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# PROCESS ORIENTED INFORMATION SYSTEMS – A KEY TO EVIDENCE BASED MEDICINE

Hanife Rexhepi , *University of Skövde, Informatics Research Centre, P.O. Box 408, SE-541 28, Skövde, Sweden*

**ABSTRACT**

The primary and basic component of healthcare is information. Being a healthcare practitioner involves using medical knowledge and patient information to deliver the best possible care. When decisions about the care of the patient are made they must as far as possible be based on research-derived evidence rather than on clinical skills and experience alone. This decision process is complex as evidence is infrequently available in a form that can be acted upon at the time decisions must be made. The aim of this paper is to present and illustrate how a prototype visualization of a process support system can support the availability of relevant medical knowledge in a way which seamlessly integrates with healthcare practitioners work practice, and thereby enables healthcare practitioners to work in accordance with EBM. An important conclusion from this research is that a process support as the one described in this paper can reshape the practice of EBM.

**KEYWORDS**

Medical guidelines; Medical decision support; Process Support Systems; Process Oriented Approach; Knowledge Management Systems; Evidence Based Medicine.

## 1. INTRODUCTION

Delivering good quality care is a complex endeavor that is highly dependent on patient information and medical knowledge (Bose, 2003; Rezazadeh et al., 2014). When decisions about the care of a patient are made, they must, as far as possible, be based on research-derived evidence rather than on clinical skills and experience alone. Evidence based medicine (EBM) is the conscientious and judicious use of current best medical evidence in conjunction with clinical expertise as well as patient values and preferences to guide healthcare decisions, see figure 1.1 (Sackett et al., 1996; Sackett et al., 2000). Clinical expertise refers to the practitioner's cumulated experience, education and clinical skills that the individual acquires through clinical experience and clinical practice. The patient brings to the encounter his or her own personal preferences and unique concerns, expectations, and

values that must be considered. The best medical evidence, also called medical knowledge, is usually found in medical guidelines, systematic reviews and other clinically relevant medical research that has been conducted using sound methodology (Sackett et al., 2000). The purpose of EBM is to provide a stronger scientific foundation for clinical work, in order to achieve consistency, quality, and safety in care (Timmermans & Mauck, 2005). The evidence based medical knowledge does not, by itself, make the decision, but it can help support the practitioner in the decision-making.

Following the principles of EBM, practitioners are required to formulate clinical questions based on the understanding of the patient's clinical condition. The patient's condition can be understood by the past and present diagnosis, as well as laboratory and administrative data (El-Gayar & Timsina, 2014). After the patient's condition has been identified and synthesized into clinical questions, the practitioner proceeds with the search of the literature for answers, evaluates the evidence for its validity and usefulness, and finally applies the information to patients (Lenz & Reichert, 2007; Mayer, 2009). The degree to which the clinician can practice EBM is thus dependent upon the availability of information about the patient (such as diagnosis, prognosis and therapy) and medical knowledge (such as medical guidelines). Patient information is a precondition for medical decisions and it is evidence based medical knowledge, clinical expertise as well as patient values and preferences that guide these decisions. The full integration of these components into clinical decisions enhances the opportunity for improved quality and safety of care.

Nevertheless, practicing EBM is challenging. One reason is the lack of information systems (IS) that support a seamless flow of patient information (both medical and administrative information) along the care process. This is highly disturbing, since the traditional single, doctor-patient relationship is increasingly being replaced by one in which the patient is managed by a team of healthcare practitioners, each specializing in one aspect of care (Bose, 2003, p. 61). Such seamless and shared care critically depends on collaboration and the ability to easily share information between healthcare providers (Iroju et al., 2013; Bose, 2003). Collaboration between healthcare providers and the patient is also essential in ensuring the proper delivery of the most appropriate care, since both parties share vital information. The healthcare practitioner offers evidence based treatment options, as well as their risks and benefits, while the patient offers his/her experience of the medical condition, values and expectations (Oshima Lee & Emanuel, 2013). Considering and incorporating the values, preferences, needs and experiences of patients in, e.g., treatment plans are important for the practice of EBM and crucial for the engagement of the patient in the decision-making. EBM is also almost impossible to practice in the everyday clinical care, as healthcare practitioners typically do not have the time to carry out literature research while the patient is in the office as medical knowledge e.g., medical guidelines and systematic reviews, are not integrated within electronic healthcare records (EHR). Therefore, literature searches will necessarily take place offline (Lenz & Reichert, 2007). Those practitioners who search for medical knowledge during the patient encounter all too often find that existing knowledge may not necessarily correspond to the issue at hand (Clancy & Cronin, 2005). Some healthcare practitioners may even decide not to actively look for the required medical knowledge because textbooks, journals, and other existing information tools are not adequate for answering the questions that arise: textbooks are out of date, information in journals is too difficult, if impossible, to translate into daily work practice and current information systems (IS) solutions such as IT-based knowledge repositories are not widely used because they have not been developed to meet practitioners knowledge needs (Smith, 1996; Krasniqi & Persson, 2012).

