own office was unexpected. It is possible that the respondents overestimated the usefulness of the system in their everyday practice, a question that needs to be clarified when exploring the actual usage.

The reasons for using the system were as expected: the usefulness of the system at work was the main determinant of adoption decision. Speed and ease of use were

considered very important characteristics of the system. The other side of the reasons, barriers to usage were mainly the speed of the system and its suitability for patient work. These factors and the attitudes of the users are discussed further in research papers 3 and 4, “Physicians’ perceptions of and intentions to a mobile medical information system: a descriptive analysis” and “Professional mobile tool: A survey of Physicians’ perceptions of and attitude towards a mobile information system”. The respondents were not at this point asked about the changes in their work practices the system could initiate, so this question will be clarified later.

The settings of usage will naturally have an effect on the impact the system will have on the work of the users. The expected usage contexts mentioned above will probably be the main areas of impact. The factors contributing to the impact remain at this stage unclear, except for the factors predicting usage according to the results from previous research using the TAM model: perceived usefulness and ease of use in general terms. These factors are comparable with system quality and information quality factors in the evaluation framework presented in chapter 4.6 The findings here will be corroborated by findings in the later studies.

5.8 Actual usage: Survey 2

In addition to the questionnaires, Pfizer Finland Oy conducted a telephone interview in June 2003, after the physicians had been using the systems for some 2 months. Forty-two doctors were interviewed. Half of them were health-center general practitioners (GPs) and the other half specialists.

The actual usage of the mobile system followed the lines of the pre-use survey (survey 1). In the telephone interviews the respondents (n = 42) stated that the services were useful in their work (71%), the most important determinants of usefulness being immediate availability of information, fast Pharmaca, EBMG and ICD-10. The respondents (7%) who found the system unnecessary for their work had two main reasons for not needing it: health care centre physicians because they always have a desktop computer at their disposal and direct access to the material on CD or Internet, and specialists because the package does not contain information about their specialty. The device itself was found somewhat bulky and awkward to use, and the Internet connection slow. There were few directly negative experiences.

The actual usage patterns followed the intentions found in the initial attitude study. The determinants of usage were, as expected, related to the usefulness of the information and immediate delivery of information. This is consistent with the freedom creation aspect presented in the logic model. The findings of the telephone survey are briefly presented in the original research paper 3. A more detailed description of the study is found in Han et al. (2005 a).

5.9 Uses, user perceptions and impacts: The interview study

During winter 2003-2004 a group of 30 medical doctors working in the public sector in the Turku area were interviewed by the author about their Communicator usage patterns. Twenty-four of the respondents were general practitioners working in health care centres and six were specialists holding positions in hospitals. The interviewees had been using the Communicator for periods between 4 and 10 months after the initial one-day training session where they were provided with the devices and instructed about the databases and how to use them.

The typical work for a general practitioner (GP) in a Finnish health care centre consists of patient consultations and some administrational tasks and is mostly carried out in the physician's own workroom.

The specialists - most of them working in a hospital or specialised care unit - have slightly different work geography. They too do most of their work in their own offices, but in addition they do their rounds and clinical work in treatment rooms - and by the bedsides they have no direct access to information handling tools - except for the Communicator.

All of the respondents had access to information search tools at their workspaces, containing usually a clinical information system, a PC-CD version of the Duodecim databases, access to the Internet and the Terveysportti.fi-portal and their personal paper-based libraries. The GP's do most of their work in their own offices and depart from there only for small errands during the day and while working on their secondary duties, which may include maternal care (in special maternal care locations), homecare, school medicine, centres for the disabled etc. Most respondents (23 of 30) had access to a desktop PC with a similar set of tools even at their secondary work locations. The contents of the mobile databases were thus available for the interviewees even in other forms, making the findings of this study valid for the mobile form of the system rather than the contents of it.

5.9.1 The interviews

The 30 interviewees were randomly chosen from a group of 80 employees of the Turku Health district who are using the Communicator. The first four interviews were conducted as a pilot to test the interview questions, and these four answers do not contain all of the data points in the later interviews. The pilots are used where sufficient material was present. Only two of the potential respondents

declined to partake in the study, and these were replaced by the next names on the list. The interviews took place in the offices of the interviewees and lasted on average 30 minutes. The physicians were asked questions about their work structure and geography, their information search methods in general and their usage of the mobile databases in particular. The questions were of both structured and open-end types. The usage of the mobile system here refers only to the usage of the Duodecim databases although the physicians interviewed were also using the built-in features of the device such as calendar and contacts list.

5.9.2 Importance of the system

As the studied mobile system is still very limited in scope containing only searchable databases of a general nature, the kind which an average doctor does need approximately 2 times a day [Jousimaa 2001], the mobile system is bound to have a limited effect on the work structures or habits of the users. The possibility of reengineering the work of a typical medical doctor by introducing more comprehensive mobile tools cannot be assessed by the findings of this study alone. The evidence from the interviews suggests that the mobile system in use has had an impact on the work habits of some doctors in some specific situations and that the changes have been positive in efficiency and in the time/quality relation in some specific work sub-processes.

5.9.3 System quality

The perceived quality of the system/device combination was assessed by a number of questions in the interview study.

The usability limitations of the mobile device (small screen and keyboard) were not considered to be crucial or impeding the use of the system. Only two of the 30 respondents complained about the difficulty in reading lengthy articles on the small screen. This is in line with the perceived usage patterns: in critical situations with urgent need for information the usability of the system is of secondary nature as long as the information is available. The mobile system compared well to the other possible means of information search: it was considered to be a more appropriate means of information search than a printed book, and the user interface of the mobile was deemed to be easiest to use by 23% of the respondents.

The context of different work situations was mentioned by four respondents who, despite their opinion of the most appropriate user interface in their normal work being something else, recognised the mobile as the most appropriate in some situations, especially outside the office or when other means of information

search were unobtainable. The easy browsability and immediate recognisability of paper documents was mentioned by one user who considered a book the easiest interface.

5.9.4 Information quality

Information quality comprises the characteristics of the contents of the system. The contents of the mobile system are basically the same as those of the printed, CD-ROM and Internet versions of the databases.

The database considered most useful by the interviewees in my sample was the EBMG(16 statements, 53%), the Pharmaca Fennica following with 10 mentions (33%). There was a difference between hospital specialists and the health centre GP:s: The specialists valued the Pharmaca higher than the EBMG, mainly due to lack of in-depth information about their own speciality.

The clarity and scope of the contents was deemed adequate by the majority of the users. For the EBMG the contents were deemed adequate by 25 respondents (86%). The dissatisfied ones judged the contents were to be narrow, containing no specialist information and no mentions of very rare conditions.

5.9.5 Use and user satisfaction

Usage and user satisfaction have been identified as crucial components of IS success. Without usage there can be no impact of implementing a system. The interview study was designed to dig deeper into the usage patterns and usage contexts of the users.

There were clearly distinct groups of users among the interviewees:

Group 1 (6) Those who find the mobile so useful that they have it open on their desks and use it even when they are sitting by a desktop PC with a 17 inch screen and access to the Internet and to the Duodecim databases on a CD.

Group 2 (11) Those who like to use the mobile in their secondary work locations where access to other information search tools is limited, or at home or in other out-of-office situations.

Group 3 (6) The specialists who conduct a large proportion of their work outside their offices and like to check things on the mobile instead of walking to the nearest computer terminal.

Group 4 (3) Those that use the mobile as a mere backup for ex-tempore situations like when travelling or at home and do not use the mobile in their everyday work at all.

The relative sizes of the groups within the interviewed group are in themselves rather revealing: both extremes; the non-users and the very enthusiastic users made up only 35% of the interviewees, the vast majority being those who use the mobile in situations where the advantages of a mobile system are most obvious. The relative sizes of the user groups are visualised in figure 9.

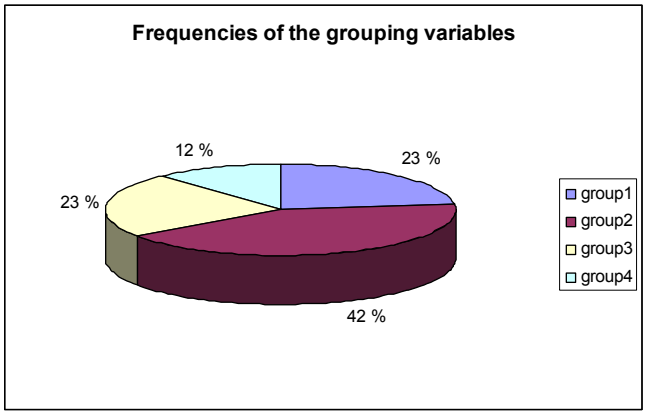

Figure 9 The relative sizes of the user groups

The categorisation of innovation adoption by Rogers (1983) predicts the following grouping: innovators 2.5%, early adopters 13.5%, early majority 34%, late majority 34% and laggards 16%. The group 1 here would include both the innovators and early adopters, making up 16% of the users, whereas in the interviews the group 1 was 23% of the users. The majority, predicted to be 68% of the population by Rogers was here groups 2 and 3, 42+23 % or 65% and the non-users (group4) or laggards in Rogers terms were 12% when the Rogers model predicted 16%. The sizes and types of the user groups were clearly close to the expectations of the diffusion of innovation theories.

The usage patterns were in general as expected: the usefulness of the mobile device in the actual work setting of each individual doctor was the most commonly stated determinant of the actual usage in the open-end interview questions. The stated usage patterns varied according to the perceived usefulness of the device in the work environment.

Despite the relative sizes of the user groups the most common setting for using the mobile system was the physician's own office – this suggests that the mobile system has advantages over the fixed systems even for the users who are not so enthusiastic about the mobile. The most common task for the system was a quick check of something- specific symptoms or latest care guidelines for some rare condition, or proper dosage of some medication. The most commonly used databases were the EBMG and Pharmaca Fennica (10 users each), and the ICD10 listing needed for filling doctor's statements (3 users). This actually confirms the surprising result of the initial survey where the users did expect themselves to use the mobile system in their normal practice.

One possible advantage of the mobile system was its being less obtrusive during patient contacts than a full-sized computer. This feature was recognised by six respondents. All interviewees were aware of the importance of maintaining eye contact with the patient, but the opinions of the mobile system as an enabler of this were highly polarised: The 6 interviewees who liked to use the mobile during patient contacts considered the mobile the best way to check something without disturbing the patient contact, but three of the respondents who liked to use a full-sized computer saw using the mobile as the most disturbing way of information retrieval during patient contacts. ("The patient might think I'm writing a Short Message (SMS)"). Only two respondents were still in favour of paper books as the fastest and least obtrusive method of searching information during patient contacts.

The mobile system containing basic medical knowledge has proven its usefulness in certain situations. The user acceptance of the system depends on the situations and settings in which the user is working and, of course, the user's personal attitude towards mobile devices. The mobile has some advantages over desktop systems even in a doctor's office due to its simplicity and unobtrusiveness. More on the usage patterns in research paper 5, "Physicians' Usage Experiences of a Mobile Information System".

5.9.6 Individual impacts

The impact of the system is the most difficult to assess aspect of IS success. The interview study had a set of questions related to the changes in work routines, work habits, perceived productivity, time use, time/quality ratio of work and ways in which a mobile system could enhance their work.

The *temporal* changes in the interviewees work were negligible. There were no major impacts on the independence of time use or the work pace of the respondents. The most visible change was in the quality / time ratio of the respondents' work. A total of 19 (63%) of the respondents reported some change in this aspect.

The *spatial* behaviour of some respondents had changed. There were changes in the work habits of 36% of the subjects, although a majority of these changes were deemed small.

The mobile system was considered mostly as a complement for the other means of information search, preferred in situations where no other means were available.

The system, given its limited contents and disconnectedness from artificial spaces (apart from e-mail capability) does not seem to have the ability to change the *contextual* environment of the physicians.

The individual impacts on physician's work are discussed further in research paper 6, "Impacts of Physician's Usage of a Mobile Information System".

5.9.7 Organisational impacts

Given the organisational structure and the surrounding society presented in chapters 5.5 and 5.6 the impact of introducing this type of a mobile tool is negligible. The systems that would enable wider organisational change would need to incorporate the existing information systems and provide information freedom from system to system. This is currently not possible. The mobile system evaluated here may serve as a catalyst in changing the ways of thinking about medical work but substantial changes in the organisation of the field would require more than that. The catalyst effect will probably arise from the fact that more and more physicians will be using mobile devices of different kinds, running systems such as the one presented here, and as the surrounding

infrastructure develops, the medical professionals will be ready to adopt new mobile solutions that will include more tangible changes in the organisations.

5.9.8 Summary

The impacts of the system under study here have been relatively small, as expected due to the limited information content of the system. The impacts have been slight changes in routines and work habits as well as reductions of using other information sources, mainly printed books. The time and effort savings are difficult to quantify but some effects in this direction were mentioned in the interviews. A system with more content and connection to patient-specific data would eventually have a greater impact.

The system is mainly used as a complement to the other information systems, including printed material. The usage is concentrated in situations where other means of information retrieval are limited or where the system is easier/faster to use than the alternatives. Situations like these are mainly outside the physician's own office, on ward rounds, secondary workplaces or at home in free time. The system was, however, used surprisingly much even in the office setting next to a desktop PC with access to the same material.

The reasons for using the system were fairly utilitarian. The system was perceived to be easy and fast to use even in situations where other means of information retrieval were available. This does not necessarily tell one so much about the mobile system but that the desktop-based system in use is not perfect and requires too much effort in some instances. One stated reason for using the system was the feeling of security that has its grounds in having relevant, up-to date guidelines along at all times.

The work processes of the interviewees were not changed dramatically by using the mobile system. The most important changes were being addicted to the electronic calendar provided by the device- not by the system under study here, and small changes in spatial behaviour due to the ability to perform fast checks on medication or conditions without having to move to the nearest computer terminal.

The settings and contexts where the mobile system had most impact on the work processes of the interviewees were consistent with the hypotheses presented in chapter 6.4. The impacts were very small and the changes naturally limited to the information search behaviour. The settings were those in the realm of remote mobility, even as the hospital specialists found most use of the system on ward rounds - a context within local mobility.

The answers to the two last research questions; in which settings the mobile information system has most effect and what factors contribute to the usage and impact of the system, are clearly found in the interview study. All the components of the logical model could be identified and evaluated, and the interactions between the components seem to follow the expectations.

The system's fit with the specific contexts where it was used was determined by:

1) Quality of information available- the same material was used by the interviewees in other forms prior to trying the mobile system. The contents were deemed to be reliable and clear, although somewhat narrow for specialist use.
2) Usability and ease/speed of use of the system in different situations compared with other alternatives. Some interviewees preferred printed books and some the Internet versions of the databases, but the very simple interface and fast search function contributed to using the system even next to a full-size desktop PC.
3) The setting in which the physician is working and the personal work habits of the user do play a significant role in forming the usage patterns of the users. The more mobile users and those with very heavy workloads tend to appreciate the system more than those who are relatively stationary and work shorter weeks.

5.10 Freedom creation

The mobile medical information systems do have a visible impact on the following parts of the everyday routines of a physician: fast checks of some critical facts like medication or the exact treatment recommendations of some condition, finding contact information, finding the ICD- code for some condition. Thus, the system can be seen to create information freedoms in certain situations where information has previously not been available. The impacts of the system are very context-sensitive. The Braudel rule presented by Keen and Mackintosh (2001) stresses changing the limits of the possible. The system presented here does change the limits of the possible, but only in certain types of situations- the routines of everyday life are not fundamentally changed. The simplified test for freedom creation suggested by Keen and Mackintosh - whether the user would be able to function without the system - gave positive results for the enthusiastic user group. The heavy users would find their lives more difficult should they be forced to abandon the system. The freedom- creating aspect of the system is further verified by the fact that some 70% of the pilot project participants have, after they had to return the pilot devices, purchased a newer Nokia Communicator (9300 or 9500) with their own money in order to continue using the system. The rest, with very few exceptions, acquired the 9210 communicators they had been using, for the market price of used devices.

The added value provided by a mobile system can partly be derived from the usage environment and routines and the level of the systems' compliance with the Braudel rule within these environments. The system in its present form is a good start but needs to be able to support more of the local mobility, which is the main setting of medical work.

5.11 Usefulness of the evaluation framework

The evaluation framework used as a basis for this study, introduced in chapter 4.6 is supported by the empirical data.

The limitations in content and device characteristics caused by the surrounding structures and existing technology were visible in the actual form of the system at hand, and this limited the impact the system can have in everyday work of the physicians.

The system and information quality components were deemed important in the initial survey, and even found sufficient in the later studies. Since there is no point of comparison, the exact effect of these is impossible to determine. The wishes for extended scope of the information content in the interview studies suggest that the information quality has a very profound effect in a professional setting.

The use and user satisfaction components were found to be interrelated and dependant on the fit of the system and the working habits and contexts of the user, on top of the system and information qualities. The personal characteristics of the users were visible in the usage patterns, but the contextual differences were deemed more important by the users themselves.

The importance of the system was visible in the usage patterns following the expected need for the type of information available - and in clearly less usage for users who have other means of obtaining information - importance seems to be a concept very close to usefulness.

The mechanism of creating individual impact through changing the limits of the possible is supported by the findings: the system is considered most useful in situations where information retrieval has previously been impossible or very difficult. However, all of the usage was not explained by creating *freedom*-level advantages. Usage of the mobile system beside a desktop computer implies that even lower-order benefits - *conveniences* and *features* were sufficient to cause the pilot users to use the system.

The individual impacts were, though small, more dependant on the freedom-creating ability of the system than mere usage - using the mobile system on a desktop beside a full-sized computer was not considered a change in the working habits, but the possibilities of using the system in the realms of remote and local mobility where it's potential is biggest was a source of changes in the working habits of the pilot users.

As the evaluation framework was not intended to be a verified causal model but a mere construct for conceptualising the phenomena around mobile systems adoption and use, the model seems to have captured most of the relevant factors for mobile systems success. An important finding per se is that a mobile system is used in a multitude of contexts and situations, and different characteristics of the system seem to define the usefulness of the system in different usage contexts.

5.12 The effects of contexts: The final survey

The patterns observed in the interviews were clear, as were their implications for the importance of the system. To validate the observed patterns and to establish the context-dependence of the system use, a survey concerning the spatial and temporal mobility of the users was designed. The same data was used to confirm the extensions to the TAM model by Shegnan Han et al. (2005 b), and only a part of the questions are of interest here. Han et al. (2005 b) studied the effects of fragmentation of working space and working time to acceptance of mobile technology. The findings of Han et al. suggest that fragmentation of working space does have a positive effect on the adoption of mobile technologies, especially when the fragmentation has a large component of remote mobility. Fragmentation of working time on the other hand had a direct negative moderating effect on mobile technology acceptance especially when paired with low fragmentation of working space. The questions, summarised in appendix 3, were used from March to October 2004, when a web questionnaire managed by Webropol Oy was sent with support from the Publisher and the project sponsor. An e-mail was sent to 578 physicians from the pilot group. The remaining 222 had changed their e-mail addresses during the project and were thus unavailable for the survey. A total of 242 usable responses were received, giving a response rate of 41.9%. The questions in this survey were concerning the spatial and temporal mobility of the users and the impacts of these on their usage of the system. The possibility of nonanswer bias should be noted.