The situation with absence of patient information and medical knowledge is untenable as the practice of EBM depends critically on the collection, seamless exchange, and utilization of information and knowledge within and across the organizational boundaries. Iroju et al., (2013) even argue that lack of interoperability amongst healthcare systems have resulted in increased healthcare cost and declining quality of patient care. Moreover, Lenz and Reichert (2007) and Iroju et al., (2013) argue that the treatment of the patient can be improved by selectively providing patient information and relevant medical knowledge according to the current context, and to support all of this in a way which seamlessly integrates with the practitioners work practice. However, current IS solutions are far away from this perspective. To achieve seamless and secure information transfer between care providers and access to relevant medical knowledge a more process-oriented approach, with supporting IT systems, must be considered. A process-oriented approach is an important foundation to achieve a system design that focuses on the care process from the patient's perspective and thereby sets the patient process in focus. This approach can streamline the flow of patient information and medical knowledge, and ensure that healthcare practitioners work according to EBM. Therefore, the aim of this paper is to present and illustrate how a prototype visualization of a process support system (PSS) can support the availability of relevant medical knowledge in a way which seamlessly integrates with healthcare practitioners work practice, and thereby enables healthcare practitioners to work in accordance with EBM. The PSS was originally developed during a research project named Future Healthcare Information Systems (FHIS) and illustrates the main features of a proposed process oriented approach for patient information distribution in future healthcare information systems. The key principles of the PSS have been presented in the paper by Åhlfeldt, Persson, Krasniqi and Wåhlander (2013), where the patient perspective is taken into account. However, since the original PSS only to a certain extent manages medical knowledge, the PSS, for the purpose of this paper, will be further modified to also visualize how such a system can improve the availability of relevant medical knowledge, and thereby support healthcare practitioners to work in accordance with EBM.

The remainder of this paper is organized as follows. In section 1.1 the theoretical background to the work is presented. Section 2 describes the research approach. In section 3 the architecture of the PSS is presented while section 4 presents the findings. The findings are discussed and concluded in section 5.

## 1.1 Theoretical Background

To achieve the goal of the paper, the research area of process orientation (PO) and knowledge management have been used.

As a response to increasing competition and more demanding customers several organizations have chosen to be more process-oriented. Process orientation (PO) means focusing on business processes ranging from customer to customer instead of placing emphasis on functional and hierarchical structures. PO emphasizes process as opposed to hierarchies with special focus on outcomes, particularly customer satisfaction (Kohlbacher, 2010, p. 135). The building block of PO is to focus on the core business process. In healthcare organizations, the patient process is considered as one of the most important processes. Therefore, in order to improve the quality and safety of care, healthcare organizations must place emphasis on organizational processes based on the patient perspective, instead of

placing emphasis on functional and hierarchical structures (Kohlbacher, 2010). A process-oriented approach with a supporting information system is crucial as it can streamline the flow of both patient information and medical knowledge, and thereby ensure that practitioners always have access to the right information when decisions must be made.

Knowledge is considered to be the most valuable and critical asset of the organization. With the entry into the "global knowledge society" where knowledge provides competitive advantage, many consider KM a useful tool for business transformation and a key factor in gaining and sustaining a competitive advantage (Wiig, 1994; Davenprot & Prusak, 1998; Jennex, 2007). Although the term KM is widely used, there is no established definition. Instead, there are varying opinions on what it is and how it should be used, if used at all (Jennex, 2007; Jennex & Olfman, 2002). However, a common denominator among the definitions of KM can be found. For example the majority of the researchers argues that KM is the process established to capture and use knowledge in an organization, for the purpose of improving organizational performance. They argue that KM involves distinct but interdependent processes of knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application (see e.g., Alavi & Leidner, 2001; Heisig, 2009). Within healthcare, the goal of KM is to promote and provide relevant and timely knowledge to healthcare practitioners where and when they need it to help them make high quality and well-informed patient care decisions. In practice, KM is pursuing this goal through the advancement of innovative knowledge-mediated solutions and their integration in organizational workflows (Abidi, 2008, p. 3). Only when this knowledge is made available to others and used by the members will it improve the quality and safety of care. Abidi (2008) emphasizes that the adoption of KM in healthcare advocates a healthcare delivery system that values medical knowledge as a vital resource to improve health outcomes. Abidi (2008) further stresses that each healthcare practitioner has unique and specific knowledge needs, depending on the clinical circumstance. Therefore, healthcare practitioners are not just asking for mechanisms to easily access knowledge, but rather the incorporation of current and relevant knowledge into daily work activities to support healthcare decisions (Abidi, 2008).