The main points of interest here are the correlations of certain types of spatial behaviour and a) self-reported usage of the system, b) fit of the system use to the respondents work style and c) degree in which the system is perceived to help the respondent in their work routines. The findings were interesting. The strongest correlations were found between “making house calls” and “working at home” versus “helps in routines” and “fits with work style”.

Correlations

		Zscore: COMP3	Zscore: FWS6
Zscore: COMP3	Pearson Correlation	1	.226**
	Sig. (2-tailed)		.000
	N	236	235
Zscore: FWS6	Pearson Correlation	.226**	1
	Sig. (2-tailed)	.000	
	N	235	239

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

Table 3 Correlations of helps in routines(COMP3) vs. making house calls(FWS6)

Correlations

		Zscore: COMP1	Zscore: FWS6
Zscore: COMP1	Pearson Correlation	1	.202**
	Sig. (2-tailed)		.002
	N	236	235
Zscore: FWS6	Pearson Correlation	.202**	1
	Sig. (2-tailed)	.002	
	N	235	239

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

Table 4 Correlations of fits into work style(COMP1) vs. making house calls(FWS6)

Correlations

		Zscore: COMP1	Zscore: FWS3
Zscore: COMP1	Pearson Correlation	1	.185**
	Sig. (2-tailed)		.004
	N	236	235
Zscore: FWS3	Pearson Correlation	.185**	1
	Sig. (2-tailed)	.004	
	N	235	238

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

Table 5 Correlations of fits into work style(COMP1) vs. work at home(FWS3)

Statistically significant correlations at 0.05 level were found between;

- use frequency and making house calls,
- fit into working style and traveling,
- helps in routines and working in own office,
- helps in routines and working at home,
- helps in routines visiting other locations, and
- helps in routines and traveling

These correlations do verify the apparent (and rather obvious) context-sensitivity of the system usage found in the interviews. The surprising finding, correlation between working in own office and the system's help in routines, suggests that the usage patterns found in the enthusiast group (having the device open at desk) may be more widespread than the interview results imply.

Chapter 6 Conclusions

This work set out to evaluate a mobile information system for physicians, with emphasis on the impacts of the system for the work routines of the users. The system in question was evaluated from a number of perspectives according to the research questions presented in chapter 1.3. The evaluation was not intended to be a mere description of the effects of the system but also to provide possible explanations to these effects. The research questions have, in light of the empirical studies, the following answers:

1) What kind of impact can a mobile information system have on a medical professional's work?

The benefits of mobile systems and other forms of knowledge mobilisation in health care are clearly demonstrated by a number of studies worldwide. Bringing information where it is needed, when it is needed, to whom needs it would clearly improve the efficiency of health care systems. Mobile systems are a part of this development, and can have a significant impact in situations where other means of information input, retrieval and use are cumbersome or impractical. These situations are not as common as one might think, and the real benefits of the mobile systems are visible where the system matches the information demands of the context. The possible impacts range from simple savings of time and effort to possibilities to rearrange work processes completely. The system under scrutiny here is limited in information content and serves merely as a means of bringing evidence-based medical knowledge to the point of need. Since most medical work is done in surroundings where other information retrieval systems are available, the impacts of this type of system are bound to be very small. However, the health care sector is very critical in the sense that an error by a physician can have lethal consequences, and a system that has the potential to reduce the possibility of error- even if mostly used in unexpected situations - can have a profound impact for individual patients and physicians in these situations.

The Finnish health care sector is slow to change the regulations and processes that affect the development of new tools. The information content most needed in the realm of local mobility, patient-specific information is heavily regulated and fragmented, making mobile access limited at best. The legal and organisational environments are slowly changing and there are possibilities for systems with wider contents and increased functionalities in the future. The system described here is a step in the right direction, and has proven that the physicians are ready to use mobile systems when useful and available.

2) How is such a system used by practising physicians?

The pilot group of users of the Duodecim Mobile System were using the system in accordance with the patterns expected and predicted by the technology acceptance models for professionals [Berg 1999, Chau and Hu 2002, Hu et al. 1999] and models of innovation diffusion [Rogers 1983]. The surveys revealed positive attitudes towards the system and widespread usage among the pilot users. The interviews unearthed the fact that both the actual usage and the perceived usefulness of the system are very context-sensitive. The information content is of such nature that the system is mainly used outside the routine work, with the exception of hospital doctors who experience a large degree of local mobility in their work. The mobile nature of the system does, however, have some advantages over the traditional means of information retrieval. The compactness of the device allows the users to carry it along at all times, enabling them to be more effective in unexpected situations, and the size of the device even helps some users to maintain eye contact with a patient during consultations. The usage is concentrated in contexts where the freedom-creating value of the system is most obvious.

3) What are the reasons for physicians to use the system?

The reasons for the physicians to use the device were very utilitarian. In situations where the mobile system gave them perceived advantage in the form of saving time or effort or even enabling them to perform diagnoses based on current knowledge in unexpected situations. Even the confidence-increasing effect and simplicity of use were important for the users.

4) How will the work processes of a physician be affected by using a mobile information system?

This question was intended to shed light on the freedom-creating ability of the system. The findings suggest that using the system has had a very limited impact on the work of a physician. The temporal and spatial changes in everyday routines were very small. Outside the routines, however, the system has changed the information retrieval habits, mainly by being a constantly up-to date substitute for printed books. The interview data even suggests that in unexpected situations the system can be invaluable and in extreme cases even save human lives.

5) In which specific settings and contexts in physicians' work does a mobile information system have most impact in their everyday routines?

The main benefits and impacts reported by the users were savings in time and effort, reduction of possible errors, ability to access information in unexpected situations (this had an effect on the younger physician's self-confidence- whether

they actually needed the information or not). The effects of the system were reported to appear in contexts like:

- At home when a neighbour or a family member asks a medical question.
- When at secondary workplaces where access to other information tools is limited.
- When making house calls.
- While travelling.
- While making ward rounds.

The contents of the system were deemed adequate for the abovementioned situations. The usability limitations of the smallish device were outweighed by the ability to access information at all, but while sitting by a desktop computer most users preferred to use the desktop. The very fast and simple interface of the mobile system was a very important feature of the system and was emphasised by the heavy users as being the main benefit of the mobile system, apart from portability.

6) Which factors contribute to the system's usage and impact in specific contexts or what would be the determinants of contextual fit between the system and medical practice in Finland?

The factors affecting the system usage were numerous. The characteristics of the users did have a noticeable impact on the perceived usefulness and intentions to use the system. The system characteristics and their fit to the contexts of intended use were, however the most important factor determining usage and impact of the system. Usage of the system was concentrated in the realm of remote mobility, suggesting that the information and usability requirements in everyday work in the workplace surroundings, which fall into the definition of local mobility, were not directly met by the system. In the realm of remote mobility the system delivered clear advantages, as predicted by the freedom creation hypotheses in chapter 4.6.1.

The mobile system presented here does have an impact on the work of practising physicians. As the contents and functionalities of the system are at this point of development rather limited, the impacts are not of suitable magnitude to change the work processes of the physicians or to justify organisational changes due to these impacts. The system is essentially a complement to the existing systems for information retrieval and has mainly substituted printed books. The implications of the pilot project are despite this numerous. The project and this study provide insight into how professionals use and perceive mobile information systems, how the context of usage is extremely important for mobile systems usage, and how the usage patterns form in actual medical work in Finland.

The evaluation framework used as a basis for this evaluation seemed to capture most of the important factors affecting mobile systems use and impact. The possible causal relations in the model could be empirically verified by testing them separately with a larger sample.

The findings here have the following weak points which should be taken into account when interpreting the results:

- The whole population of users of the Duodecim mobile system is located in Finland – the patterns of usage of similar systems elsewhere may differ from those observed here.
- The surveys reached a fairly large sample of the pilot user population, but it is possible that some nonanswer bias is present in the findings.
- The interview study had a small sample with geographical concentration. Even as the interviews were continued until no radically new patterns could be found, there is a possibility of different phenomena outside the interviewed group.
- The evaluation framework has not been empirically tested and may oversee some important factors. As a framework for conceptualising the factors present, the framework does not directly address the causal relationships between the factors. Therefore the findings and the explanations should be considered in the light of these shortcomings.

6.1 Further research

The findings of this study suggest that the most important factor in designing a mobile system is the contextual fit between the attributes of the system and the needs that arise in intended or actual usage situations. The existence of different information and function needs in different contexts does justify a closer scrutiny, in order to enable development of mobile systems that fulfil the promises of knowledge mobilisation. This gives room for the following interesting research questions:

Are the patterns found here directly applicable to other types of professionals or even the general public? Similar studies of other professionals could reveal interesting developments.

Can the contextual fit between a system and the multiple usage contexts be measured during the concept-testing phase of system development with reasonable accuracy? As the most important determinant of impact of the mobile system studied here seems to be the contextual fit between the often occurring work contexts and the system characteristics, a model could be developed to measure the potential for individual impact based on this. The model could be very close to the Task-Technology Fit model, with the extension of multiple Task/Context variables.

Can the evaluation framework here be used as a basis for development of a causal model of mobile systems impact? The framework implies some causal relations that were unfortunately not verified here. The relations have been proven to exist separately in tests of the underlying DeLone and McLean model, some TAM-variations and even other success models. A study to determine the relative strengths of the causal relations could advance the understanding of mobile systems acceptance and success.

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Appendices

Appendix 1, the interview question frame

Duodecim Mobile package: Interview questions
Date and Time:,Place:

Background

Interviewee:
Name, age, education, gender, years in profession, work categories (GP, specialist…),familiarity with Nokia communicator 9010i, years of computer usage, usage of mobile phones /usage of advanced mobile services?

1. Describe your typical working day.

Fragmentation of working time

1.1 the 3 most important activities of the day
1.2 the 3 most time-consuming activities of the day
1.3 the 3 most frustrating activities of the day
1.4 What kind of interruptions You experience in your work
1.4.1 The duration of the interruptions
1.5 How many hours You work in a typical week

Fragmentation of working space

1.6 How often do you move around your working place in a day?
1.7 How often do you have to visit other locations/buildings in a day?
1.8 Do you have access to your tools and information sources in
1.8.1 Your primary workplace
1.8.2 Other locations?
1.9 Apart from your possible clinical tools, which devices (clipboard, mobile terminal, voice recorder etc) do you carry with you when in different locations?
1.10 How often do you need something that is located somewhere else / should you carry even more items with you?
1.10.1 Which things are most often misplaced?

2 Usage of Duodecim databases

1.1. Which other means of information retrieval do you use (papers, books, other websites or databases?)
1.2. Usage on a typical day/ how much and in which environments/situations?
1.2.1. Paper-based(books)
1.2.2. CD-based Duodecim databases
1.2.3. Internet portal
1.2.4. Other Internet resources
1.2.5. Mobile package
1.3. Which of these four different ways to access Duodecim databases is your most favored one currently? Describe situations.
1.3.1. Do you intend to use mobile package in the future more frequently than the other three?

1.3.2. Has the availability of mobile package decreased your use of some other ways of information search? In which way, and why?
1.3.3. Which particular database is the most useful in the mobile package/ which databases do you use most in the mobile package ? Why?
1.3.4. Are the contents of the mobile databases clear and complete enough or do you often feel a need to search for more information? Which particular parts would need more attention?
1.3.4.1. EBMG
1.3.4.2. Pharmaca
1.3.4.3. IDC-10
1.3.4.4. Cochrane Abstracts
1.3.5. Which user interface do you find most appropriate for your use? (Mobile, Internet portal, CD version, paper book)
1.3.6. Which user interface do you find most easy to use? (Mobile, Internet portal, CD version, paper book)

1.4. Is there a speed difference at your workstation between the CD and Internet versions of the databases
1.4.1. Is the CD installed in Your own machine or a server?

1.5. Do You use some means of information retrieval during patient contact?
1.5.1. Which device/ interface supports best the patient contact?
1.5.2. Which device/ interface disturbs least the patient contact?
1.5.3. Could information search during patient contact be enhanced somehow?

1.6. How significant are the limitations of screen size and keyboard of the Nokia Communicator for this type of application (1-5)
1.6.1. Which other functions of the communicator(calendar, email etc) do you use regularly?
1.6.2. Do you use another mobile device or is the Comm your main communications channel?
1.6.3. Do you keep the Comm with you in Your free time? (always/often/never)

2. **Describe reasons for your adoption of mobile EBMG or, if present, explicit reasons not to.**
2.1. Adoption drivers (multiple reasons? Benefits? values?), 3 most important?
2.2. Reasons for refusal (all you can think of, 3-5 most important)(of course one will do as well)
2.3. If you have recently used the mobile package, describe 3 situations where you most liked to use it.

3. **Mobile package usage effects**
3.1. Do you think the usage of mobile package has (1-5)
3.1.1. Sped up Your routines?
3.1.2. Reduced the possibility of error?

3.1.3. Enabled better concentration or time use during patient work?
3.1.4. Decreased Your weekly work hours

3.2. Fragmentation of working time- has using the mobile… (positive effect/negative effect/neutral)
3.2.1. Increased/decreased Your independence of time use?
3.2.2. Increased/decreased Your work pace?
3.2.3. Affected the time/quality ratio of Your work?
3.2.3.1. How?
3.2.4. Affected Your work routines or schedules?

3.3. Process changes: has the mobile…
3.3.1. changed your way of working? How? Significance of the changes 1-5
3.3.2. replaced or only supplemented the other three forms of guidelines?
3.3.3. Could Your work be rearranged somehow and what kind of tools/systems that would require?
3.3.4. Could the communicator or other mobile device support these changes?

4. Will you continue or discontinue to use the Mobile package?
5. Your feedback and ideas on system design and content improvement

Appendix 2 the questions in the internet survey

1. -5 background variables
6. Age
7. Gender
8. You are:
9. Your main work is (in / as)
10. Experience in the medical practice
11. How long have you used Duodecim mobile databases
12. On the average I use the Duodecim medical mobile package
13. Estimate how many hours each week you are using the mobile medical package
14. My work schedule is often influenced by unexpected events during my working day
15. I do work in my free time (non-office time)
16. I usually do many things at the same time
17. I usually achieve what I have planned in my typical working day
18. I usually try to keep to a specific schedule at work
19. My working day is built of routines
20. My work schedule often depends on other peoples' schedules
21. I usually do work in my own office
22. For different reasons, I visit other places (e.g., reception, wards)

23. I do work at home some times
24. I regularly visit other healthcare locations (other hospitals or healthcare centres)
25. I do work on a transportation vehicle (e.g. bus, train, plane)
26. I take "house call" visits frequently
27. Among my colleagues, I am usually the first to try out new information technology
28. I like to experiment with new information technology
29. When I hear about new information technology I aim to try it
30. In general, I am hesitant to try out new information technology
31. I find the Duodecim medical mobile package useful in my practice/patient care
32. Using the mobile package enables me to accomplish tasks more quickly
33. Using the mobile package in my job increases my productivity
34. Using the mobile system makes it easier to do my job
35. Learning to operate the Duodecim mobile package is easy for me
36. I find the Duodecim mobile package easy to use
37. It is easy for me to become a skilful user of the mobile package

38. I find the mobile package inflexible to interact with
39. My colleagues and peers think that I should use the mobile package
40. The opinions of my colleagues and peers are important to me
41. My family members think that I should use the mobile package
42. The opinions of my family members are important to me
43. Using the mobile package fits into my work style
44. I think that using the mobile package fits well with my life style
45. Using the mobile package helps me in my working routines
46. I intend to use the mobile package for my patient care as often as needed
47. I predict I will use the mobile package
48. I intend NOT to use the mobile package in my work routinely

Part 2

Original research publications

1: Harkke Ville and Landor Pär: Mobile E-Health - the Challenge of Eight Obstacles, *Proceedings of DSIAGE 2002*, Cork, Ireland 4-7 July 2002, © Oak Tree press 2002, reprinted with permission

2: Harkke Ville and Collan Mikael: Structures Surrounding e- Health: Effects of Legal and Administrative Structures on Development of IT in Health Care Services - focus on Finland, a chapter in "*Human Organizational Dynamics in e-Health: A Global Perspective*", Editor(s)David Bangert, Robert Doktor, and Michael Valdez (Assistant Editor), Radcliffe Medical Press, Oxford 2004, © Bangert D, Doktor R, editors. Human and Organizational Dynamics in e-Health. Radcliffe Publishing; 2005. Reproduced with permission of the copyright holder.

3: Han Shengnan, Harkke Ville, Mustonen Pekka, Seppänen Matti and Kallio Markku (2004): Physicians' perceptions of and intentions to a mobile medical information system: a descriptive analysis, *Innovations Through Information Technology: Proceedings of the 15th Information Resources Management Association International Conference* New Orleans, *USA, 23-26 May 2004,* Information Resources Management Association, USA 2004, © Idea Group Inc. reprinted with permission

4: Han Shengnan, Harkke Ville, Mustonen Pekka, Seppänen Matti and Kallio Markku (2004): Professional mobile tool: A survey of Physicians' perceptions of and attitude towards a mobile information system, *Proceedings of the 5th GITM conference*, San Diego, 13-15 June, 2004

5: Harkke Ville (2005): Physicians' Usage Experiences of a Mobile Information System, *Proceedings of the 38th Annual Hawaii International Conference on System Sciences(CD-Rom),*03-06 Jan. 2005, Editor R.H. Spregue jr, Computer Society Press 2005, IEEE los Alamitos 2005, 6 Pages, © 2005 IEEE. Reprinted, with permission, from Proceedings of HICSS-38, Hawaii 2005

6: Harkke Ville : Impacts of Physician's Usage of a Mobile Information System, Submitted 19.12.2005 for publication in the *International Journal of Electronic Healthcare*

Paper 1

Harkke Ville and Landor Pär: Mobile E-Health - the Challenge of Eight Obstacles, *Proceedings of DSIAGE 2002*, Cork, Ireland 4-7 July 2002, © Oak Tree press 2002, reprinted with permission

Mobile E-health: The Challenge of Eight Obstacles

Ville Harkke — Pär Landor*

Institute for Advanced Management Systems Research/Åbo Akademi University, Lemminkäinengatan 14 B, FIN-20520 Åbo, FINLAND

ville.harkke@abo.fi
par.landor@abo.fi

ABSTRACT: The health care sector worldwide has been slow to adopt information technology in order to improve its efficiency, even though Finnish doctor's already complain that up to 50 percent of their working time is wasted on searching for patient and expert information stored on paper somewhere in the clinic. The emergence of new mobile communications may provide possibilities for vast improvements in the work processes of the health care professionals and the ways in which the patients communicate with their doctors. This paper monitors the state of mobile health services for both producers and consumers, and outlines the major obstacles on the way towards fully integrated mobile health care systems. Although there are some technology and security related issues, the basic reasons for slow adoption of digital services in the health care sector seem to be structural and outdated mental models within the sector itself.

KEY WORDS: mobile commerce, mobile e-health, information systems, efficiency

*Both authors have contributed equally to this article

1. Introduction

The health care sector in any part of the world has long traditions and inevitably uses some practices that seem quite anachronistic in the 21st century. As most of the other industries have taken advantage of the development of information technology, the heavily regulated health care sector has been lagging behind. The new technology can enhance efficiency in both the clinical and commercial processes involved in health care and increase consumer satisfaction by involving individuals more in their personal health care management.[1] The emergence of electronic patient records, telemedicine, telemetry, virtual consultations and systems supporting simple routines such as time management and billing are slowly changing the processes of the industry. In this article we define the problem field and argue that the major problems hindering adoption of mobile medicine are not technological in nature, but merely organizational, legislative, and mental.

The emergence of electronic media in the health care sector has created a new field of technology, commonly referred to as E-health. This term that has its origins in the Internet commerce and stems from the same root as terms like E-commerce and E-business. It has not been clearly defined, but basically encompasses all use of computers and information technology related to health care. One way to grasp the concept is by the goals of E-health could be defined as: *Any use of the Internet or related technology to improve: The health and wellness of the population; The quality of healthcare services and outcomes; Efficiencies in healthcare services or administration.* [2] Another way to define E-health is by examining the fields of life it effects: *E-Health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care worldwide by using information and communication technology*.[3]

Mobile E-health, or M-health is created by adding a mobile component to the electronic health concept. It could be defined as the use of mobile communications in order to reach the same goals as in traditional E-health.

[1] Fortune (2001)
[2] Staudenmeir, (2001)
[3] Eysenbach, (2001)

2. Needs and Expectations of the Health Care Professionals

The health care sector is a complex system involving a number of different professionals ranging from MD's to insurance and legal experts. Many of today's workflows in the sector are paper-based and include actions with a number of separate, incompatible systems. Some sources estimate that only five percent of the U.S. physicians use electronic medical-record systems; the remaining 95 percent of patient medical records are paper-based[4]. The emergence of new technologies gives opportunities for substantial savings in time and cost by streamlining the processes and making information instantly available information. Estimates suggest that up to 80 percent of insurance-related work can be automated.[5] Depending on the country and the local legislation there are at least the following major processes that could benefit of electronic communications: (1) The MD's information search and continuous training, as well as expert consultations; (2) Communication with the patients; (3) Drug information and prescription; (4) Medical records handling; (5) Insurance claims and other financial processes; and (6) Patient monitoring.

There is a large number of medical information providers on the Internet, and the MD's could in principle use these vast resources in their daily practice. However, the early e-health solutions would require the doctors to be tied to a computer terminal, which is difficult in the highly mobile context of health care. The e-health applications for doctors must be designed to match their multiple needs, including mobility, accuracy, validity, reliability, time efficiency and ease of use.[6] We suggest that this is possible with the new mobile appliances. The use of Personal Digital Assistants (PDAs) among the doctors is rising, although today only 26 percent of the U.S. doctors are using one.[7] The growing user base of mobile terminals will enable creation of more sophisticated networked systems pooling vast amounts of medical resources.

3. Needs and Expectations of the General Public

The customers of health care services could be categorized according to their health status, from chronically ill to perfectly healthy individuals. One group that uses a lot of health care resources is the *chronically ill* patients that need constant care and monitoring. This group has got substantial gains to expect when the wireless medical services become widely available. Communication with the doctors, including sending and receiving test results and connecting monitoring devices directly to the care unit's network over wireless networks will greatly enhance the mobility and quality of life for the chronically ill.

[4] Noffsinger Chin (2000)
[5] Marietti (2001)
[6] Goldstein (2000)
[7] Harris Interactive (2001a)

The general public, when faced with *acute illness,* also has a lot to gain. According to a study by Harris Interactive the health care customers have a number of sources of frustration while interacting with a doctor. The most widely remembered are: forgetting to ask all the relevant questions when visiting a doctor, having to see a doctor personally to ask questions that could be answered by telephone or e-mail, getting through to someone who could answer questions, and providing the same information over and over again when visiting a doctor's office.[8] These frustrations are remedied with relative ease when a functioning mobile system that allows the doctors to allocate their time better while having all the relevant information at hand is installed.

A third group of general public to gain from the mobile systems are the healthy people who wish to retain or *enhance* their *wellness*. A mobile terminal is an ideal platform for personalized health control programs, as the customer is likely to have the device available at all times and can use the systems provided exactly when needed. Training programs, weight control programs, quit smoking programs, and similar systems that help the people to maintain or improve their health make a definitely needed group of mobile commerce products.

4. A Brief Technology Overview

The field of mobile communications is developing rapidly. There are multiple solutions for data transfer, and a number of different mobile terminals. The most likely terminals of choice for professionals are PDAs or similar devices capable of displaying multimodal information and. For the general public the most likely device would be the mobile telephones, since adoption of PDAs seems slow. These devices can connect to a network either by today's wide-coverage cell phone networks and wireless local area networks (WLANs) or by infrared connection. The transmission speeds of the mobile networks are constantly increasing while new network technologies are introduced (GPRS, UMTS, 802.11a WLAN).

5. Usability, Personalization and Localisation Issues

The technologies available have a significant impact on the services available for both the general public and the health care professionals. The devices available today do limit the services for the general public, as true graphical content cannot yet be transmitted at a adequate speed. For the health care professionals the situation is somewhat different as the benefits of purchasing a terminal device capable of delivering various types of content might well outweigh the somewhat high price of the new technology.

The screens of the PDAs of today are already good enough for preliminary consultations of computerized tomography scans by neuroradiologists[9], and the transmission speeds over today's mobile networks are acceptable although far from optimal. As the devices and the networks will continue to develop, almost any type of data

[8] Harris Interactive (2001b)
[9] Reponen et al. (2000)

can be displayed on a handheld screen. This will enable the usage of practically any information system remotely, including information about the location of the terminal into the system enabling both doctors and patients to access critical information fast and efficiently.

6. Existing solutions

During July and August 2001 we conducted an exhaustive Internet search for mobile medical services in order to get an oversight of the market, both for the professionals and the general public. Information was gathered by using mobile health-related keywords in searches with Google (www.google.com) and Lycos (www.lycos.com), and by checking the mobile services offered by portals such as Yahoo(http://mobile.yahoo.com/).

6.1. Healthcare professionals

A number of companies are extending their Internet services for physicians for use with PDAs or other mobile terminals. The services range from simple medical dictionaries to sophisticated patient data systems capable of handling digital images and lab test results. Another set of applications is being financed by the pharmaceutical companies and focuses naturally on the creating and handling of drug prescriptions.

All the existing PDA operating systems are supported. By July 24th last year there were the following amounts of services for health care professionals listed in the Yahoo! Mobile portal: 53 for Pocket PC, 50 for Windows CE, one for Symbian and 285 for Palm OS. The shares of the operating systems in the other listings in the Internet follow the same lines as Yahoo.

Palm OS has become something of a standard due to its large market share even among medical practitioners. The number of services available is of course far greater than these displayed in one portal, but the relative market shares of the operating systems are clearly visible.

The services offered for the professionals can be roughly divided into the following groups: (1) Guides; (2) Special calculators; (3) Databases; (4) Diagnosis assistants; (5) Medications assistants; and (6) Workflow and billing tools.

The existing WAP phones serve solely as text-based browsers of the Internet, without possibility to include interactive features such as calculators that would run on the terminal device itself. The amount of WAP-based services for the health care professionals is diminutive compared with the supply for PDAs. The solutions on the market today are mainly databases that can be accessed through a mobile phone; either information sites or personal databases that can be updated with a mobile terminal. The slow takeoff of WAP-solutions seen on the consumer market is present also in the professional health care sector.

6.2. Patients and customers

For the PDAs there is a growing supply of different personal healthcare solutions. By July 24th last year Yahoo! Mobile had 41 different downloads for Palm OS-using PDAs under the "Personal Healthcare" heading. These products have in general the shortcoming that they are interactive only in the sense that the user can interact with the program, but not with any networked resources. For the telephone terminals there is a much smaller supply of services to the general public than for the PDAs. The communication standards of today, WAP and SMS, do not seem to attract the full attention of software and service developers. The Yahoo! Mobile WAP Health Links included 18 services by July 24th, 2001, which is very little compared with the amount of services available for the PDAs.

There are numerous software solutions designed for PDAs to help people suffering from various chronic illnesses. Typical solutions are glucose level calculators and medication reminders. For WAP users there are various information sites. Some solutions for remote patient monitoring with specialised GSM phones with ECG-electrodes are in use today, for example the German Vitaphone (www.vitaphone.de).

In case of emergency or acute illness a PDA equipped with the right software can be a valuable life-saving device. Software providing instructions of CPR and other first aid is widely available. A mobile phone is, of course, always practical in emergencies and there are even some WAP-based services for emergencies.

For people who wish to enhance their wellness, there are numerous solutions for controlling different aspects of life in order to improve one's health. Guides for exercising and diets, as well as guides and aides for quitting smoking or controlling one's alcohol consumption are available, as well as some more exotic guides such as databases of herbal medicine etc. The PDA solutions are standalone programmes and there is interactive systems running through SMS and WAP interfaces.

7. Factors Slowing Down the Development of mobile E-health

As a part of our project we conducted a preliminary expert survey by having a group of five occupational health care professionals (doctors and nurses) in a private hospital and health care centre[10] evaluate their work processes on basis of a questionnaire with open-ended questions. The insights were deepened by unstructured interviews of four health care network experts from Sonera, a Finnish telecommunications operator[11]. The findings suggest that there are a number of non- technological hindrances on the way to mobile e-health.

1) *The Non-mobile Infrastructure*: Development of fully functional mobile systems would naturally require that the data used is stored in electronic form somewhere. This seems to be one of the greatest obstacles hindering the creation of mobile health care systems. Electronic patient record systems are emerging, but so far only a fraction of the medical information is being stored electronically. Another problem is that where

[10] The Pulssi Clinic in Turku, Finland. One of the biggest private clinics in Finland

[11] Now fusioned with the Swedish Telia operator company

electronic medical records do exist, they are not compatible with each other. In the U.S. physicians will want the records, insurance and prescription information for at least six of every ten patients to be handled by a single device, but no pharmacy management company covers 60 percent, raising the prospect of a doctor having to juggle several different vendors' hardware and software.[12] There are national and international efforts to create standards for information exchange by organizations such as the Health Level 7 and the European Health Telematics Observatory but a lot needs to be done before health-related information will flow electronically.

2) *Security Issues*: Health records and other personal information are in most countries considered very confidential, and electronic distribution of these raises a number of issues. In the U.S. there is a law known as the Health Insurance Portability and Accountability Act of 1996 (HIPAA) regulating distribution and storage of health related financial information. Similar legislations are emerging all over the world, effecting the development of health information systems. A special issue is the security of drug prescriptions, where a paper copy of a prescription is still required in some areas, and the concept of electronic signature and electronic document verification is still in its infancy. The mobile applications are naturally affected by the security regulations, but as the mobile terminal-network link is relatively easy to secure by various encryption technologies, the major security issues concern the traditional networks running on the background. In fact, the highly personal mobile terminals, could act as a security-adding feature, helping the systems to recognize the user.

3 *Mobile Systems incompatibility*: Apart from the problems caused by the fixed infrastructure there are obstacles on the road to acceptance of handheld devices that are directly linked to the mobile environment of today. One of the greatest problems is the lack of consolidation on the market. There are numerous software developers whose products are not compatible with each other, on top of the fact that there are different, non-compatible operating systems.

4) *Mobile Systems are Expensive*: Another problem is the cost of the infrastructure and the devices. Unless there are real benefits to the doctors, the price for a PDA or other mobile terminal is too high to allow wide acceptance. Some efforts to provide the doctors with hand-held devices for free have been taken, but the cost of providing every doctor with a device even in a limited geographical area is very high.

5) *Investment Risks*: The current insecurity about the future standards of mobile communications is another factor inhibiting fast adoption of mobile devices – and services. The possibility of investing in wrong technology with high cost and dubious benefits has kept the market waiting for the emergence of a standard, whether it is agreed upon by the industry players or a de facto standard as a result of some operating system gaining the critical mass, as happened with the desktop PC and Microsoft.

6) *Still too Slow Systems*: The data transfer speeds of today are not quite satisfactory, either and only when the next generations of mobile standards are in use is there suitable bandwidth for applications that would handle the graphic-heavy data formats necessary for truly ubiquitous medical practice.

[12] Freudenheim (2001)

7) *Searching for Papers Seems to be Medicine*: As we pointed out earlier, public hospitals and private clinics are in the very beginning of using information systems in order to make the flow and the handling of information more efficient. There are lot of reasons to this − for example public slowness to change, infrastructural reasons − most of the information is still on paper even if the hospitals and clinics would buy very modern information systems at this very moment. The chain of managing patient information includes a lot of health care personnel. In other words, dealing with information on paper has become a major part of the medical activity in hospitals, private clinics, and other health care institutions. As the experts in our survey pointed out, one of the most time consuming and frustrating things for a doctor is to be searching in the whole clinic for information stored on paper, when the folder or the paper has not bee archived properly. Still, very few doctors − at least in Finland − argue actively for technology based information systems. Why so? The answer seems to be that since the information system of health care has been based on paper and human activity, this information gathering procedure, no matter how time consuming it is, has become a part of practicing medicine.

8) *Private/Public Service Obstacles*: Generally, private health care organisations are more eager than the public ones to try out mobile solutions. However, in Finland the public sector also seems to have found the IT technology. For example in the city of Pori there is a system for mobile help.[13] This mobile system is based on conventional GSM calls for getting concrete help to ask for an assistant to your home, to making appointments with physicians, to be working in partnership with the authorities to estimate the seriousness of a certain situation for being directed to the right health care.

The private sector is more flexible than the public sector, because it has to be alert in a hard competition climate. A couple of the biggest Finnish private doctor clinics have carried out different pilots and the interest in mobile and other IT solutions is increasing, since the private health care sector has realised the great value addition and the competitive advantage on in using modern information technology. Effective information systems also give the private sector competitive advantages over the public health care sector, which will become even slower and more cemented if it does not pick up modern information solutions. The Finnish union of municipal doctors expressed its concerns in Finnish media in November this year. The union said that their doctors are using too much working time on dealing with information on paper. Some doctors even use up to fifty percent of their working time handling information. According to the union the doctors would like to have the information handling process much faster and simpler so that they could use their working time for the purpose they are educated − to cure patients.[14]

8. Conclusion

The health care sector has a lot to gain from the new mobile technology. The industry has been slow to adopt the earlier advancements in computing and electronic communications, mainly because the earlier solutions would require the user to sit by a

[13] http://www.makropilotti.fi/english/
[14] Valtola (2001)

computer terminal, which is not how the health care professionals work. The new mobile terminals however enable the professionals to use electronic services more freely, making a breakthrough in electronic health care possible.

On the other hand the emergence of mobile Internet provides the general public with new forms of electronic interaction with health care organizations. The new forms of communications are changing the ways people interact and there are tremendous possibilities for enhanced efficiency of health care and better customer satisfaction.

There is, however a number of obstacles on the way to digital healthcare. In our pilot studies we found the following eight: 1) Complex or nonexistent existing infrastructure, 2) Security concerns, 3) Lack of consolidation in the mobile communications, 4) Expensive systems, 5) Risks involved in investing in unproven technology, 6) Inadequate data transfer speeds, 7) Rigid, paper-based work processes and 8) rigid social and political structures.

Future research should deepen the understanding of these issues, especially the organisational and social obstacles, as the technological ability to build functional systems practically exists already.

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Paper 2

Harkke Ville and Collan Mikael: Structures Surrounding e-Health: Effects of Legal and Administrative Structures on Development of IT in Health Care Services - focus on Finland, a chapter in "*Human Organizational Dynamics in e-Health: A Global Perspective*", Editor(s)David Bangert, Robert Doktor, and Michael Valdez (Assistant Editor), Radcliffe Medical Press, Oxford 2004,

Structures Surrounding e-Health: Effects of Legal and Administrative Structures on Development of IT in Health Care Services – focus on Finland.

Ville Harkke M.Sc
TUCS / IAMSR
Åbo Akademi University
Lemminkäinengatan 14 B
FIN-10520 ÅBO
FINLAND
ville.harkke@abo.fi
Mikael Collan M.Sc
TUCS / IAMSR
Åbo Akademi University
Lemminkäinengatan 14 B
FIN-10520 ÅBO
FINLAND
mikael.collan@abo.fi

Ville Harkke is an information systems researcher at the Institute for Advanced Management Systems Research at the Åbo Akademi University in Turku, Finland and in the Turku Center for Computer Science. His main research areas are mobile applications for health care and assessing the impact of implementing mobile information systems.

Mikael Collan is a researcher at the Institute for Advanced Management Systems Research at the Åbo Akademi University in Finland. He is involved in researching management decision support for investments with applications of fuzzy systems. Collan is also involved in research applying neural networks in medical diagnosis of cancer.

Abstract

Technological innovation has great potential in enhancing productivity of any information-heavy work, including health care. The health care sector as a whole and especially the public sector has been slow to take advantage of the latest developments, despite some relatively successful pilot projects. In the case of Finland there are some distinct non-technological issues that are hindering development even as the stakeholders in the health care industry do see the potential benefits. Our preliminary survey suggests that the real positive impact of technological innovation will be clearly visible only after the systems of private and public organizations are compatible with each other.

Introduction

During the latter half of the 20th and the beginning of the 21st centuries developments in information technology (IT) and automating work have changed the work processes in most information-heavy fields of human activity, resulting in gains in productivity and reducing the effects of human error[1]. This has generally not been the case for the health care sector, except for automating some financial and administrative tasks. The technologies necessary for reorganizing work even in this sector have existed for some time, but wide adoption of these technologies has been slower than one would expect. As the world economic growth has slowed down after the 90´s, health care systems in most of the industrialized world are facing increased pressure towards enhanced efficiency due to diminishing public financing and an aging population[2]. The need for increased use of new technology and new work methods is clearer than ever.

Introduction of new technology does, of course, not solve the problems of the field as such; proper implementation and wide enough use of the systems are important requirements.

The use of semi-automated processes and partially implemented systems can even have adverse effects on efficiency and quality of care, as suggested by Lederman and Morrison[3].

There is an observable difference in IT usage between public and private health care institutions, at least in Finland. The private clinics have a direct financial incentive to cut costs and to maximize the satisfaction of their customers, whereas the public institutions are constantly struggling with financing problems and understaffing and generally lack the ability to invest in the newest technology. The health service providers are, however, not the only players in the field of healthcare. Insurers, pharmacies, laboratories and regulating bodies all have their stake in the structure of health care systems, and cooperated efforts are necessary for truly beneficial changes. It seems that the private health care enterprises are embracing disruptive technologies to enhance their efficiency just as discussed in the classic article, but the public organizations are more prone to use new technology to support existing processes thus limiting the scope of organizational change.

The critical changes of the processes and implementation of better systems will not even be possible until the information systems in different organizations are able to function together and the critical information

flows between the organizations are automated. Technological innovations as such will only function as catalysts of required organizational change, but as such catalysts these are invaluable. This is clearly visible in the layered presentation of the problem field presented in this book; Technological innovation can only thrive where the underlying cultural and organizational contexts allows and encourages it, and even then the level of success depends on management of change, cooperation between the stakeholders and, fundamentally, on changes in the mental models about healthcare processes.

This article is composed as follows: firstly, we describe the organizational framework in Finland within which the e-health services exist, and look at administrative issues within the framework that are not supportive of advancement in the sector. Secondly, we elaborate some issues particular to e-health from a legal perspective. Thirdly, we address the discussed issues from the point of view of some of the actors in the sector. We base the third part on a small (non-representative) survey sent to actors in the field of health services in South Western Finland. Finally, we draw some conclusions and summarize.