It is clear that healthcare organizations can profit from many advantages that KM provide, such as; improved patient care, safety and satisfaction, team-building across organizational boundaries and more informed decision-making by learning from others and building on individual experiences etc. (De Brún, 2007). The Swedish healthcare system, as the healthcare system in other countries, is facing significant challenges of delivering high-quality care, at lower costs. At the same time, there is growing recognition that healthcare organizations are knowledge-intensive and are suffering from information overload (Wickramasinghe, Gupta & Sharma, 2005; Chen, Liu & Hwang, 2011; Acharyulu, 2011). Therefore, the healthcare sector needs to embrace KM strategies, processes, IT-tools and techniques as it can support healthcare organizations to create greater value by delivering higher care quality more cost effectively (Wickramasinghe, Gupta & Sharma, 2005). In recent years, researchers have tried to resolve the gap between evidence and practice by introducing different solutions for how information systems can be used to support evidence-based medicine. , Lenz et al., (2007) have in their research demonstrated how pathway compliance can be improved by the development of a successful IT-application that brings pathway recommendations to the point of care by reusing online routine documentation. The application is closely integrated into the electronic patient record system and is based on workflow-enabled electronic forms in which coded data from a central database are reused to place reminders and alerts. As the main purpose of computer based clinical guidelines is to decrease errors and increase quality and

safety, validation and verification techniques are other topics of interest to many researches (Peleg, 2013). Other researchers have focused on studying how clinical guidelines can be integrated into EHRs and organizational workflows. Peleg, Keren and Denekamp (2008) for example, have in their research studied how encodings of guidelines in a computer-interpretable format and integration of them with EHR can enable delivery of medical knowledge, in form of patient-specific recommendations, when and where needed. El-Gayar and Timsina (2014) have in their research presented a research agenda for leveraging business intelligence and big data analytics in evidence based medicine, and illustrate how analytics can be used to support EBM. In Sweden several national projects have been initiated with the aim of developing IT-based knowledge repositories. The solutions are based on web-based services that help practitioners to access and use best practice. Some well-known project initiatives are "Kunskapsguiden" and "Vårdaktörsportalen". These IT-based knowledge repositories aim to give healthcare practitioners easy access to medical knowledge such as medical guidelines. The information is made available in "document form", containing a multitude of pages. Even though these knowledge repositories contain crucial knowledge, none of them are integrated with existing information systems, such as an EHR. They are thus "stand-alone" systems that have been developed and are still being developed separately from existing information systems. Finding relevant knowledge at the time when it is needed and related to the clinical situation is therefore difficult

Up until know, supporting evidence based decision making has primarily focused on reminders and integration of medical guidelines with the EHR. Computer based medical guidelines provide important summaries of good quality evidence, but they are usually limited in scope and topic coverage. Therefore, and as a complement to computer based medical guidelines, IT-based knowledge repositories solutions should be integrated with the current information system, such as with a process support system. As existing research has focused either on the integration of medical guidelines with EHR or on the development of IT-based knowledge repositories, this paper will demonstrate how these two solutions can be combined in on order to improve the availability of current and relevant medical knowledge according to the patient process, and to support all of this in a way which seamlessly integrates with the healthcare practitioners work practice.

## 2. RESEARCH APPROACH

The research presented in this paper is based on two case studies.

### 2.1 Case Study One

In the first case study a prototype visualization of a PSS that demonstrates the requirements for future process-oriented information system support in healthcare was developed. The vision for PSS is that healthcare practitioners, from all levels of healthcare, and patients should have access to effective collaborative IS that supports a process-oriented care where the patient is a distinct and active collaborator. The PSS was developed in close collaboration between researchers and healthcare practitioners from a local hospital in the Region of Västra Götaland, Sweden. Since, addressing all the healthcare processes with related information systems seemed like an impossible task for the project, it was necessary to select an

appropriate delimitation. Therefore, the project selected a healthcare process that repeats throughout the healthcare system and that can demonstrate patient and healthcare communication; initiating, planning, carrying out and following up a patient's visit to a healthcare provider. This process was termed "Patient meeting". Before developing the PSS empirical data was collected regarding (1) how current IS support healthcare practitioners' in their daily work practice with regard to availability of patient information, and to a small extent availability of medical knowledge (2) how patients´ experience the information exchange with healthcare organizations and (3) identify user requirement for future process-oriented IS support. For this purpose, different data collection activities were conducted:

1. ***Current state analysis:*** This activity was carried out in close cooperation with healthcare practitioners as well as patients from an orthopedic clinic. Eighteen semi-structured interviews and direct observations with healthcare practitioners (nursing assistant, nurses, doctors, and administrative staff) were conducted. In addition, seven direct observations and interviews with patients were conducted. All interviews were recorded and transcribed. Field notes were taken during the observations. The analysis of the transcribed interviews and the observation field notes have been conducted with inspiration from the Grounded Theory research method. Data obtained from the interviews and observations resulted in "As-Is" process models that described the patient meeting. The models were developed using the Visuera Business Process model tool method (Visuera, 2014). The models have help in getting an overall picture of the business practice in the organization. They have helped to describe how things are done in the patient meeting and which information that is needed in order to perform various work activities. The models also helped in identifying user requirements for the PSS.
2. ***Modeling the intended future state:*** Based on the assessment of the current situation and "As-Is" process models, the work began by specifying the requirements of the proposed future state (To-Be models). Identification of requirements started with an "idea seminar" with the reference group of the project. During this seminar a number of "objectives" for the future state were identified. These objectives and the current state description of the first project activity formed the basis for the requirements. Based on these requirements, the future patient meeting processes were elaborated in order to identify the sub-processes and information flows. Process models of the different sub-processes comprising activities, roles, and information flows were then created. An important part of this work was to identify the detailed contents of the information needed for the various activities in the process models. The information content was sketched in forms with the Visuera Business Process Modelling 2007 tool (Visuera, 2014). The following goals were identified for the future state; *Increased access to information both from practitioners' and patients' perspective, the need for increased coordination of both clinical and administrative information based on the patient process, the need for a holistic approach based on the patient's perspective, increased patient involvement, and improved quality of care*.
3. ***Prototype development*** Based on the identified user requirements and after a number of iterations to ensure the quality of the process models and the information content, an initial prototype was developed with several user interface screens. The prototype was developed in close collaboration with the healthcare practitioners. The prototype was evaluated through numerous channels, involving both healthcare professionals, patients and IS providers. Based on this feedback the prototype was refined. By using prototype development, the practitioners

got a better understanding of how the PSS can improve the availability of information in the patient process. The Visuera method (Visuera, 2014) was used to develop the prototype.

## 2.2 Case Study Two

This case study was conducted within the frame of a project called the "Knowledge repository project" The aim of the project was to explore the possibility of creating a structured, resource-efficient and sustainable model for developing and managing a coherent IT-based knowledge portal for different areas of knowledge bases in healthcare. Coherent, means that there is one entrance to the medical knowledge that the portal includes. Two studies were conducted within the frame of the project.

**Study one**: aimed at analyzing the characteristics and challenges of Swedish IT-based knowledge repositories containing medical knowledge. The results from this study are presented in the paper by Krasniqi and Persson (2012). Within the first study 15 IT-based knowledge repositories were included in the analysis. To collect the data two methods were used: (1) inspection of the repositories according to predefined questions. This inspection aimed at collecting a variety of repositories at national, local and regional level which would demonstrate the multitude of approaches to creating knowledge repositories. The second method was: (2) telephone interviews with managers of the repositories. This study did not only identify challenges that current knowledge repositories in Sweden are facing, but also the need for a comprehensive IT-based knowledge repository (Krasniqi & Persson, 2012). Based on these results, the project continued with the implementation of the second study.

**Study two**: aimed at exploring:

- How healthcare practitioners' experience, availability of medical knowledge when and where they need it.
- What kind of medical knowledge is missing and/or is difficult to obtain at the point of care, as well as how they would like to access that information.
- Conditions for developing a coherent IT-based knowledge repository for different areas of knowledge bases in healthcare.

Within this study two interview guides were developed; one for managers and one for practitioners. The questions were based on the KM life cycle, which means that the following aspects were addressed:

- Processes for capturing and creating knowledge
- Processes for packaging, storing, sharing, applying and measuring knowledge.

In total, 62 semi-structured interviews were conducted with managers, nurses and nursing assistants from primary care, specialist care and municipality healthcare. All interviews were recorded and transcribed. The analysis of the transcribed interviews has been conducted with inspiration from the Grounded Theory research method. The study results confirmed that practitioners lack access to medical knowledge when preparing and conducting patient visits, as well as when making decisions about the care of the patient. Hence, they experience difficulties in the practice of EBM. One of the main reasons is that the participating organizations have failed to embed the KM process in everyday processes. In addition, the results confirmed that practitioners lack access to adequate IT-support for accessing and sharing knowledge. To simplify access and ensure application of knowledge that guides practitioners in delivering high quality care, practitioner expressed an urgent need to integrate medical guidelines and relevant knowledge sources such as IT-based knowledge repositories

with EHRs. Some also requested integration of reminders with EHRs. Practitioners also expressed a need for a comprehensive IT-based knowledge repository. There is also an urgent need for IT that supports sharing of tacit knowledge between practitioners within and outside the organization.