Organizational environment in Finland

In Finland health care is basically organized around publicly financed organizations and supported by private institutions in larger cities. The universal health insurance provided by the Social Insurance Institute of Finland (SIIF) covers use of the public health care services fully and a percentage of the privately produced services [4], for example 60% of the private doctor's fees [5] A certain level of health care is guaranteed by law for every Finnish citizen. The primary administrative units, the municipalities, have since the 1990's had the right to choose how the services demanded by law are produced, including buying the services from private service providers [6].

The private service providers act as a catalyst for restructuring even the public systems by showing in practice that the same services can be produced with a smaller use of resources.

Despite the existence of a universal health insurance the citizens tend to be insured even in private insurance companies, either by themselves through home insurance healthcare packages (covering mainly accidents etc.) or by their employers. This complicates the administrative processes in cases of work-related illnesses, acute injuries and other situations where a patient is insured by several organizations.

Due to the independence of the municipalities the health systems in different parts of the country are very different from each other, all naturally providing the level of service required by law. In most districts there are organizations for everyday illnesses, for special care, in-patient wards etc. that have all been founded at different times and there is no generally applied organizational structure even within the municipalities or health districts. The existence of different organizational cultures within the bigger health care structures cause some administrative problems of their own, but even make development of information systems difficult due to differences in work processes and information requirements.

Information systems compatibility is a major issue in developing functional health care systems [7]. In Finland the fragmentation of information systems has been a major obstacle on the road towards systems that would significally alter the processes of the health care system, increasing efficiency and effectiveness. This situation has been noted by the governing authorities, and the Ministry of Social Affairs and Health has started a project for preparing a nation-wide electronic health record system. The project is organized as a work group and the main objective is to define the contents and criteria for a national electronic health record system and to maintain a cooperation network for implementing the system. The workgroup presented a strategy to the Minister of Social Affairs and Health in January 2004. This strategy contains standards for data structures, data communication protocols and data security that are to be implemented by all health centers and hospitals by 2007[8]. This provides the public sector with not only a more secure environment for investing in information technology but even with a direct incentive to do so.

Some examples of IT use in the Finnish Health Care System

Electronic prescriptions

Delivering drug prescriptions electronically has been possible in principle since the 1995 Ministry of Social Affairs and Health regulation for delivering prescription drugs. The regulation allowed for electronic data transfers on a general level but provided no specific guidelines as to how the system should work.
There have been two major publicly financed pilot projects around electronic prescriptions in Finland: the SIIF smart card project in 1989-

1993 and the health care cooperation project in the Satakunta region 1998-2000 called Satakunnan Makropilotti. The smart card project used personal health cards as data storage for prescriptions. It was a limited success, but the system was never intended to be the default system for the whole country[9]. The Makropilotti project had as its main goal to develop information technology (local information system, reference database, secure email and local service portal) to support service development in health and social services. A special law was enacted to enable patient data transfer between the different organizations within the seven municipalities partaking in the pilot. The electronic prescription service never got to wider pilot use and the project was terminated in 2000. The project cannot be described as a success as such but it unveiled a number of obstacles in the way of developing health systems: there is (i)no clear structure for service development, (ii)unclear limits of responsibilities and (iii)no authority governing the whole customer service process [10].

Based on the previous experiences the Ministry of Social Affairs and Health has in November 2003 initiated a more extensive pilot for testing electronic prescriptions. The pilot covers four public health care districts and a number of private pharmacies, and is based on a central prescriptions database maintained by the SIIF. The serious involvement of the SIIF will relieve the users of the pilot system from most of the insurance-related paperwork, thus enabling true process improvements. The pilot project is legally based on a special decree of the Ministry of Social Affairs and Health (771/2003) and will run until the end of 2004. Should the results of the pilot be positive, the permanent legislation around the subject is likely to be changed rapidly.

One of the central obstacles in developing electronic prescriptions has been the absence of clear norms and standards about, among other things, electronic signatures which verify the identity of the describing doctor [9]. The law governing electronic signatures was passed in the Finnish parliament 24. Jan 2003, and defines the acceptable forms of verification for electronic interaction with public servants and government organizations[11]. This alone will not remove all of the problems, but now there is at least basic jurisdiction on which future guidelines can be built.

Telemedicine

There are a number of telemedicine applications in use in Finland, especially in northern parts. The Finnish Office for Health Care Technology Assessment (FinOHTA) together with Northern Ostrobothnia

Hospital District, organized a project to assess the effectiveness and the cost-effectiveness of telemedicine, focusing on applications in radiology, psychiatry, surgery and ophthalmology. The personnel using the systems learnt the new methods fast, but usability of the systems was not deemed perfect. The main advantages lie in reduced travelling of the personnel, making telemedicine applications financially viable only over considerable distances as in Northern Finland. [12] Telemedicine applications have to struggle with the same legal and organizational problems as the rest of health care informatics: the electronic connection is understood as an extension of the presence of the doctor/patient and transfers of medical data between organizations is still subject to several data secrecy laws and regulations.

Electronic patient records and image processing

There are several different electronic patient record systems in use, as well as different image processing systems. One of the main tasks of the work group mentioned above is to create guidelines for nation-wide compatibility. Most of the electronic imaging systems in use in Finland are compliant with the DICOM (Digital Imaging and Communications in Medicine) standard, and the EHR (electronic health records) systems built today are following HL7(health level 7) structures. There are functioning region-wide radiology information systems (RISs) in the Turku and Helsinki regions, enabling remote consultations and digital archiving of the images, and similar systems are under development in other regions[13]. These systems will probably not be fully compatible as the regulation governing them is very vague, and the systems are, naturally, developed by competing systems development companies each trying to add features their competitors did not include. The basic structures do, however, follow the international standards so a general mishmash like the one created in the hospitals of Finland in the seventies by a large number of in-house development projects could be avoided.

Legal issues affecting e-Health implementation

E-Health services consist of parts that are not unknown to legislation. However, as a combination of electronic and physical transactions e-Health is unique, and there are very few laws that are specifically drafted to answer to the special circumstances of e-Health, or cyber medicine. The

major parts that make e-Health are telecommunications, information technology and health services. Each one of these is governed by a set of laws, which are special to each one of the parts. E-Health is therefore governed by a combination of the laws governing its parts. This means that there are a number of regulatory and other legal issues that govern e-Health directly or indirectly.

Below we present some issues that are special for e-Health, and are known to hinder the implementation of e-Health services:

1. Medical data and patient data enjoy a high level of protection of privacy in many legal systems. For controlled substances identification of the buyer is important.

When patient information is transmitted between doctors within a company, usually there doesn't seem to be any problems with regulation and jurisdiction, as in-house systems are perceived as closed systems. However, when patient data is transferred from one service provider to another (e.g. public to private or vice versa) there may be problems of compatibility between systems and different security measures in place. The systems of the public organizations are required to keep archives of every document connected to their actions [14]. Archives do not need to be on paper anymore, but in some organizations most of them are. This causes some administrative problems in trying to create seamless information flows. It is not unacceptable to think that from the point of view of security, the systems used in private sector are at least of the same quality, if not of higher quality, than in the public sector. However, as the legal requirements are different or carried out differently, systems compatibility between private and public sector systems is not easily achieved. It seems that protection of anonymity of patients and the secrecy of information is not an issue that creates obstacles, however, the discussion is about what kind of cryptography and other security measures need to be in place for growing flows of patient information.

The marketing and selling of controlled substances (e.g. certain medicines) brings forth another issue: validating the identity of the buyer is necessary to ensure that the substances are not ending up in the wrong hands. If, for example, medication is sold through the Internet, it is plausible to think that the service must at some point include an identity check - how this is accomplished is not clear. Another issue, although connected to selling of

controlled substances, is the issue of electronic drug prescriptions. If a doctor electronically transfers information to pharmacies (or to a data base, where pharmacies can check prescriptions for patients), problems with counterfeit prescriptions can be circumvented, providing that the practitioners using the service operate according to the law, and can be identified. Now as the new law governing electronic signatures is in place in Finland the communication between doctors and pharmacies could be arranged. As the SIIF is involved in most of the medication transactions and there was no paperless system (or even precise guidelines for developing one) for delivering insurance claims to the SIIF, prior to launching the pilot project mentioned above, the systems development was slow. Development of fully paperless systems is still hindered by the National Agency for Medicines (NAM) requirements. NAM requires paper records of all the delivered drugs as well as 10 year archiving of prescriptions (original paper documents) of certain drugs affecting the central nervous system, as well as drugs classified as narcotics [15].

2. There is no universal licensing system for medical practitioners which would govern international medical consultations made through the Internet.

Because there is no international community for medical practitioners that would or could give licenses to practitioners that ensure quality of the service, it is difficult for a user of e-Health services offering medical consultations to be sure of the quality of the product. If there is a risk that someone is posing as a medical practitioner (doctor) it jeopardizes the credibility of e-Health.

Another issue that may play an important role in the acceptance of e-Health services is the position that different patient insurance systems take towards them. If insurance will cover consultations made through the Internet, or perhaps a mobile device, there is considerably less hindrance for adaptation by users. In the case of private insurance the step to accept at least some selected e-Health services may be low. However, in cases of public insurance (e.g. Finland), the process of acceptance may be a long registration and regulatory process.

3. Issues of contracts between parties in transactions made through the Internet may in some cases resemble transactions *not made* through the Internet. However, in cases of litigation, Internet presents problems.

Important questions arise, like where a transaction, or in the case of e-Health, a consultation has taken place when a patient resides in another location than the service provider. In other words, which country's jurisdiction is applied in, for example malpractice suits filed on consultations made over the Internet? This type of problems are avoided if services operate within national borders. However, as the Internet is global it is not hard to imagine problems arising from enforcing and litigating contracts signed only on the Internet.

The number of issues that do not have a clear answer is large, this means that there is considerable uncertainty as to what can (and what cannot) be done by providers of e-Health services. This translates to management decisions about investments in the sector, and means that investments can be postponed, because the companies do not wish to find themselves in situations where their investments are suspended by regulatory decisions. Paradoxically it seems that it is not possible to get binding pre-investment information about the regulatory status of projects, or getting such information will take so long that the investment is no longer worthwhile and getting the information is a very exhausting process. The initial answers from the Finnish regulatory bodies concerning a number of possible projects have been ex-ante negative, which means there has been very few stakeholders who even begun to explore innovations other than those they knew to be possible.

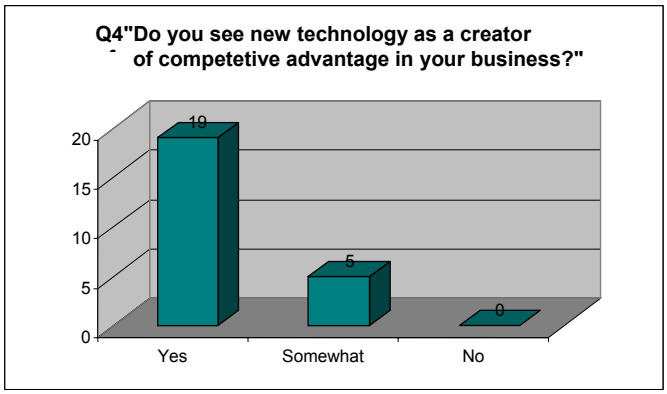
Views of stakeholders about the administrative and judicial framework governing IT in health services.

In order to understand better the feelings and thoughts of the actual stakeholders in the field of health services production, an exploratory survey about the use of e-Health was prepared in cooperation with students from the Turku School of Economics and Business Administration in 2002. The survey was sent to approximately one hundred companies providing healthcare services, ranging from pharmacies and individual private doctors to large health care centers. Answers were received from 25 companies, usually from managers responsible for investments in IT in the company. The questions on the survey varied from basic questions about the readiness of the respondents to utilize different e-Health innovations (in connection with the Internet) and what their attitudes are towards e-Health as an addition to their business generally and specifically. One of the issues

taken up in the questionnaire was the interest of parties to engage in using e-prescriptions. The reason for this was that the authors were aware of the difficulties in the development of systems regarding e-prescriptions and the administrative hindrances that are slowing the progress of using e-prescriptions. The authors wish to point out that the survey is not a representative survey and the results are only exploratory. Therefore they can only be used in creating a basic understanding of the attitudes of the community of health service providers in Finland.

In the following we will go through the results from the survey in four phases, according to issues that were thought relevant by the authors:

i) It seems that the stakeholders are positive about the use of IT and feel that it has potential for enhancing their productivity.
Fig.1: Opinions on new technology as a source of competitive edge



Three fourths of the respondents (75%) indicated that they were either ready immediately or would be ready within 1-3 years to use e-Health services. Only one respondent answered that it would take them more than 3 years. The rest were not sure how long it would take. More than 86% of the responses indicated that the respondents already have the needed infrastructure and readiness for launching e-Health services. More than 87% of the respondents reported that they feel that new technology gives at least to some extent a possibility to gain competitive advantages in the field. The term "e-Health" is not very commonly known to the companies in the field; however, on the basis of their readiness and attitudes most companies are ready to adopt e-Health services very fast.

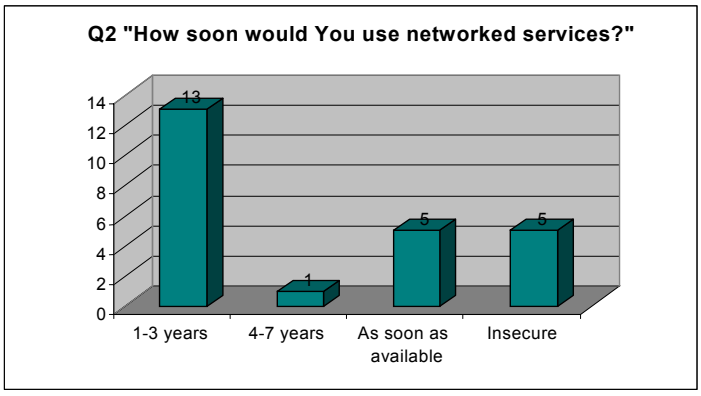


Fig.2: Readiness to use e-Health(networked) services

ii) In-house tasks are often already done with IT-solutions, and there are positive experiences.

All the answers indicated that the respondents feel that an information system is or would be important to their operations, and more than 86% stated that they have a functioning information system at work in their business. Roughly 54% of the respondents said that they either were thinking about using the Internet as a marketing channel for their products, or are already using it (~21%). The number of answers that were negative to using the Internet as a marketing channel has partly to do with the fact that 7 of the responding firms were pharmacies. Pharmacies are highly regulated in Finland and it seems that even if regulation is not prohibitive in all aspects of marketing via the Internet, it seems to be a hindering factor. It is probable that marketing alone is not perceived as a sufficient justification to build new systems. For those respondents who have already been using the Internet as a channel for their marketing, their experiences have been mostly positive. 25% of the respondents indicated that they have plans to sell their products on the Internet, but only one indicated that they have actually sold their products via the Internet. They had positive experiences due to enhancements in routines of ordering and delivery with customers who were using the Internet service. From the answers of the pharmacies that had not sold their products in the Internet, the comments specified that this was due to administrative and regulatory hindrances; selling drugs on the Internet is not presently allowed. Further comments stated that the actual delivery of the drugs would have to be realized by a credible and trustworthy company. One response suggested that the

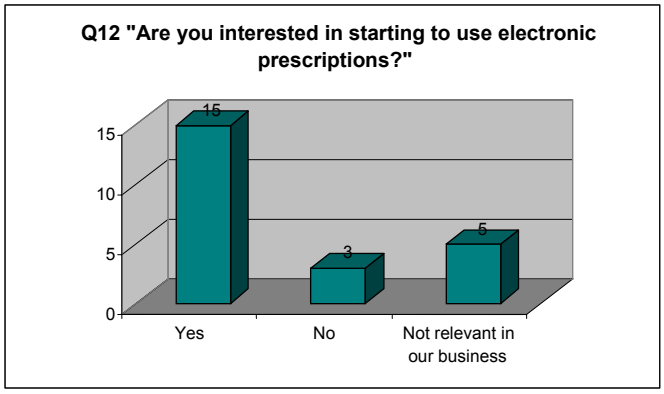
products that would most likely be sold over the Internet would be products already most well known to the customers (at least in the case of retail customers). On a further note, some of the respondents are actually service providers and do not per se concentrate in selling any products. The attitudes towards Internet as a way to enhance their business varied from mildly reserved to very positive. Also a concern over the truthfulness of information mediated through the Internet was voiced in one answer.

iii) On a number of occasions it was mentioned that the administration by the Social Insurance Institution of Finland (SIIF) and the National Agency for Medicines (NAM) are hindering development.

From the limited material at our disposal we could detect a feeling of frustration from among the respondents. It seems that there is a wall that the service providers and especially pharmacies are facing when trying to launch innovations in the level of preliminary acceptance from the administrative bodies. It seems to us that as companies' internal information systems do not fall under the jurisdiction of the governing bodies they seem to be experiencing constant development, and are used to enhance the operational efficiency of the companies. The thought just expressed is not based on any extensive research material, but is rather derived from the loosely structured information and based on the survey results.

iv) Most of the respondents specify that incorporationg electronic drug prescriptions would be an important step. This is, however, not possible due to administrative hindrances.

Fig.3: Interest in electronic prescriptions



Nearly 80% of the answers stated that the businesses would be interested in using electronic drug prescriptions. One answer stated that based on observations from a longer period of time it seems quite hard to expect any changes in the near future due to lack of cooperation from administrative bodies.

In general it can be said that most of the respondents have an information system in use and that they have a positive picture of IT in the production of health services. This indicates that there is interest within companies to develop their information systems to further enhance their productivity and services. However, it was quite obvious that stakeholders feel uncertain about pursuing development in IT as the administrative and legal frameworks are not transparent.

Discussion and conclusion

We have introduced the main setting of the Finnish administrative framework for health care services and seen that service production is divided into the services provided by private companies and the public services. There is a gap between the productivity of private services and public services and we feel that one of the reasons for the existence of the gap can be more advanced use of IT. One factor hindering the development in the public sector – and indirectly even the private sector, as the systems will need to communicate with each other- is the existence of administrative and legal barriers that do not take into account the possibilities offered by the technologies available today. Legislation and administration have not been able to develop in pace with technical innovations. This has caused a bottleneck in areas such as production of health care services that have a strong focus on privacy and customer (patient) protection. The lack of up-to-date governance (laws and administration) of IT in health care is a major source of uncertainty and a serious hindrance for development in the sector. The obvious conclusion is that in order to work optimally from the point of view of all stakeholders, the legislation and administration of IT in health care service production should be brought up-to-date with the technological advances, otherwise we will most likely see a stagnation in the development of such systems. Companies operating in the field of health services provision need proof of cooperation from the regulators to invest in and fully embrace new technology. The legislation, of course, has as a main goal to secure the quality and accountability of care, and laws in the health field cannot be

changed radically overnight as the organizational structures are built around the existing ways of practicing medicine. But without proper standards, guidelines and legislation, even incremental changes may be deemed impossible. The processes within tradition-bound and complex health care organizations are difficult enough to change due to organizational inertia and resistance to change, so every hindering factor from the surrounding society may turn into a major obstacle. The very slowly diminishing uncertainty about the legal and administrative issues in implementing and designing IT infrastructure in Finland has been felt by companies operating in the sector. Our survey found that companies would be interested in implementing new systems but are sometimes unable to do so, because of institutional constraints. A fast pre-approval procedure for health care systems by regulators or a set of clear rules and principles of conduct would promote acceptance and implementation of IT in the health care sector. The latest developments in legislation and the numerous government projects aiming at developing guidelines for IT in health care do manifest a commitment to change in the highest levels of administration, but the health care sector will probably nevertheless remain a few years behind the rest of our society in the field of information technology usage.

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Paper 3

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PHYSICIANS' PERCEPTIONS AND INTENTIONS REGARDING A MOBILE MEDICAL INFORMATION SYSTEM: SOME BASIC FINDINGS

Shengnan Han
Ville Harkke
Turku Centre for Computer Science (TUCS),
Institute for Advanced Management System Research (IAMSR)/Åbo Akademi
Lemminkäinengatan 14 B, 20520, Åbo/Turku, Finland
Tel. +358-2-2153336, + 358-2-2153337; Fax. +358-2-2154809
{shengnan.han; ville.harkke}@abo.fi
Pekka Mustonen
Matti Seppänen
Markku Kallio
Duodecim Medical Society
PL 713, Kalevankatu 11A, 00101, Helsinki, Finland
Tel. +358-9-61885411, +358-50-5876183, +358-50-5121932; Fax. +358-9-61885400
{pekka.mustonen; matti.seppanen; markku.kallio}@duodecim.fi

ABSTRACT

The article describes a mobile medical information system developed to meet physicians' information needs in their daily work. As a basis for future studies, a questionnaire survey (n=500) was conducted at the initial adoption stage in April 2003. Follow-up telephone interviews (n=42) were conducted in June 2003. Basic findings of the two surveys indicated that usefulness and ease of use were important determinates of physicians' adoption of the system. Also the value-adding contents of the system are drivers for using it. The lack of enough mobile devices (Nokia Communicator 9210) is the biggest barrier to adoption. The physicians thought using the system would improve the productivity of their working time. They would use it mostly at home or while making house calls. Future research is discussed briefly.

1 INTRODUCTION

Despite promising increases in efficiency gained from IT investment, (Devaraj and Kohli 2000, Borzekowski 2002), healthcare organizations have generally been slow to adopt information technology (The Economist 2002). One possible explanation is that physicians are seldom at their desks and thus cannot use traditional desktop computers. Therefore mobile solutions must be sought to handle information (Stammer 2001). Goldberg and Wickramasinghe (2003) argue

that mobile e-health services offer a panacea to meet healthcare challenges in the 21st century.

Duodecim Medical Publications Ltd, a publishing company owned by the Finnish Medical Society Duodecim, designed a mobile medical information system. It is a set of medical information and knowledge databases, containing evidence-based medical guidelines - EBMG (www.ebm-guidelines.com), also called a doctor's handbook (both in English and Finnish) with Cochrane abstracts, the pharmacology database Pharmaca Fennica, an international diagnosis code guide (ICD-10) in Finnish, an acute care guide by Meilahti hospital, a medical dictionary of over 57000 terms, wireless update service for a complete medicine price list and a comprehensive database over healthcare-related addresses and contact information (pharmacies, hospitals, health centers). It is built on an XML database and can easily be modified to work in most mobile devices with different operating systems e.g., Symbian, Palm OS and Windows CE, etc. In Finland the device most commonly used as a platform is the Nokia 9210 Communicator. The mobile medical system is delivered on a 128 MB (later 256MB) memory card and is self-installing, containing the search engine, user interface programs and the core databases. The material is updated semi-annually. Currently the updates are delivered as physical memory cards, the users returning the older ones. In the near future the system will be able to update itself partly or completely through the wireless network.

In order to provide a basis for further studies on physicians' usage of the system, and its impacts on their working practice, a survey was conducted to detect physicians' perceptions and intentions regarding the system in April 2003 - the initial adoption stage. Follow-up telephone interviews were made in June 2003. We describe here some basic findings from these two surveys.

2 RESEARCH BACKGROUND

2.1 User Adoption of Technology

Users' perceptions of and intentions to adopt an information system (IS) and the rate of diffusion and penetration of technology within and across organizations are two important foci in IS research (e.g. Straub et al. 1995). They are understood to represent the essential aspect, property or value of the information technology (Orlikowski and Iacono 2001). It is generally accepted that using information systems at work could increase employees' productivity in their work, and improve individual and organization performance. System use is an important way to measure IS success (DeLone and McLean 1992 and 2003). In the last few decades, the conclusions of many studies based on different theoretical approaches, e.g. diffusion of innovation, technology acceptance model, the Unified Theory of Acceptance and Use of Technology, etc. (e.g. Davis et al.

1989, Moore and Benbasat 1991, Venkatesh et al. 2003), have confirmed that usefulness or performance expectancy - the degree to which an individual believes the system will help to improve job performance - and ease of use or effort expectancy - the degree of ease associated with using the system - are two fundamental factors determining user acceptance of technology.

Pedersen and his colleagues have made several studies on user acceptance of mobile technology and services including mobile internet, text messaging, contact services, mobile payment, mobile gaming and mobile parking services based on these approaches (e.g. Pedersen 2002, Pedersen et al. 2003, Pedersen and Nysveen 2003). They also found that usefulness and ease of use are very important factors determining user acceptance of mobile technology.

There are two temporal dimensions of adoption behavior. One is pre-adoption or initial adoption behavior (initial adoption, first-time usage, and possible rejection at the pre-implementation stage). The other is post-adoption or post-implementation behavior, (sustained continuous usage, and discontinued usage). As users gain more experience of a system, ease of use will have weakened effects on user adoption behavior but usefulness is a strong determinant for continued usage regardless of temporal impacts. (e.g., Parthasarathy and Bhattacherjee 1998, Karahanna et al. 1999, Venkatesh et al. 2002).

2.2 IT and User Productivity

We have to be aware that system usage by individuals is only a necessary, not a sufficient condition for bringing about performance improvements (Davis et al. 1989). Basically, we could focus on three measurements to understand IT impacts on individual productivity: *efficiency* means IT could speed up processes and activities, *effectiveness* indicates IT may change the means of pursuing desired goals, and *expansion of limits* means IT might save individual limited time and allow attention to be directed to other activities (Kvassov 2002).

Green (2002) indicated that mobile computing and telecommunications technologies mediate time in relation to mobile spaces, but the practical construction of mobile time in everyday life remains firmly connected to "working time" and "family time". When people are working on the move (geographical movement), they have less control over the configuration of their environment and the way they organize their work (Perry et al. 2001). Mobile technologies promise to remove these bindings between fixed time and space and try to create a seamless working context regardless of time and space. Mobile technologies have the potential to improve the productivity of mobile workers.

3 DATA COLLECTION AND ANALYSIS

In April 2003 the Publisher, with support from Pfizer Finland Oy, started a trial involving 500 physicians who would be provided with a Nokia 9210 communicator with the databases for free. Our survey questionnaires were handed out during initial training sessions when they received their communicators. The questionnaire was to investigate how the physicians perceived the mobile system and whether they intended to use it as well as other details about their work considered important by the publisher. Our main attention here is to present findings concerning their perceptions and intentions regarding the mobile system. With 379 returned questionnaires, the response rate was 75.8%. The variation in useful data is due to missing answers.

In addition to the questionnaires, Pfizer Finland Oy conducted a telephone interview in June 2003, after the physicians had been using the systems for some 2 months. Forty-two doctors were interviewed. Half of them were health-center general practitioners (GPs) and the other half specialists.

The SPSS 11.0 was used to analyze the data. The frequency and descriptive statistics were run to get first insights into the issue.

4 FINDINGS

4.1 Physicians' Perceptions and Intentions Regarding the System at the Initial Adoption Stage

Table 1 displays the frequencies and valid percentages of the results. Mobile phone usage was very widespread among the respondents: of the 120 valid responses only 2 did not have a mobile phone. The remainder had, and 77% had owned one for 4 years or more. One hundred and twelve had used it to send SMS messages. However, only one had used WAP services. Of the 118 valid responses 115 believed that ease of use was a very important feature of mobile services for physicians. Limiting the content to information useful only to physicians was considered important by 51 and very important by 54. Services covering only their own specialty were a very important feature for 40 and an important feature for 58. A total of 298 of 365, or 81.6%, respondents would like to use the system at home. Two hundred and eighty seven out of 359 believed they would use it at work. Even though house calls are not common in Finland, 174 of 328 thought they would use it when making house calls. Less than half (158 of 337) of the respondents said they would use it when on rounds visiting patients in hospitals.

The main reason given for not using the system, 42 of 69 answers or nearly 61%, was that mobile services were too slow. Only 28% (19 of 67) indicated "no need

to use" as a barrier to usage while 33% (24 of 73) said usage might influence the physician's "encounter manner".

The availability of EBMG and Pharmaca in the communicator was the most important reason for buying a communicator; in favor were 57.3% (59 of 103) and 51.5% (51of 99) respectively. Features such as the office package and Internet connection were less important but still worth mentioning. The service contents were the main reasons for physicians to buy a communicator in Finland.

Lack of enough communicators for physicians was the most important hindrance to widespread use of the system; 93% (n = 116) of the respondents recognized it. Another considerable obstacle was that time was lacking to learn to use the new mobile system. This was recognized in 56% (n = 115) of the answers. Only 13% (n = 113) considered the mobile EBMG useless in their work.

If the information in Pharmaca and EBMG could be found easily with a mobile device, 87 of 121 respondents said they would use the mobile Pharmaca and 97 the mobile EBMG instead of a traditional book. If the information in medical textbooks was easily available both from a mobile device and a PC, 46.5% (n=114) said they would use a PC, but 53.5% would use a mobile device. We also asked physicians to rate the service contents - the core databases they found most important in the system. The statistics showed that EBMG, Pharmaca and ICD-10 were the three most important. The majority (66% of 368) agreed that EBMG and Pharmaca would be more useful to them in mobile form than in printed, Internet or CD versions.

Speeding up the work process by using mobile Pharmaca compared to using a book was considered possible by a slight majority; 52% (n = 115) of respondents agreed. Seventy-nine percent found using the mobile EBMG faster than a printed book.

A fast, always-on mobile Internet connection would affect the usage patterns of Internet-based services. Over 40% of the respondents thought they would use the Terveysportti portal (n = 117) and the Internet EBMG (n = 118) daily, and over 30% 2-4 times a week.

Table 1 Findings

Questions	N.	%	Questions	N.	%
Usage of mobile phone			*The most important features*		
Have mobile phone	120		Easy to use and fast	118	
Yes	118	98.3	Very important	115	97.5
No	2	1.7	Important	3	2.5
Years owned			Only medical information	118	
Less than 1 year	3	2.5	Very important	51	43.2
1 year	2	1.7	Important	54	45.8
2 years	7	5.9	Not very important	11	9.3
3 years	15	12.7	Not important	2	1.7
4 years or over	91	77.1	Only own specialties	117	
Send SMS			Very important	11	9.4
Yes	112	93.3	Important	40	34.2
No	8	6.7	Not very important	58	49.6
Use WAP services			Not important	8	6.8
Yes	1	.8			
No	119	99.2			
Mobile contents			*Effects on work efficiency*		
Mobile Pharmaca	121		Mobile Pharmaca speeds up the work	115	
Yes	87	71.9	Yea	60	52.2
No	34	28.1	No	55	47.8
Mobile EBMG	121		Mobile EBMG speeds up the work	115	
Yes	97	80.2	Yes	91	79.1
No	24	19.8	No	24	20.9
Mobile textbooks	114				
Yes	61	53.5			
No	53	46.5			
Possible reasons for non-use			*Situations of using the system*		
Too slow for patient work	69		At home	365	
Yes	42	60.9	Yes	298	81.6
No	27	39.1	No	67	18.4
Feel no need to use	67		On practice, e.g. reception	359	
Yes	19	28.4	Yes	287	79.9
No	48	71.6	No	72	20.1
Influence the encounter with patients	73		On house calls	328	
Yes	24	32.9	Yes	174	53.0
No	49	67.1	No	154	47.0
			On ward rounds	337	
			Yes	158	46.9
			No	179	53.1

Reasons for buying a communicator			*Barriers to use*		
Internet features	102		Not enough communicators	116	
Yes	43	42.2	Completely agree	76	65.5
No	59	57.8	Agree	32	27.6
SMS features	102		Neutral	3	2.6
Yes	29	28.4	Disagree	4	3.4
No	73	71.6	Strongly disagree	1	.9
Office applications: Word, Excel. PPT	99		No time to learn	115	
Yes	40	40.4	Completely agree	21	18.3
No	59	59.6	Agree	43	37.4
Mobile EBMG	103		Neutral	22	19.1
Yes	59	57.3	Disagree	25	21.7
No	44	42.7	Strongly disagree	4	3.5
Read mobile journal	99		Not useful	113	
Yes	18	18.2	Completely agree	1	.9
No	81	81.2	Agree	14	12.4
Mobile Pharmaca	99		Neutral	41	36.3
Yes	51	51.5	Disagree	44	38.9
No	48	48.5	Strongly disagree	13	11.5
Read mobile news	98		*Future usage of mobile Internet*		
Yes	25	25.5	to access Internet EBMG	118	
No	73	74.5	Daily	48	40.7
Interested in mobile devices in general	100		2-4 times/week	41	34.7
Yes	51	51.0	Once a week	10	8.5
No	49	49.0	Less than a week	14	11.9
Mobile ICD-10	98		No use	5	4.2
Yes	35	35.7	to access Terveysportti	117	
No	63	64.3	Daily	51	43.6
			2-4 times/week	44	37.6
			Once a week	12	10.3
			Less than a week	6	5.1
			No use	4	3.4

4.2 Actual Usage Patterns

The actual usage of the mobile system followed the lines of the pre-use survey. In the telephone interviews the respondents (n = 42) stated that the services were useful in their work (71%), the most important determinants of usefulness being immediate availability of information, fast Pharmaca, EBMG and ICD-10. The respondents (7%) who found the system unnecessary for their work had two main reasons for not needing it: health-center physicians that they always have a desktop computer at their disposal and direct access to the material on CD or Internet, and specialists that the package does not contain information about their specialty. The device itself was found somewhat bulky and awkward to use, and the Internet connection is slow. There were few directly negative experiences.

5 DISCUSSION

This paper sets out to investigate physicians' perceptions and intentions regarding a new mobile information system in healthcare. The information collected here is aimed as a basis for future research.

The findings from these 2 preliminary surveys are quite similar. First, physicians have positive perceptions and intentions regarding the mobile system. They are willing to use it in their work. Ease of use and usefulness of the system are main drivers for them to adopt it. Physicians showed, however, considerable interest in buying a Nokia Communicator the first time if the mobile system was available in it. The lack of enough such devices is the biggest barrier to adoption.

Second, the contents of the mobile system are crucial for its acceptance. EBMG, Pharmaca and ICD-10 were valued as the three most important contents. Higher quality information - the service content - constitutes a positive value for users (Landor 2003).

Third, the system is generally used either on the move or at home. The possible explanation for this is that physicians in Finland generally acquire information and manage their patient care through computers and Internet connections at their place of work. At home, they are away from those channels; consequently, they easily turn to the mobile system for help. Mobile services are seen primarily as supplements to rather than as substitutes for the wired Internet and PC-based tools at the moment.

User adoption theories assert that intention is a proper proxy to examine and predict a user's behavior towards information systems (e.g., Davis et al. 1989). Our study convinced us that such a mobile system designed for healthcare is needed by physicians. There is a high potential for mass adoption in the future. Physicians could be the early adapters of mobile technology.

IT can usually enhance users' productivity in their work. As mobility becomes a must in modern world, professionals, such as physicians, have to seek support from mobile technologies (Kakihara and Sorensen 2002). Most of the physicians in our surveys expected the mobile system to speed up their work. It might improve efficiency of work, an important aspect of productivity. Such "speed up", could save physicians time as well, especially when they are on the move or making a house call. They can access information immediately. The mobile system also provides a good alternative for physicians to complete their information search and help them with patient care, which is effectiveness of productivity.

6 CONCLUSIONS

There seems to be a need for the kind of mobile information system Duodecim has developed. As a first version the system could still be improved. In our future research we will concentrate on actual usage of the system and the impact it has on the physicians' work. The system is being continuously developed and the usefulness of new features such as mobile prescription will be evaluated. One aspect of introducing new tools is that they may function as catalysts for changes in organizational cultures and work processes, thus enabling even greater efficiency gains than the tools per se can accomplish. One problem of modern-day medicine, at least in Finland, is the amount of paperwork deemed unnecessary by most actors in the field. Reducing unnecessary and frustrating red tape would free resources and capital for improving the most important aspect of healthcare, the care itself.

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Paper 4

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PROFESSIONAL MOBILE TOOL: A SURVEY OF PHYSICIANS'

PERCEPTIONS OF AND ATTITUDE TOWARDS A MOBILE INFORMATION

SYSTEM

Shegnan Han, M.Sc, TUCS/IAMSR/Åbo Akademi University, shan@abo.fi, +358 2 215 3336
Ville Harkke, M.Sc, TUCS/IAMSR/Åbo Akademi University/, vharkke@abo.fi, +358 2 215 3337
Pekka Mustonen, MD,PhD, Finnish Medical Society Duodecim , pekka.mustonen@duodecim.fi
Matti Seppänen, MD, Finnish Medical Society Duodecim, matti.seppanen@duodecim.fi
Markku Kallio,MD, Docent, Finnish Medical Society Duodecim, markku.kallio@kolumbus.fi

Abstract

Usage of information technology in health care is slowly changing the work of medical practitioners. This paper examines usage of a mobile information system, attitudes towards the system and the factors affecting usage and attitudes through a questionnaire survey of 379 medical practitioners in Finland. The physicians' preferences were found to correlate with types of work and usage of Internet-based systems and, to a lesser extent, age, gender and education.

Introduction and theoretical background

The ubiquity of different services provided by the existing and upcoming mobile systems, symbolized by the mobile commerce slogan "Anytime, Anywhere", has a clear demand within the health care sector. Patient care is a mobile experience, and the professional's ability to access different services with mobile devices at the point of care has enormous potential in saving time and reducing errors.

The main determinant of information technology—IT usage in health care by physicians is the degree in which IT is perceived to be useful for performance in their jobs (e.g., Berg 1999, Chau and Hu 2002, Hu et al. 1999). Besides, the information tools or technologies have to be inserted in their work structure carefully in order to make their skills' interaction with the tool possible (Berg 1999). Berg argued that utilization of IT tools in health care "*is dependent on the meticulous interrelation of the system's functioning with the skilled and pragmatically oriented work of health care professionals"*. Research on user technology adoption usually conceptualizes individual characteristics as external variables that directly or indirectly effect the users' perception of usefulness or attitude or behavior intention towards the technology under investigation (e.g., Davis et al. 1989, Legris et al. 2003, Venkatesh and Davis 2000, Zmud 1979). Age, gender and education are important demographic variables that have been approved that have significant effects on users' perceptions of a new technology (e.g., Hubona and Kennich 1996, Gefen and Straub 1997, Venkatesh and Morris 2000, Venkatesh et al. 2003, Agarwal and Prasad

1999). Employment categories or job categories and experience are variables that may cause individual differences as well. Employment categories had, for instance, direct influence in physicians' use of MSWord in the work practice (Jayasuriya 1998). Experience effected physicians' current attitude towards evidence-based medicine positively and their actual usage of the system (Mayer and Piterman 1999).