Based on the results from case study two the PSS has, for the aim of this paper, been further ***modified*** to also visualize how such a system can improve the availability of relevant medical knowledge, and thereby support healthcare practitioners to work in accordance with EBM. The modification of the PSS is seen as relevant for two reasons; (1) the original PSS deals with the access to medical knowledge to a small extent and therefore needs to be extended, and (2) healthcare practitioners, especially from case study two (and to some extend from case study one), have emphasized the need for information systems that; (1) include medical guidelines, and reminders, and (2) supports sharing of clinical experiences.

## 3. OVERALL ARCHITECTURE OF PROCESS SUPPORT SYSTEM

The vision for PSS is that healthcare practitioners and patients should have **access** to effective collaborative IS that supports a **process-oriented care** where the patient is a distinct and active **collaborator**. The words in bold are concepts that the FHIS project paid particular attention to, meaning that:

- Appropriate parts of the PSS are available for both patients and practitioners taking into account usability for different user groups.
- The involved roles/users interact through the PSS. The underlying approach is process oriented.
- Various relevant individual information systems interact with patients and practitioners through the PSS.

The PSS can be viewed as a layer of abstraction or user interface above the various individual IS, enabling enactment of the process and interaction between patients and healthcare practitioners through computers and mobile devices without accessing each individual IS (Perjons et al., 2005). The PSS drives the process forward, ensuring that it is carried out properly and hence, supports users in performing their work tasks. The PSS also provides a user interface to the various systems involved in performing a work activity. The principle is described in Figures 1 and 2.

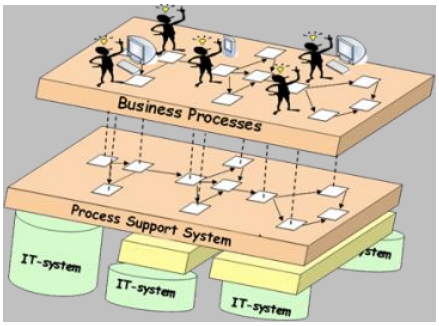



Figure 1. The principle of the PSS (Adapted from Perjons et al., 2005)

Moreover, the architecture makes it possible, at least in theory, to replace individual IT systems without significant effect on the user. The PSS connects the following aspects:

- Access to relevant patient information, both medical and administrative.
- Process control providing integrated support for the user.
- Access to relevant medical knowledge through integration of medical guidelines and an IT-based knowledge repository.

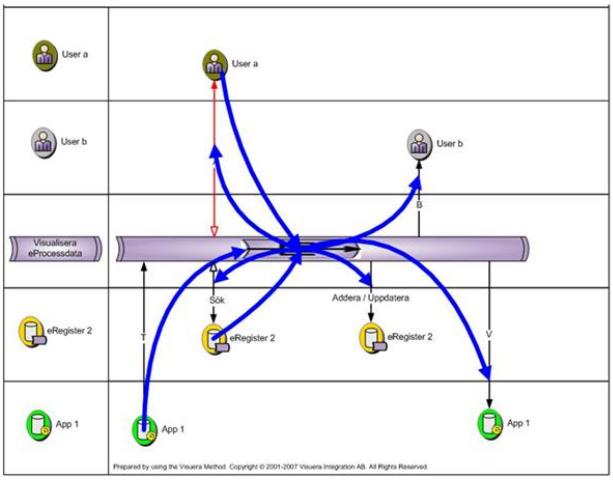



Figure 2. Communication between the user, PSS and IS (Åhlfeldt, Persson, Krasniqi & Wåhlander, 2013)

## 3.1 Key Design Principles for PSS

The key design principles for the PSS have been identified during case study one (Åhlfeldt, et al., 2013). To understand how a PSS can support the availability of relevant medical knowledge in a way which seamlessly integrates with healthcare practitioners work practice, one need to understand the design principles. Therefore, a brief description of the key design principles is given below:

**The patient process is in focus:** The PSS focus on the patient process through healthcare and on the patient information and medical knowledge that is needed by healthcare practitioners within the context of this process.

**The PSS is based on standardized information:** Having the right information when it is needed is a challenge in the healthcare context. To improve the availability of information, it is essential that the information is standardized and structured. To achieve this in the PSS, the information content of the national quality registers for selected diagnoses has been used. The types of information stored in quality registers have been transformed into checklists for each diagnosis. For example, when the physician plans for medical examinations for a patient with hip osteoarthritis the PSS provides support by showing what medical activities that should be prioritized and also conducted.

**Digital booking and coordination of patient treatments and examinations:** The process support enables electronic booking and coordination of the patients' treatments and examinations. It is also possible to follow the status of these activities. If some activities, such

as e.g. laboratory tests, are not completed before the scheduled patient meeting/visit, then this visit can be cancelled in advance. In this way one prevents the patient to come to an unnecessary meeting as test results have not yet been received.

**Electronic care request/referral:** The PSS enables the patient to submit an electronic referral through his/her user interface screen (see figure 3). A practitioner can also through his/her user interface send in an electronic referral to another healthcare provider.

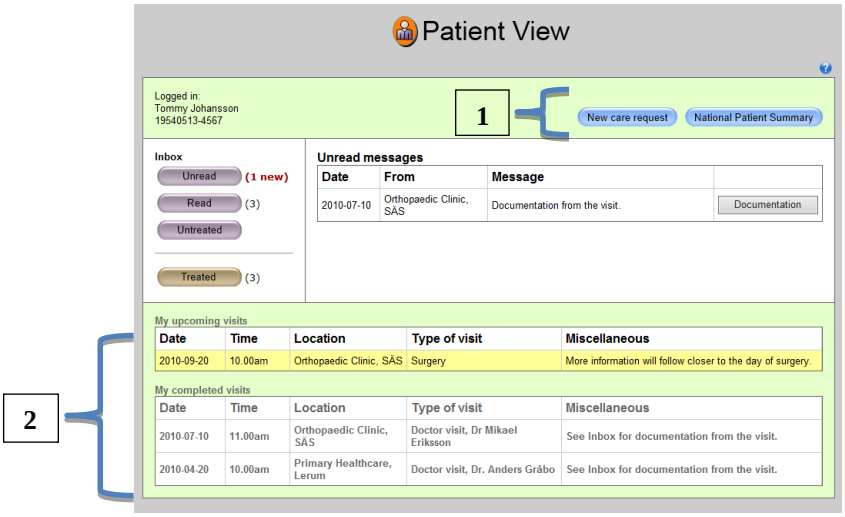



Figure 3. The patients view: From this view the patient can for example (1) create a new care request, (2) see past and future patient visits

The care request within the PSS is based on standardized checklists designed from national quality registers. In order to prevent incomplete referrals, the care request within the PSS is based on mandatory information that must be filled in by the doctor before it can be sent. The information in the referral is thus based on standardized checklists from predefined national medical pathways/care plans. The information displayed in the referral is in turn governed by the selected patient health issue or diagnosis.

**Efficient information flows:** By adopting a process-oriented approach the information flows can be more efficient. The PSS can ensure that the patient and the practitioner carry out the right activities during the different parts of the process. The challenge here, particularly in today's decentralized healthcare, would be to determine which healthcare provider that should be responsible for performing which work activities and who should provide a specific type of information to the PSS. Furthermore, by structuring for example the referral, it is possible to ensure that all important information that is recorded in the referral follows the patient process. Moreover, a major advantage of a process-oriented approach and tools that supports the patient process is that the PSS drives the process forward. For example, when a work activity is completed, the PSS will present nearby activities that must be performed. For example, when a practitioner in secondary care has written and signed the final documentation for the patient record, the PSS automatically picks up the form "response to care request" that must be sent back to the referring physician from primary care.

# 4. RESULTS AND PRINT SCREEN EXAMPLES

To clarify the new function of the process support prototype related to the availability to medical knowledge, a hip osteoarthritis patient scenario will be used. The hip osteoarthritis scenario is about a 67-year-old man. The patient has previously been treated for chest pain and is taking medicine for high blood pressure. There are three general views in the PSS, representing the main roles in the patient meeting process. These are; the Patient View, the Care Planner View and the Patient Visit Leader View. Patient Visit Leader is defined as the healthcare practitioner (e.g., a physician or a nurse) who is responsible for the patient visit. Care Planner is defined as the healthcare practitioner (e.g., a physician or nurse) who prioritizes the care request and plans the upcoming visit. To visualize how relevant medical knowledge can be made available to healthcare practitioners the "care planer view" will be used in this paper.

The layout of the Care Planner View and Patient Visit Leader View is basically the same as the Patient View (see fig. 4). The credentials of the person who is logged into the system are presented in the upper left corner (see figure 4). In the left part of the view the Care Planer can access care requests that have been sent in by patients (inbox). In the middle of the view a notification box is presented.