This paper explores the usage patterns and possible explanations to them for one existing solution, a mobile medical database for physicians. In this exploratory study, we analyze 6 factors that can be assumed to have an effect on physicians' opinion on the mobile system: The first is the 'working full time in' to define physicians' working environment, i.e. whether they work full time in primary health care centers, hospitals, or as private doctors. The second is their positions in hospitals, in case they work in hospitals, to indicate their job categories, i.e. general practitioners, specializing or specialists. The third to the fifth are demographic factors: Age, gender and education. Instead of academic education, the practical education leading to specialist status is selected. In Finland there is a practically identical 6-year curriculum in each of the five medical schools, and the specializing education after the basic degree might have identifiable effects on the technology adoption behavior. The sixth is the current usage of Terveysportti.fi (an Internet portal by Duodecim with content nearly identical to the mobile system, used by the whole public health care sector in Finland), as a measurement of physicians' experience on using electronic information databases. The findings and the implications for physicians' work are presented and discussed.

The system

The mobile application, developed by Duodecim Medical Publications Ltd., consists of a set of searchable databases containing the same material as the printed and electronic versions of a set of Duodecim's books: the Doctor's Handbook (Evidence-based Medicine Guidelines or EBMG), Pharmaca Fennica (a complete guide to all drugs available in Finland), ICD-10 diagnosis code database, Abstracts from the Cochrane library, a contact information database for all the health care related organizations, including pharmacies in Finland, acute care guide by Meilahti hospital and a medical dictionary of over 57000 terms. The system runs on a Nokia 9210 Communicator with Symbian OS, versions for other operating systems are available.

Data collection

The Publisher has, with support from Pfizer Finland Oy, started a pilot project in which 800 physicians are given access to Nokia 9210 Communicators equipped with the Duodecim databases. As the system is continuously updated and enhanced, there are semiannual training sessions during which the users receive the updated software on a memory card and get information about the new features of the system. During these training sessions the physicians are each time asked to fill a questionnaire about their usage and opinions of the mobile system as well as other details about their work considered important by the publisher. The data sets used as basis for this paper were collected during spring 2003 from 500 physicians that attended to training sessions in Helsinki. The respondents are all medical practitioners holding different positions in health care, each of them using the communicator application.

Findings

A total of 379 responses were collected and deemed to be valid, giving a response rate of 75.8%. Of the respondents 152 were from the capital Helsinki area, including the cities of Helsinki, Espoo and Vantaa. 51 were from the North city- Oulu, 15 and 47 from the cities of Turku and Tampere. The youngest respondent was 23 years old, the oldest 67. Table 1 shows the frequencies and valid percentages of our respondents' profiles. The main findings concerning (i) physicians' preference of information delivery channels, i.e. mobile, Internet and printed-paper, (ii) usefulness of mobile contents, (iii) important features of the mobile tool and (iv) the barriers to use mobile system are presented below. Due to the space restriction, the frequency table is omitted. The individual difference effects that are significant at the .05 level are summarized in table 2.

Table 1 Respondents profile

Individual differences	N.	Valid%	Individual differences	N.	Valid%
Work full time in/as	378		*Gender*	374	
Health centre	153	40.5	Male	222	40.6
Hospital	176	46.6	Female	152	59.4
Private doctor	26	6.9	*Education*	374	
Researcher	4	1.1	General practitioner	105	28.1
Other	19	5.0	Specialist	269	71.9
Positions if you work in a hospital	226		*Current usage of Terveysportti*	96	
Student	1	0.4	Daily	25	26.0
Specializing	47	20.8	Weekly	44	45.8
Specialist	112	49.6	1-2 /month	26	27.1
General practitioner--GP	66	29.2	No use	1	1.0
Age	375		*Academic education*	373	
20-34	35	9.3	Bachelor of Medicine-BM	3	0.8
34-39	55	14.7	Licentiate in Medicine-LM	225	60.3
40-44	81	21.6	LM, in doctoral program	44	11.8
45-49	94	25.1	Doctor	69	18.5
50-54	61	16.3	Docent	32	8.6
55-70	49	13.1			
Mean age	45.02				

Generally, the physicians had a rather high preference of information delivered by mobile channels. 71.9% (N=121), 80.2% (N=121) and 53.5% (N=114) preferred mobile Pharmaca, MEBMG and other mobile textbooks to the corresponding paper and PC-based versions. Physicians in health care centres rated the mobile textbooks higher than the others

The overall perception of usefulness of the mobile tool was positive. Whole 74.9% (N=368) of the respondents agreed on the mobile version of the EBMG being more useful than a paper- or internet-based version. The corresponding percentages for Pharmaca, Medical news and an education calendar are 67.1% (N=368), 55.1% (N=366) and 76.7% (N=365). From nonparametric tests we found that the external parameters affecting physicians' preference of mobile version vs. paper version of the databases were: *workplace* for EBMG, Pharmaca and education calendar with significance levels of .031, .000 and .002, the hospital doctors being more positively inclined towards mobile Pharmaca and education calendar and private doctors towards mobile EBMG. *Gender*, the male physicians had slightly more positive perceptions of mobile EBMG than the female. For the Pharmaca even the practical *education* level had an effect: The specialists, compared to general practitioners, had a more positive attitude towards a mobile version than a paper version. The *daily Terveysportti users* perceived a mobile professional training calendar as much

more useful for them than the other 2 usage groups, with a significance level of .045. Those using the portal more seldom than weekly even found the mobile EBMG more useful for them.

Frequency data showed that 97.5% (N=118) of the respondents believed that being easy and fast to use is a very important feature of a mobile system. 43.2% and 45.8% of the 118 answers indicated that content restricted to information only useful for doctor's work is very important or important. Only 9.4% and 34.2% of the 117 respondents found limiting information to only their own specialties very important or important. Individual differences did not have a statistically significant influence in these opinions.

Frequency summary showed that 65.5% of the 116 answers completely agree and 27.6% agree on lack of communicators being a big barrier to usage of the system. 18.3% (N=115) completely agree and 37.4% agree on lack of time to learn how to use it being a barrier. Only 13.5% (N=113) consider the system's not being useful a barrier. The daily Terveysportti users rank 'no time to learn' as a bigger barrier to usage than the two other 2 user groups. The younger physicians were more critical towards the usefulness of the system than older ones.

Table 2 Individual differences test

Individual differences	Mobile textbook			Mobile EBMG			Mobile Pharmaca			Mobile education calendar			Not useful			No time to learn		
	N.	Mean	Sig.	N.	Mean	Sig.	N.	Mean	Sig.	N.	Mean	Sig.	N.	Mean	Sig.	N.	Mean	Sig.
Work full time			.038			.031			.000			.002						
Health centre	72	47.82		147	188.91		147	199.26		146	189.17							
Hospital	18	63.56		173	163.41		173	151.07		171	154.61							
Private doctor	13	59.15		26	153.50		26	177.12		26	189.92							
Total	103			346			346			343								
Terveysportti						.036						.045						.048
Daily				23	47.37					23	39.07					24	34.81	
Weekly				42	50.85					42	46.58					41	48.70	
1-2 / month				25	34.80					25	49.60					25	50.52	
Total				90						90						90		
Age															.021			
20-34													14	49.29				
34-39													19	42.24				
40-44													27	58.15				
45-49													28	55.11				
50-54													15	65.30				
55-70													10	82.80				
Total													113					
Gender						.017												
Male				216	171.67													
Female				147	197.18													
Total				363														
Education									.008									
GP							104	205.67										
Specialist							262	174.70										
Total							366											

Discussion

The examination of individual differences' impact on physicians' perceptions of usefulness and barriers to the mobile information system has provided us with some insights of the information needs in the practical health care work. The 6 tested factors, except for positions in hospitals, do make a difference on physicians' perceptions of and attitudes towards the system. *The working environments* influence physicians' preferences of information delivery channels and their perception of usefulness of mobile the

databases. *Usage levels of a traditional Internet portal* do affect physicians' opinions on the usefulness of mobile EBMG and education calendar and their judgment of barriers to using a mobile system. *Age* has an impact on physicians' consideration of lacking usefulness being a barrier to usage. *Gender* influences the perception of usefulness of the mobile EBMG. *Practical education* differentiates attitudes towards the mobile Pharmaca compared to Internet-and paper-based versions.

One big advantage of mobile technology is to provide personalized services to the user. Our results point out that there are individual differences in mobile content preferences among the physicians and that at least some of these differences can be explained by external factors. This might help the developers of future systems to identify the needed features in each system and make the mobile tools of the future more attractive to the users. As well, mobile technology adds value through knowledge mobilization by bringing information, communication, and collaboration to users instead of their seeking for the resources themselves; this is knowledge freedom (Keen and Mackintosh 2002). The findings from our survey could be used as user requirements or profiles to improve or personalize a system. The personalized services for physicians' medical information and knowledge needs will enhance their work performance by accessing the desired information immediately at the point of care. Lack of time was identified as a paramount issue and a major factor that hindered physicians' information searching behavior (Dawes and Sampson 2003). Therefore, a personalized medical knowledge database might be a better mobile information service for physicians. By "knowledge freedom", physicians might even have motivation to use the mobile system in their leisure time for knowledge capital building. It may increase the personal well being by higher satisfaction or gained expertise from using such mobile system and by being recognized as a mobile computer expert. (Vimarlund et al. 1999). Encouraging physicians' usage of the mobile system will be a win-win strategy both for individuals and the health care organizations.

Conclusions and future research

Generally, physicians have rather positive perceptions of and attitudes towards the mobile information system. They frequently use it in their work, thus giving the further development of the system potential for changing their work. Due to individual difference impacts on their perceptions and attitude, the future refinement of the system needs to take personalized information services into consideration. This study has proven the existence of individual differences among physicians in their perceptions of a mobile information system. The findings presented here were, however, aimed merely to serve as a starting point for further analysis of the matter. Our further research will therefore include analysis of additional factors of physician's professional life with considerably bigger samples (N>500) and revised questionnaires, as well as a series of deep interviews of mobile system users in order to capture relevant factors presently overlooked by us.

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Paper 5

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Physicians' Usage Experiences of a Mobile Information System

Ville Harkke
Turku Centre for Computer Science, Institute for Advanced Management Systems Research/Åbo Akademi University
ville.harkke@abo.fi

Abstract

The health care professionals are increasingly using handheld devices in their practice. This paper presents some findings from an interview study conducted on users of a medical information system running on a Nokia 9210 Communicator. The users have in general a positive picture of the system but the actual usage patterns and the settings in which the system is used vary.

Introduction

Different handheld computers have won some popularity among the medical practitioners. As technology advances the handheld devices may become very valuable tools for practicing medicine [1]. The handhelds are suitable for clinical practice due to their handy size, affordability and ease of use [2]. Most systems worldwide are based on a PDA. In Finland the medical publisher Duodecim Publishing Ltd has developed a set of mobile databases that run on a Nokia 9210 Communicator- a smart phone with full keyboard. This paper aims to describe the uses and user experiences of a group of pilot users of the system. The experiences were gathered by personal interviews of 30 medical practitioners in the Turku region in Finland during winter 2003-2004. The main questions this study
is set to answer are: How are the new devices used in the actual medical work? Are there distinct groups of users with different usage patterns? How well does the device under study fit to the work patterns of different medical practitioners?

Information search tools for medical practitioners

The practice of medicine is very information–intensive. A physician uses up to a third of her time recording and synthesising information [3]. Despite extensive education or long experience a physician frequently needs to find pieces of information in order to deal with the varying medical conditions. The information needs of physicians are categorised by Gorman[4] and Smith[5] as: Information on particular patients, data on health and sickness within local population, medical knowledge, local information on doctors available for referral etc, information on local social influences and expectations and information on scientific, political, legal, social, management, and ethical changes that will affect both how medicine is practised in a society and how doctors will interact with individual patients. The information sources used to gather these types of information

vary from the patients themselves and colleagues to formalised textbooks, journals and databases.

The types of information handled by the system considered in this paper are medical knowledge and local contact information. These types of information are traditionally provided by electronic means as databases running on a desktop computer or the Internet or as paper documents, textbooks and catalogues.

The Finnish medical publisher Duodecim Publishing Ltd, a forerunner in electronic publications, has developed a mobile application for the Nokia 9210 Communicator. The application is a set of searchable databases containing the Doctor's Handbook (Evidence-based Medicine Guidelines or EBMG), Pharmaca Fennica (a complete guide to all drugs available in Finland), ICD-10 diagnosis code database, Abstracts from the Cochrane library, a contact information database for all the health care related organisations in the country, including all pharmacies in Finland, acute care guide by Meilahti hospital, a medical dictionary of over 57000 terms and a laboratory guide by The Helsinki University Hospital. The application in its present form does not provide information about any specific patient and does not have links to the clinical information systems running in the workplaces, thus limiting the content to the two types of information (medical knowledge and local contact information) mentioned above. The contents of the databases are also available on paper form in textbooks by the publisher, on CD-Rom and in the Internet via the publisher's Terveysportti.fi portal.

Methodology

The setting

The Duodecim mobile system has been on the market since 2000 and is being continuously updated. In order to gather information about the system and its suitability for the work patterns of medical practitioners, the Publisher initiated a pilot project with support of Pfizer Finland. A group of 800 medical practitioners were provided with a Nokia 9210 Communicator and the databases during year 2003.

During winter 2003-2004 a group of 30 medical doctors working in the public sector in the Turku area were interviewed about their Communicator usage patterns. Twenty-four of the respondents were general practitioners working in health care centres and six were specialists holding positions in hospitals. The interviewees had been using the Communicator for periods between 4 and 10 months after the initial one-day training session where they were provided with the devices and instructed about the databases and how to use them.

The typical work for a general practitioner (GP) in a Finnish health care centre consists of patient consultations and some administrational tasks and is mostly carried out in the physician's own workroom.

The specialists - most of them working in a hospital or specialised care unit - have slightly different work geography. They too do most of their work in their own offices, but in addition to that they do their rounds and clinical work in operation rooms – and by

the bedsides they have no direct access to information handling tools- except for the Communicator.

All of the respondents had access to information search tools at their workspaces, containing usually a clinical information system, a PC-CD version of the Duodecim databases, access to the Internet and the Terveysportti.fi-portal and their personal paper-based libraries. The GP's do most of their work in their own offices and depart from there only for small errands during the day and while working on their secondary duties, which may include maternal care (in special maternal care locations), homecare, school medicine, centres for the disabled etc. Most respondents (23 of 30) had access to a desktop PC with a similar set of tools even at their secondary work locations. The contents of the mobile databases were thus available for the interviewees even in other forms, making the findings of this article valid for the mobile form of the system rather than the contents of it.

The interviews

The 30 interviewees were randomly chosen from a group of 80 employees of the Turku Health district who are using the communicator. The four first interviews were conducted as a pilot to test the questions, and these four answers are omitted due to subsequent changes in the questions. Only two of the potential respondents declined to partake in the study, and these were replaced by the next names on the list. The interviews took place in the workrooms of the interviewees and lasted on average 30 minutes. The physicians were asked questions about their work structure and geography, their information search methods in general and their usage of the mobile databases in particular. The questions were of both structured and open-ended types. The usage of the mobile system here refers only to usage of the Duodecim databases although the physicians interviewed were also using the built-in features of the device such as calendar and contacts list.

The Analysis

The respondents were grouped in distinct groups according to their perceptions of their own usage of the mobile databases. The questions in the interview referring to these were: How often do you use the mobile databases? (categorised: Not at all, not every day, once-twice/day, 3-5 times/day, more than five times/day), in which setting or situation do you prefer to use the mobile? (open-ended), preferred form of information search tool? (categorised: printed material, Internet, CD, Mobile) The answers to these questions were scored by giving higher score for more frequent usage, usage at primary workplace and preferring of the mobile. The specialists working in hospitals (N=6) were separated as a special group due to their different work geography. Frequencies of the answers to the structured questions were calculated Statview 5.0.1 and the open-ended questions were analysed by judgemental, qualitative methods

General findings

The usage patterns were in general as expected: the usefulness of the mobile device in the actual work setting of each individual doctor was the most commonly stated determinant of the actual usage in the open-ended interview questions. The stated usage patterns varied according to the perceived usefulness of the device in the work environment.

All respondents found the mobile system useful in at least some situations. The actual usage of the mobile system during work time in a typical work location was a completely different matter. The interviewees could be divided into four distinct groups:

Subj.	GP/ Specialist	Usage level	Usage setting	Preferred tool	∑of scoring variables	Grouped as
1	GP	2	1	1	4	group1
2	GP	1	1	0	2	group2
3	GP	1	1	0	2	group2
4	GP	1	1	0	2	group2
5	Spec	2	2	0	4	group3
6	GP	2	2	1	5	group1
7	GP	1	1	0	2	group2
8	GP	0	0	0	0	group4
9	GP	1	1	0	2	group2
10	GP	1	1	0	2	group2
11	GP	1	1	0	2	group2
12	GP	1	1	0	2	group2
13	GP	2	2	1	5	group1
14	GP	2	2	1	5	group1
15	GP	1	1	0	2	group2
16	GP	0	0	0	0	group4
17	GP	2	2	1	5	group1
18	GP	0	0	0	0	group4
19	GP	1	1	0	2	group2
20	GP	0	2	0	2	group2
21	Spec	1	2	0	3	group3
22	Spec	2	2	1	5	group3
23	Spec	1	2	1	4	group3
24	GP	2	2	1	5	group1
25	Spec	1	2	1	4	group3
26	Spec	1	2	1	4	group3

Table 1 the grouping of the user categories

1) Those who find the mobile so useful that they have it open on their desks and use it even when they are sitting by a desktop PC with a 17 inch screen and access to the Internet and to the Duodecim databases on a CD.

2) Those who like to use the mobile in their secondary work locations where access to other information search tools is limited, or at home or in other out-of-office situations.

3) The specialists who conduct a large proportion of their work outside their offices and like to check things on the mobile instead of walking to the nearest computer terminal.

4) Those that use the mobile as a mere backup for ex-tempore situations like when travelling or at home and do not use the mobile in their everyday work at all.

The relative sizes of the groups within the interviewed group are in themselves rather revealing: both extremes; the non-users and the very enthusiastic users made up only 35% of the interviewees, the vast majority being those who use the mobile in situations where the advantages of a mobile system are most obvious. The relative sizes of the user groups are visualised in fig. 1.

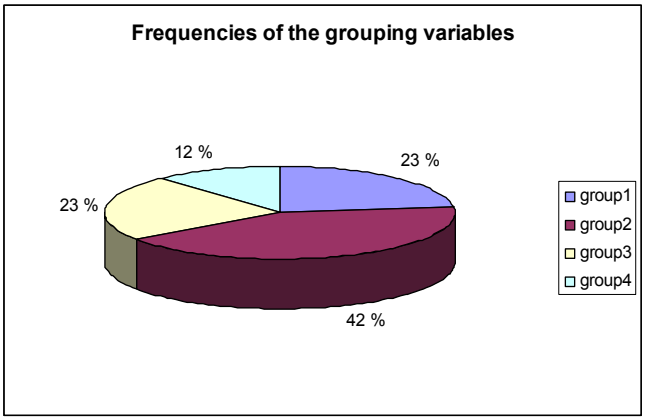

Fig.1 The relative sizes of the user groups

The perception of the most useful database in the system varied slightly according to type of work position: The GP's found the EBMG most useful, the specialists, needing less general medical knowledge, found the Pharmaca Fennica database most useful the differences were, however, not statistically significant.