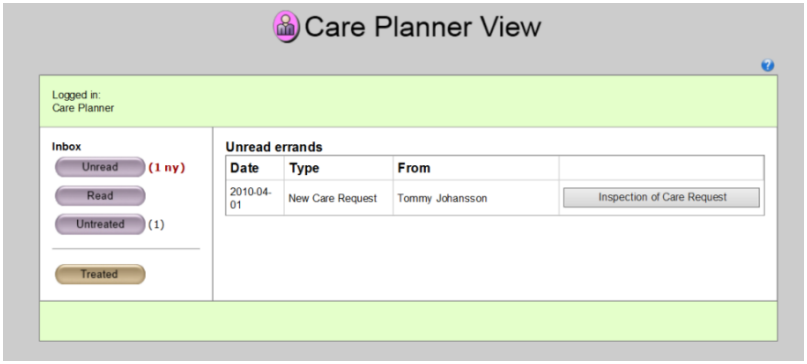



Figure 4. Overview of the Care Planner View (Åhlfeldt, Persson, Krasniqi & Wåhlander, 2013)

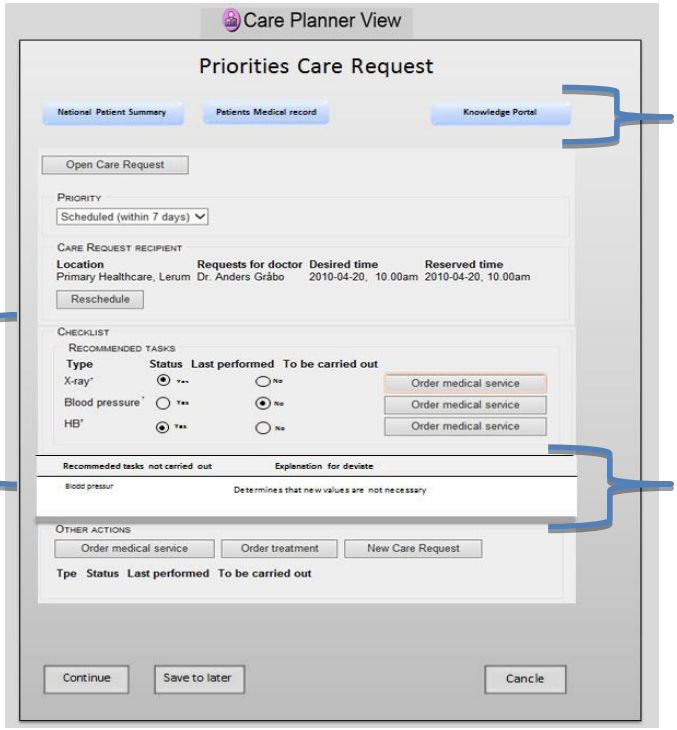
## 4.1 How a Process Support System can support the Practice of EBM

A PSS can significantly contribute to improving quality of care and enable practitioners to work from EBM, by providing timely access to up-to-date patient information - matched with relevant medical knowledge and with an IT-based knowledge repository (see figure 5). In the screen shot below (fig 5) the Care Planner (who in this scenario is a physician) has received an "own care request" (also called referral) from a patient regarding hip pain.

A patient with hip pain sends in a care request to a physician in primary care. When the patient fills in the symptom/disease, the patient is requested to fill in specific information related to hip pain depending on his/her health issues. When the patient has submitted the "own care request", the role Care Planner, a doctor, receives the referral, checks the information and plans for further actions. In order to ensure that the physician works from the latest scientific medical knowledge, the PSS is based on national evidence-based medical

guidelines and on standardized checklists designed from national quality registers. Medical guidelines deliver patient-specific advice at the time and place of a consultation and can therefore reduce variability in practice and improve patient outcome.