User experiences

As the studied mobile system is still very limited in scope containing only searchable databases of general nature, the kind which an average doctor does need approximately 2 times a day [6], the mobile system is bound to have a limited effect on the work structures or habits of the users. The possibility of reengineering the work of a typical medical doctor by introducing more comprehensive mobile tools cannot be assessed by the findings of this study alone. The evidence from the interviews suggests that the mobile system in use has had an impact on the work habits of some doctors in some specific situations and that the changes have been to the positive in efficiency and in the time/quality relation in some specific work sub-processes.

The group who was most aware of the positive effects of the mobile tool to their work routines was naturally the enthusiastic user group. An enthusiast could be described as computer-savvy: He has been using computers for a long time, in case of a younger doctor his whole life. In general terms of innovation diffusion [7] these doctors are definitely the innovators or early adopters of any technology. This is, however, not important for this study. What is, is that these enthusiasts are using the mobile device in ways that are far from obvious and that might show the way for at least some of the majority. Here are some examples of the more advanced uses of the system:

Checking something during patient contact- the mobile device may be less disturbing for the patient-doctor-contact then a desktop computer - maintaining eye contact with the patient is easier with the device between the doctor and patient as opposed to the desktop which requires turning one's back to the patient.

Having the contacts directory open at all times- the device enables making a phone call by clicking a contact – in a hands free mode if the device is open.

A male doctor in his thirties has the mobile device open at all times besides his desktop computer. He runs small fast searches for specific topics – especially ICD-10 codes or contact information on the mobile instead of the desktop computer.

The vast majority of the interviewees were using the system only in situations where other means of information search were unavailable or would require more effort than using the mobile. Typical situations would be :

Checking about some condition at home or while travelling when need arises. (One must keep in mind that a medical doctor is one even while on vacation.) Typical such usage would be checking the right medication and dosage for a relative who calls or a neighbour who has been bitten by a dog.

Checking something from the EBMG when on a secondary workplace without access to a full information system

A female doctor in her 40's uses the mobile to check medication while she is working in a centre for disabled children. She still has to write the prescriptions by hand but hopes that even this will change soon.

The specialist work setting differs from that of the GP's and causes a slight modification of the usage patterns. All six specialists in this study could be categorised as enthusiasts according to their usage patterns. The difference in working environments would, though, justify a grouping of the specialists with the vast majority of health centre physicians - using the communicator in situations where they are lacking access to traditional means of information search. The difference lies in the fact that the specialists work routines with ward rounds and hospital work cause much more such situations and thus facilitates communicator usage. In fact, the limiting factor for the specialists was not lack of perceived need for a mobile system but the so far rather limited contents of the system. The specialists tended to see the pharmacological database as the most useful part

of the system, their information needs in their own specialities exceeding the level of information provided by the EBMG. A typical usage scenario for a specialist is checking some medication from the mobile pharmacopoeia while on a ward round or other location far from the nearest computer.

An older specialist of internal medicine was travelling on a train when a patient called on his phone. He was able to diagnose a rare condition with help from the Mobile EBMG- the condition being outside his own specialty.

The final group of users could actually be defined as non-users. These doctors saw no reason whatsoever to use a mobile device in their everyday work. The reasons did vary, but in general there was a real lack of perceived usefulness of the system- the traditional computer systems were deemed quite adequate- or where these had their flaws, using the Communicator would not help. The information needs of these physicians were not met by the contents of the mobile or the device itself was considered cumbersome compared to a desktop computer. Most members of this group would still use the mobile databases on their free time or when travelling. Only one respondent stated that she has not opened the device once after the initial training session provided by the Publisher. This group of users sees the mobile system as a valuable help in unexpected situations but not as a tool for everyday work.

In the interview structure there was a question about the last time the user has used the mobile system- this type of inquiry is known as the critical incident method [8] giving a fairly reliable snapshot of the real usage situations without filtering or other problems associated with self-assessment. The locations of the last usage session of the respondents are depicted in Fig.2.

Despite the relative sizes of the user groups the most common setting for using the mobile was the physician's own office – this suggests that the mobile system has advantages over the fixed systems even for the users who are not so enthusiastic about it. The most common task for the system was a quick check of something- specific symptoms or latest care guidelines for some rare condition, or proper dosage of some medication. The most commonly used databases were the EBMG and Pharmaca Fennica (10 users each), and the ICD10 listing needed for filling doctor's statements (3 users).

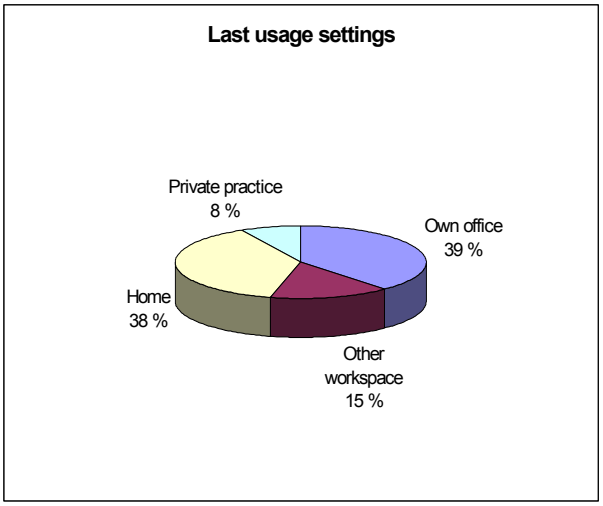

Fig. 2 Setting of last reported usage of mobile databases

Usage during patient consultations

One possible advantage of the mobile system was its being less obtrusive during patient contacts than a full-sized computer. This feature was recognised by six respondents. All interviewees were aware of the importance of maintaining eye contact with the patient, but the opinions of the mobile system as an enabler of this were highly polarised: the 6 interviewees who liked to use the mobile during patient contacts considered the mobile the best way to check something without disturbing the patient contact, but three of the respondents who liked to use a full-sized computer saw using the mobile as the most disturbing way of information retrieval during patient contacts. ("*The patient might think I'm writing a Short Message (SMS)*"). Only two respondents were still in favour of paper books as the fastest and least obtrusive method of searching information during patient contacts.

Conclusions

The mobile system containing basic medical knowledge has proven its usefulness in certain situations. The user acceptance of the system depends on the situations and settings in which the user is working and, of course, the user's personal attitude towards mobile devices. The mobile has some advantages over desktop systems even in a doctor's office due to its simplicity and unobtrusiveness. As the mobile systems develop to encompass even patient-related data the mobile tool might change the way in which medical practitioners work and meet patients.

Further research

This study was aimed to be a starting point in anticipating the changes in medical work that will be caused by widespread use of mobile technologies. The findings of this study are to be used as hypotheses for a study with a larger sample and carefully defined question structure. Systems supporting teamwork and virtual consultations are currently under development and more rigorous studies about the impact of mobile systems such as the one presented here are underway by the author - and hopefully other researchers around the world. As all technology, mobile systems are intended to increase efficiency of human work and identifying the points in medical practice where mobile systems will have a positive impact is a goal worth pursuing.

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Paper 6

Harkke Ville : Impacts of Physician's Usage of a Mobile Information System, Submitted 19.12.2005 for publication in the *International Journal of Electronic Healthcare*

Impacts of Physicians' Usage of a Mobile Information System

Ville Harkke

IAMSR/Åbo Akademi University

Lemminkäisenkatu 14 B

FIN-20520 ÅBO Finland

Ville.harkke@abo.fi

Abstract: The health care professionals are increasingly using handheld devices in their practice. The applications for the handhelds are numerous and their usage contexts and environments vary. The impact these mobile systems has on physician work has been somewhat unclear. This paper presents some findings from an interview study conducted on users of a medical information system running on a Nokia 9210 Communicator. The impact on the work routines of the users was rather limited, despite the generally positive attitude towards the system. The actual usage patterns and the settings in which the system is used vary, and along with these the perceived impacts of the system on the work habits and routines of the users.

Keywords: Mobile information systems, Impacts of technology, medical informatics, Information systems evaluation

Bibliographical notes: MSc Ville Harkke is a researcher at the Institute for Advanced Management Systems Research /Åbo Akademi University. He is currently finishing his DSc dissertation about mobile systems for medical professionals in the Turku Centre for Computer Science. He has done research in mobile commerce, usability and technology adoption and impact. He is the author of 14 published articles and book chapters.

1 Introduction

Different handheld computers have won popularity among the medical practitioners. As technology advances the handheld devices may become very valuable tools for practicing medicine (Fisher et al. 2003). The handhelds are suitable for clinical practice due to their handy size, affordability and ease of use (Al-Ubaydli, 2004). Most systems worldwide are based on a PDA. The contents of the systems range from simple medical calculators to comprehensive wireless access to clinical information systems. In a review of literature Jousimaa (2001) found that information needs frequently arise when physicians see patients. The questions that arise are most likely to be about treatment and drugs (Jousimaa 2001). A large portion of the questions do, however, remain unanswered (Ebell 1999, Ely et al. 1999). A possible solution to this problem is a tool that is easy to use, fast, portable and requires no excessive training or great technical skill (Fontelo and Ackerman 2004). In Finland the medical publisher Duodecim Publishing Ltd has developed a set of mobile databases that run on a Nokia 9210 Communicator- a smart phone with full keyboard. This paper aims to describe the uses and user experiences of a group of pilot users of this system, with special emphasis on the impacts of system usage on their work. The experiences were gathered by personal interviews of 30 medical practitioners in the Turku region in Finland during winter 2003-2004. The users were asked a set of questions about their use of the system, their perceptions of the system's characteristics and the effects the system has had on their work.

2 Information search tools for medical practitioners

Information processing is a very important part of practicing medicine. A physician uses up to a third of her time recording and synthesising information (Hersh and Lunin 1995). Despite extensive education or long experience a physician frequently needs to find pieces of information in order to deal with the varying medical conditions. The information needs of physicians are categorised by Gorman (1995) and Smith (1996) as:

- Information on particular patients
- data on health and sickness within local population
- medical knowledge

- local information on doctors available for referral etc
- information on local social influences and expectations
- information on scientific, political, legal, social, management, and ethical changes that will affect both how medicine is practised in a society and how doctors will interact with individual patients.

The information sources used to gather these types of information vary from the patients themselves and colleagues to formalised textbooks, journals and databases.
The types of information handled by the mobile system considered in this paper are medical knowledge and local contact information. These types of information are traditionally provided by electronic means as databases running on a desktop computer or the Internet or as paper documents, textbooks and catalogues.

The Finnish medical publisher Duodecim Publishing Ltd, a forerunner in electronic publications, has developed a mobile application for the Nokia 9210 Communicator. The application is a set of searchable databases which at the time of the study contained the following :

- the Doctor's Handbook (Evidence-based Medicine Guidelines or EBMG)
- Pharmaca Fennica (a complete guide to all drugs available in Finland, both complete and short form),
- ICD-10 diagnosis code database (searchable and menu-based versions)
- Abstracts from the Cochrane library
- Contact information database for all the health care related organisations in the country, including all pharmacies in Finland,
- Emergency care guide by Meilahti hospital,
- Medical Finnish-English dictionary of over 57000 terms
- Laboratory guide by The Helsinki University Hospital.

The application in its present form does not provide information about any specific patient and does not have links to the clinical information systems running in the workplaces, thus limiting the content to only two types of information (medical knowledge and local contact information) mentioned above. The contents of the databases are also available on paper form in textbooks by the publisher, on CD-Rom and in the Internet via the publisher’s Terveysportti.fi portal.

3 Methodology

The setting

The Duodecim mobile system has been on the market since 2000 and is being continuously updated. In order to gather information about the system and its suitability for the work patterns of medical practitioners, the Publisher initiated a pilot project with support of Pfizer Finland. A group of 800 medical practitioners were provided with a Nokia 9210 Communicator and the databases during year 2003.

During winter 2003-2004 a group of 30 physicians working in the public sector in the Turku area were interviewed about their Communicator usage patterns. Twenty-four of the respondents were general practitioners (GP) working in health care centres and six were specialists holding positions in hospitals. The interviewees had been using the Communicator for periods between 4 and 10 months after the initial one-day training session where they were provided with the devices and instructed about the databases and how to use them.

The typical work for a general practitioner in a Finnish health care centre consists of patient consultations and some administrational tasks and is mostly carried out in the physician's own workroom.

The specialists - most of them working in a hospital or specialised care unit - have slightly different work geography. They too do most of their work in their own offices, but in addition to that they do their rounds and clinical work in operation rooms – and by the bedsides they have no direct access to information handling tools- except for the Communicator.

All of the respondents had access to information search tools at their workspaces, containing usually a clinical information system, a PC-CD version of the Duodecim databases, access to the Internet and the Terveysportti.fi-portal and their personal paper-based libraries. The GP's do most of their work in their own offices and depart from there only for small errands during the day and while working on their secondary duties, which may include maternal care (in special maternal care locations), homecare, school medicine, centres for the disabled etc. Most respondents

(23 of 30) had access to a desktop PC with a similar set of tools even at their secondary work locations. The contents of the mobile databases were thus available for the interviewees even in other forms, making the findings of this article valid for the mobile form of the system rather than the contents of it.

The interviews

The 30 interviewees were randomly chosen from a group of 80 employees of the Turku Health district who are using the communicator. The four first interviews were conducted as a pilot to test the questions, and are thus missing some data points that were added to the interview structure. Only two of the potential respondents declined to partake in the study, and these were replaced by the next names on the list. The interviews took place in the workrooms of the interviewees and lasted on average 30 minutes. The physicians were asked questions about their work structure and geography, their information search methods in general and their usage of the mobile databases in particular. The questions were of both structured and open-ended types. The usage of the mobile information system here refers only to usage of the Duodecim databases although the physicians interviewed were also using the built-in features of the device such as calendar and contacts list.

The Analysis

The system is scrutinised from a wide array of perspectives. In order to handle these perspectives the interview data is analysed on basis of an evaluation framework, depicted in Figure 1. The framework is built on two basic constructs: the DeLone & Mc Lean Information Systems Success model (DeLone & McLean, 1993), used in a form refined by Seddon and Kiew(1996), and the Keen and Mackintosh (2001) classification of mobile systems according to their ability to create freedoms. The freedom creation aspect is further conceptualised according to the Kakihara and Sørensen division of mobility into spatial, temporal and contextual components. The original DeLone and McLean model has been validated and tested by several authors, and the original authors have published a new revised model (DeLone and McLean, 2003). The logic model used here is based on the original model due to the fact that it has been sufficiently validated (See e.g. Rai et al, 2002)

The DeLone and MacLean model of information systems success is a relational model that includes six success factors: system quality,

information quality, IS use, user satisfaction, individual impact and organisational impact. The addition by Seddon & Kiew (1996), importance of the system is very important for voluntary systems use, as in this case. DeLone and McLean stressed the specifying of the success models for a given context. The main contextual issue here is the mobility of the system. The system and information quality aspects, meaning the ability of the system to provide the needed information in a useful way, are rather general even for mobile systems. The use and user satisfaction components are not that different from those of fixed systems either, with the possible exception of the mobile system being potentially used in a number of different contexts, affecting both use and user satisfaction. The individual impact component, however, needs a closer scrutiny. "…one of the major premises of mobile technologies is to remove the bindings between a fixed space and a person's information and communication resources. By supporting access to these resources wherever they go, the argument is that uncertainty associated with the contextual constraints while mobile is removed"(Perry et al, 2001) The Individual impact of a mobile system is here understood as follows:

The construct by Keen and Mackintosh distinguishes three types of mobile services, according to their potential impact on everyday life: A *freedom* is changing the limits of possible in everyday life- that is: firstly, the context in question is common-everyday, secondly, the mobile enables the user to do things that would be impossible or very inconvenient with other means of information retrieval. A *convenience* offers saving time and effort in doing what is already possible within the daily routines. A *feature* offers some new options in those routines. (Keen & Mcintosh 2001, p.4) This distinction enables a researcher to evaluate a mobile system by its potential impact: systems that create freedoms are most likely to have an impact on the users and the society as a whole.

Changing the society by mobile information systems is not exclusively a question of overcoming geographical constraints. Kakihara & Sørensen (2002) introduced three different aspects of mobility; the *spatial* mobility that refers to the global flux of people, objects, symbols and space itself, *tempora*l mobility that considers the detachment of human activities from linear clock time, and *contextual* mobility that encompasses the flexibility of interaction between different contexts.(Kakihara & Sørensen, 2002)

Spatial mobility is not limited to human movement. Interconnectedness of different systems has led to information mobility where signals and sounds and data move freely over different information and communication networks, and the Internet has changed the space itself, creating virtual environments and communities.(Basole, 2004)

Spatial mobility itself is not a heterogeneous concept. Bellotti & Bly (1996) found in their study of design professionals that there are two types of mobility that need different support from information systems: *Remote* mobility where the user of a system is outside the normal working environment, using means of transport or public spaces, and *local* mobility- simply walking between rooms in a local site.(Bellotti & Bly, 1996)

The mobile nature of the system has even other effects on usage and impact: the mobile system cannot have the full information richness of a desktop-based system or a printed book. This makes the mobile more suitable for certain types of contexts than others. Thus, the system quality, information quality, use and user satisfaction have all to be evaluated in connection to a specific context. The freedom creating capacity is also context-sensitive. The situations where the mobile is most useful and appreciated varies from person to person according to their work type and style. In order to have an impact the system has to fit the user's work and provide true "freedoms" in at least some situations. This context-specificity is a special condition for mobile systems and it has been recognised in both designing the questions and the analysis of the results.
The Keen & McKintosh freedom classification is here extended by the Kakihara & Sørensen definitions of mobility in order to create a rich picture of the freedom- and impact creating mechanism.

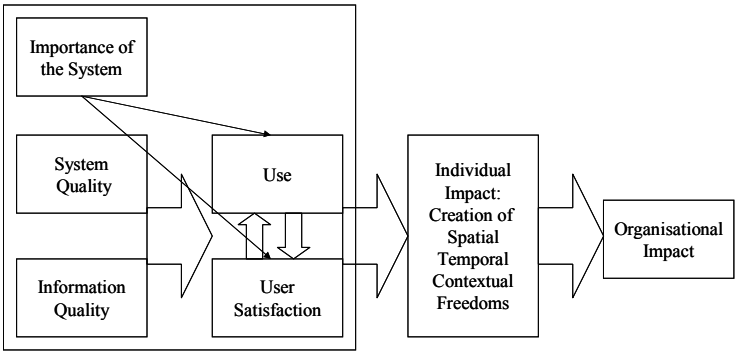

Figure 10 The evaluation framework

The left-hand side of the model represents the antecedents of possible impact. These factors were evaluated in order to find the conditions limiting and enhancing the possible impact. The right-hand side represents the impacts and the potential for different types of impact.

As all of the factors in the model are intertwined, scrutinising only one part of the model would probably yield inaccurate results. The framework is not intended to be a comprehensive causal model but merely serves as a guideline for analysing the data and finding the underlying patterns.

4 Information environment of the users

The interviewees were relatively mobile in their work. Local mobility: 21 (70%) of the respondents stated that they move around in the same building at least once or twice/day and 9 (30%) moved more than 5 times/day.

Apart from moving around within their workplaces the respondents were mobile even in the remote sense: The respondents were moving between buildings in average 2 times/week, mainly when working on their secondary duties. Only one respondent was moving between buildings more than five times/week.

There was a perceived need to carry along more items while changing work location: 13 (43 %) respondents recognised a need to carry along more items than they do, while moving to their secondary workplaces. The

items needed ranged from medical records to specialist handbooks and a geographical map.

The information search methods used varied. Practically everyone interviewed used paper journals as a method of information search. 21 respondents used internet resources other than the ”Terveysportti.fi” portal provided by the publisher. Other sources were books, colleagues, and info leaflets by the pharma companies

Printed books were still used as a method of information search. 13 (43%) of the respondents were using printed books once or twice/day. 6 (20%) used books less than every day and another 6 (20%) never used books. More accustomed users of printed books were 2 (6%) using books 2-5 times/day and 3 (10%) more than five times every day. The most used book was the Pharmaca Fennica, mentioned by 8 respondents. Stated reasons for using paper books were: better suitability for browsing and clear format.

The CD-rom version of the databases was used less frequently. Seven (23%) of the respondents never used the CD-version and another 10 (33%) less than every day. The stated benefit of the CD was being able to show the patient pictures from the database.

The Internet-based databases (Terveysportti.fi) were used similarly to the CD: 6 (20%) did not use them at all and 12 (40%) used them less than daily. The advantage of the TP was the ability to print patient advice and the information being up-to date.

Other information sources (non-Duodecim Internet and journals etc) were used even less frequently: Eight (26%) respondents did not use them at all and 16 (53%) less than daily. The benefits of other information sources were availability of specialist information and access to non-medical information. It must be pointed that the Terveysportti.fi portal has links to a large number of quality medical information sites and the difference between these and the Terveysportti’s own contents was slightly blurred for some respondents.

5 Success factors in the case

Importance of the system

As the studied mobile system is still limited in scope containing only searchable databases of general nature, the kind which an average doctor does need approximately 2 times a day (Jousimaa 2001), the mobile system is bound to have a limited effect on the work structures or working habits of the users. The possibility of reengineering the work of a typical medical doctor by introducing more comprehensive mobile tools cannot be assessed by the findings of this study alone. The evidence from the interviews suggests that the mobile system in use has had an impact on the work habits of some doctors in some specific situations and that the changes have been to the positive in efficiency and in the time/quality relation in some specific work sub-processes.

System quality

The limitations of the mobile device (small screen and keyboard) were rated as not important, the mean being 2 on a 5-point Likert scale. The limitations were not considered to be crucial or impeding use of the system.

When compared with other methods of information search the mobile system did relatively well. For information search in the respondents work, the Internet version was considered to have the most appropriate user interface, chosen by 12 respondents (40%). The CD interface was next in appropriateness with 7 (23%) choices. The mobile was considered most appropriate by 6 respondents (20%), a percentage higher than that of those who preferred printed books, 5 (16%). The interface easiest to use was for most users the Internet, 12 responses (40%), but the interface preferred by the second-largest group was the mobile with 7 (23%) ”easiest interface” choices, more than both the CD version and printed book. The context of different work situations was mentioned by four respondents who, despite their opinion of the most appropriate user interface in their normal work was something else, recognised the mobile as most appropriate in some situations, especially outside the office or when other means of information search were unobtainable. The easy browsability and immediate recognisability of paper documents was mentioned by one user who considered a book the easiest interface.

Information quality

The most useful database for my sample was the EBMG.(16 statements, 53%), the Pharmaca Fennica following with 10 mentions (33%). There was a difference between hospital specialists and the health centre GP:s: the specialists valued the Pharmaca higher than the EBMG, mainly due to lack of in-depth information about their own speciality.

Clarity and scope of the contents of the EBMG: the form & clarity of the information was considered satisfactory. Only two respondents (6%) were dissatisfied with the form of the EBMG articles. The problem was difficulty in browsing the rather lengthy materials on the small screen and the slow page change. The contents of the database were also deemed adequate by 25 respondents (86%) By the dissatisfied ones the contents were judged to be narrow, containing no specialist information and no mentions of very rare conditions.

The Pharmaca Fennica was considered even more adequate: The clarity was appreciated by 28 respondents(93%) as for the EBMG, the inability to see a whole dosage table at once being the most imminent problem. The completeness of the contents was, too, appreciated by 28 (93%) respondents, the two dissatisfied ones criticising the out-of-date price list which was later developed to be automatically updated through the wireless GSM-Data connection.

The other databases were used more sporadically and relatively few respondents had formed an opinion on the content quality of them. The responses acquired were all positive and no direct flaws were mentioned.

Use & User satisfaction

The respondents were grouped in distinct groups according to their perceptions of their own usage of the mobile databases. The questions in the interview referring to these were: How often do you use the mobile databases? (categorised: Not at all, not every day, once-twice/day, 3-5 times/day, more than five times/day), in which setting or situation do you prefer to use the mobile? (open-ended), preferred form of information search tool? (categorised: printed material, Internet, CD, Mobile).

The answers to these questions were scored by giving higher score for more frequent usage, usage at primary workplace and preferring of the

mobile. The specialists working in hospitals (N=6) were separated as a special group due to their different work geography. Frequencies of the answers to the structured questions were calculated using Statview 5.0.1 and the open-ended questions were analysed by searching for patterns in the transcribed answers.

The usage patterns were in general as expected: the usefulness of the mobile device in the actual work setting of each individual physician was the most commonly stated determinant of the actual usage in the open-ended interview questions. The stated usage patterns varied according to the perceived usefulness of the device in the work environment.

All respondents found the mobile system useful in at least some situations. The actual usage of the mobile system during work time in a typical work location was a completely different matter. The interviewees could be divided into four distinct groups:

Subj.	GP/ Specialist	Usage level	Usage setting	Preferred tool	∑of scoring variables	Grouped as
1	GP	2	1	1	4	group1
2	GP	1	1	0	2	group2
3	GP	1	1	0	2	group2
4	GP	1	1	0	2	group2
5	Spec	2	2	0	4	group3
6	GP	2	2	1	5	group1
7	GP	1	1	0	2	group2
8	GP	0	0	0	0	group4
9	GP	1	1	0	2	group2
10	GP	1	1	0	2	group2
11	GP	1	1	0	2	group2
12	GP	1	1	0	2	group2
13	GP	2	2	1	5	group1
14	GP	2	2	1	5	group1
15	GP	1	1	0	2	group2
16	GP	0	0	0	0	group4
17	GP	2	2	1	5	group1
18	GP	0	0	0	0	group4
19	GP	1	1	0	2	group2
20	GP	0	2	0	2	group2
21	Spec	1	2	0	3	group3
22	Spec	2	2	1	5	group3
23	Spec	1	2	1	4	group3
24	GP	2	2	1	5	group1
25	Spec	1	2	1	4	group3
26	Spec	1	2	1	4	group3

Table 1 the grouping of the user categories

Group 1 (6), Those who find the mobile so useful that they have it open on their desks and use it even when they are sitting by a desktop PC with a 17 inch screen and access to the Internet and to the Duodecim databases on a CD.

Group 2 (11), Those who like to use the mobile in their secondary work locations where access to other information search tools is limited, or at home or in other out-of-office situations.

Group 3 (6), The specialists who conduct a large proportion of their work outside their offices and like to check things on the mobile instead of walking to the nearest computer terminal.

Group 4 (3), Those that use the mobile as a mere backup for ex-tempore situations like when travelling or at home and do not use the mobile in their everyday work at all.

The relative sizes of the groups within the interviewed group are in themselves rather revealing: both extremes; the non-users and the very enthusiastic users made up only 35% of the interviewees, the vast majority being those who use the mobile in situations where the advantages of a mobile system are most obvious. The relative sizes of the user groups are visualised in figure 2.

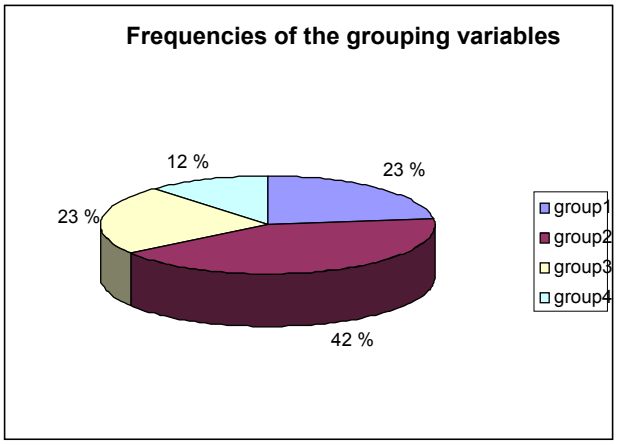

Figure 2 Relative sizes of the user groups

The perception of the most useful database in the system varied slightly according to type of work position: The GP's found the EBMG most useful, the specialists, needing less general medical knowledge, found the Pharmaca Fennica database most useful. The differences were, however, not statistically significant.

In the interview structure there was a question about the last time the user has used the mobile system- this type of inquiry is known as the critical incident method (Flanagan,8) giving a fairly reliable snapshot of the real usage situations without filtering or other problems associated with self-assessment. The locations of the last usage session of the respondents are depicted in Figure 3.

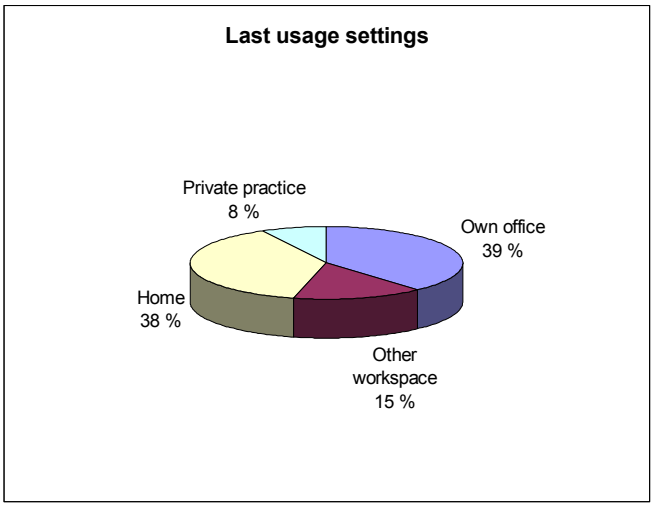

Figure 3 the reported context of last usage session

Despite the relative sizes of the user groups the most common setting for using the mobile was the physician's own office – this suggests that the mobile system has advantages over the fixed systems even for the users who are not so enthusiastic about it. The most common task for the system was a quick check of something- specific symptoms or latest care guidelines for some rare condition, or proper dosage of some medication. The most commonly used databases were the EBMG and Pharmaca Fennica (10 users each), and the ICD10 listing needed for filling doctor's statements (3 users).

Usage during patient consultations

One possible advantage of the mobile system was its being less obtrusive during patient contacts than a full-sized computer. This feature was recognised by six respondents. All interviewees were aware of the importance of maintaining eye contact with the patient, but the opinions of the mobile system as an enabler of this were highly polarised: the 6 interviewees who liked to use the mobile during patient contacts considered the mobile the best way to check something without disturbing the patient contact, but three of the respondents who liked to use a full-sized computer saw using the mobile as the most disturbing way of information retrieval during patient contacts. ("*The patient might think I'm writing a Short Message (SMS)*"). Only two respondents were still in favour of paper books as the fastest and least obtrusive method of searching information during patient contacts.

Impacts on work quality

The respondents were asked to rank the impact of the mobile system for their work in the following categories: Speeding up routines, reducing errors, enhancing time use and reducing work hours on a five- point Likert scale. The results are presented in figure 4.

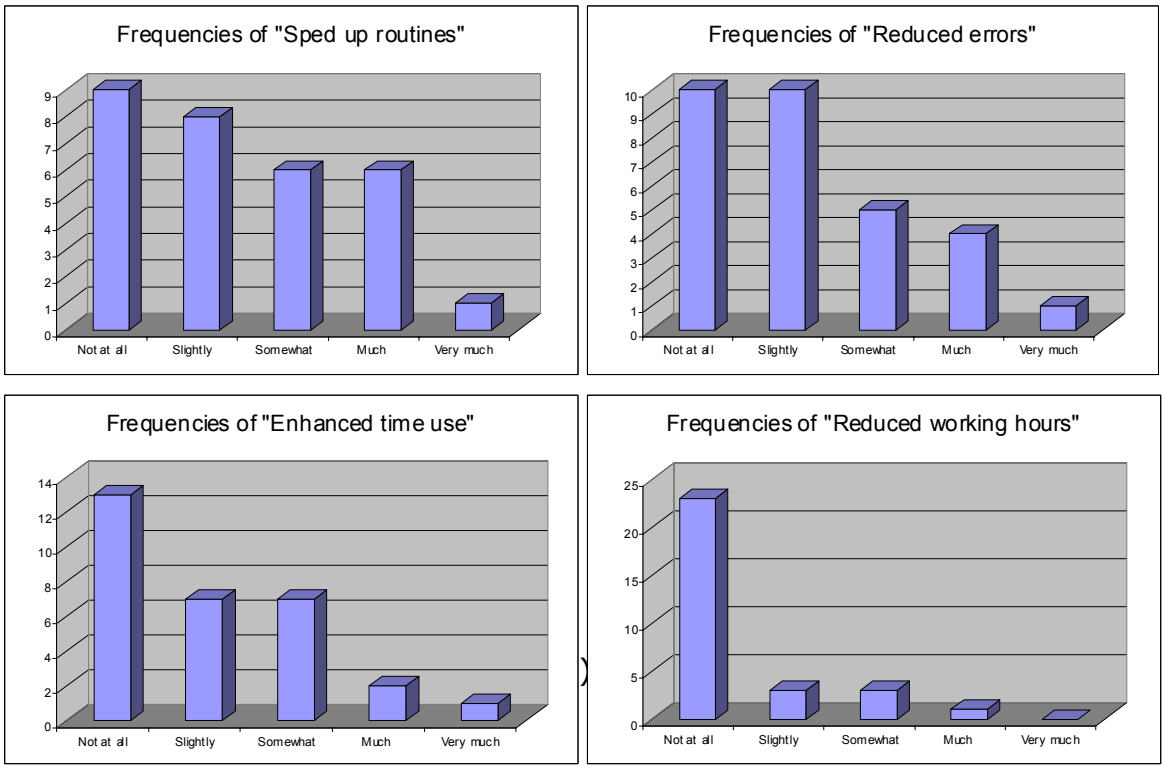

Figure 4 the frequencies of effects on work quality

The perceived effects on these aspects of work were rather limited. The biggest group of responses for every proposed effect was “Not at all”.
In addition to the above the respondents were asked if the mobile system has had an effect on their a) independence of time use, b) work pace, c) work quality/time ratio, d) routines and e) working habits.

Temporal impacts

The independence of time use was generally not affected by the system. A majority of 21 respondents (70%) found no effect on independence. Eight (26%) respondents saw some increase and one (3%) respondent marked increase of their temporal independence. No decrease of independence of time use was reported.

The effect on work pace was even less. Full 28 (93%) respondents saw no effect on their work pace, and only two (7%) had increased it slightly with help of the mobile system. Both respondents with increased work pace were GPs.

Geographic impacts

The perceived effect on Quality / Time ratio was more recognisable. 19 (63%) of the respondents reported some change in this aspect. When asked to identify the changes the answers ranged from being able to check something fast when away from the computer to easier search if ICD-numbers than on the desktop system and making notes when on lectures.

The work routines had changed for 9 (30%) of the respondents. The changes included faster information access, one respondent even used the mobile as her primary search instrument, the built-in calendar functions had changed the organisation of work, ability to check messages wherever and less need to carry heavy books along. One respondent stressed the effect of the reassured feeling carrying their device causes when information is available at all times.

The working habits or working style had changed for 11 (36%) of the interviewed. The changes were deemed to be small by 6 (54%), moderate by 2 (18%) and substantial by 3 (27%). The changes included being

dependent of the built-in calendar and not having to search for information elsewhere.

Contextual impacts

The mobile system can be seen as a substitute or a complement to earlier systems. Most respondents (22 or 73%) considered the mobile a complement and only 8 (27%) a substitute for the earlier systems. As the earlier systems do even include printed books the relatively high percentage of substitute view is more understandable: 18 (60%) of the interviewees had diminished their usage of some other method of information search due to the Communicator. Majority of these (83%) used less printed books than before receiving the mobile. The rest had even decreased their use of Internet and CD-based databases, especially at home.

All of the interviewed wished to continue using the mobile, even the ones who used it very little in their present work.

The system, given its limited contents and disconnectedness from artificial spaces (apart from e-mail capability) does not seem to have the ability to change the contextual environment of the physicians.

The nature of the system is such that there was no recognisable contextual impact of the nature highlighted by Kakihara and Sørensen. The work or communication of the users was not moved into any realm of virtual space.

Validity of the framework

The Basic framework by DeLone and McLean has been shown to have good explanatory power in different settings. The focusing on the impacts of mobile systems by using perspectives presented in the methodology chapter seems to give us a picture of the nature of the benefits provided by a mobile system. The effect of different contexts to different types of impact was clearly visible in the results of this evaluation, suggesting that the framework does indeed capture at least some of the major factors regarding mobile systems usage in a professional setting.

5 Conclusions

A mobile information system containing general medical knowledge has proven its usefulness in certain situations. The situations arise mostly in the

realm of remote mobility and have very small effect on the everyday routines of a medical practitioner. The system evaluated here is, naturally mostly a complement to other means of information retrieval, and in the contexts where mobile access could have most impact- in the realm of local mobility and teamwork surroundings- the contents and the functionality of the system are not quite comprehensive enough. Despite this, given the limited information contents the system has won a surprisingly wide usage even in the everyday office surroundings. This can be an effect of the simple and fast user interface- compared with the alternatives available. Since the system is used a limited number of times/day the impacts of the system on the geographical, temporal and contextual arrangement of medical work have been negligible. The secondary effects of system usage; increased confidence due to easy availability of information and ability to use professional tools in the free time are probably as important as the direct effects on work practices.

Limitations

The study presented here has the following limitations:
1) The sample is small and geographically limited- there may be other patterns of usage and impact in other areas or work cultures.
2) The framework serving as basis for the analysis has not been formally validated and is merely a means of constructing the data in a meaningful way. There are aspects not included in the model that do have an effect on the phenomena in question. (e.g. the personal characteristics of the users)
3) Using the system was voluntary but supported by the higher management of the health care district. This may have caused some bias in the answers in favour of the system.
4) The usage patterns and impacts were self-reported and do not necessarily exactly match the actual usage patterns.
These limitations should be kept in mind when interpreting these results.

Further research

This study aimed at finding the possible and recognisable impacts a mobile information system can have on a physician's work. The effects of the system at this point of development where the information content is limited to non-patient-specific were limited. However, some interesting patterns do arise: The usage and impact of the system seem to follow a pattern formed by the usage context, the information content in the system and the information need in the given context. The link between a system's

characteristics as depicted in the DeLone and McLean model and the requirements of the usage environment seems to indicate that the contextual fit between a system and the multiple usage contexts is an important determinant of mobile system impact and should be researched further.

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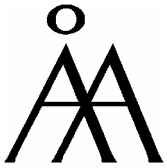

Åbo Akademi University
- Department of Computer Science
- Institute for Advanced Management Systems Research

Turku School of Economics and Business Administration
- Institute of Information Systems Sciences

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