To ensure that only relevant knowledge is made available to the physician within the patient process the knowledge-sharing solution is carried out in two stages. In *stage 1*; unique patient information is matched with relevant medical knowledge (in this case medical guidelines) within the PSS. Medical guidelines can thus be derived from previously entered patient data. For example, as the care request regards hip osteoarthritis, only medical guidelines and recommendation concerning this health issue will be shown to the healthcare practitioner. In this case the knowledge is more focused case-specific. Deviation from a medical guideline is possible but needs to be documented (see fig. 5). If a specific guideline cannot be followed because of the patient's condition the PSS will generate a warning. For example, if the guidelines suggest that the patient should be prescribed drug X but the patient has an allergy to the drug, a warning will be generated. Moreover, to improve the safety and quality of care is not enough for the information a practitioner needs to be available someplace in the system application. Therefore, *stage 2* provides a more holistic knowledge view related to the entered patient information via a comprehensive IT-based knowledge repository that is linked with the PSS. If the Care Planer needs more specific information related to a medical guideline or the patient's condition (in this scenario hip osteoarthritis) a comprehensive IT-based knowledge repository is integrated within the PSS. When accessing the knowledge repository the medical information presented is automatically linked to the diagnosis and / or problem that the patient has applied for and to the specific part of the process that the physician is within. This implies that the practitioners do not need to explicitly search for the medical knowledge as this information is easy assessable from the PSS. Within the knowledge repository one can find different functionalities; (1) a search engine where practitioners easily can search for publications as articles, books, medical guidelines, video and audio, (2) EBM in practice. Here practitioners can learn more about EBM such as, how EBM can be used in decision making, how to find relevant evidence to support practice and how to implement EBM in practice. Here they can also find example databases that only provide evidence based knowledge, systematic reviews and summaries of primary research conducted at different hospitals in the country and at universities. The practitioner can narrow the search by entering a specific hospital or university. To ensure access to up-to-date and relevant medical knowledge practitioners can create an (3) individual profile, where they can get news and updates as they are published, including RSS feeds from selected research area/subject e.g., hip osteoarthritis and selected sources such as MEDLINE . Through the profile they can also get example of mobile apps which allow them to access healthcare information from the smartphone. Learning materials (4) as requested from healthcare practitioners in case study two are also available. They are presented according to topics. However, for this to work people must be willing to share their materials.




**Direct access to the IT-based knowledge repository**

**Embedded medical guidelines**

**Deviation from a guideline is possible but needs to be documented**

Figure 5. A snapshot of the patient's digital "care request" in the Care Planner View, showing how medical knowledge is integrated with the PSS.

Additionally, to support healthcare practitioners to practice EBM, IT-based knowledge repositories should not only be (1) integrated within the PSS or within an EHR in order to provide a single integrated point of access, (2) provide access to more structured information, but also (3) include the communication perspective. This perspective implies that the current traditional view of IT-based knowledge repositories must evolve from simply being one-way retrieval of information to a two-way system that provides collaborative and exchange futures that support transfer, exchange and capture of knowledge. Some researchers such as Quinn et al. (2014) argue that portals have evolved from being an efficient web tool for retrieval and transfer of information to a platform for collaboration. However, collaborative futures in IT-based knowledge repositories are limited within the Swedish healthcare, although they are highly requested by healthcare practitioners, as shown in case study two. In contrast to Quinn et al., (2014) researchers as Jetha et al. (2008) and Peirson, et al. (2013) argue that current knowledge portals could be improved by enhancing collaborative features. Therefore, while in the knowledge repository practitioners can share tacit knowledge through informal online discussion forums, knowledge cafés and community of practice (CoP). Within the forums, but especially within the CoP, practitioners with common problems and interests of getting together can share knowledge. In this case technology can be a very effective enabler of creating a collaborative learning environment for experience mediated knowledge sharing. According to Abidi (2007) online discussions forums where healthcare practitioners are bound by a common objective of interest provide a virtual meeting space to engage in problem-specific decisions that leads to the explication and sharing of knowledge. Sharing

knowledge through discussion forums and/or CoP can have a problem-solving and a learning aspect where practitioners can explore ways of working in order to solve a specific clinical problem and identify new solutions. Although the knowledge that is shared in not evidence based, it may have high trust value as it originates from colleges (Abidi, 2007). The knowledge that is created from the e.g., online discussion forums can be captured (if relevant) to explicit knowledge which then can be packaged, stored and shared through the knowledge repository or be integrated as a guideline in the process support system. Another way of supporting practitioners in different clinical situations is through so called Peer Assists methodology. Likewise, technology can be a very effective enabler by making it possible to bring together a group of peers from the organization to elicit feedback on a clinical problem. Different professional roles from different departments and organizations can be brought together.

## 5. DISCUSSION AND FUTURE WORK

This paper has presented a prototype that visualizes how availability of medical knowledge can be improved through a PSS. The healthcare sector is a highly knowledge intensive environment where both tacit (e.g., clinical expertise) and explicit (e.g., medical guidelines) knowledge is recognized as being critical for EBM and therefore crucial for the quality and delivery of patient care (Abidi et al. 2005). A challenge in the increasingly knowledge-intensive healthcare is not only to offer current knowledge, but to only offer relevant knowledge according to the current context, and to support all of this in a way which seamlessly integrates with the healthcare practitioners work practice (Lenz and Reichert, 2007). A key solution to the problem presented in the visualization of the PSS is to view medical knowledge and patient information as interconnected such that they continually impact on the other. This solution is based on the assumptions that relevant medical knowledge such as medical guidelines can be derived from previously entered patient data. In this manner we can ensure that healthcare practitioners always have access to relevant and the best scientific explicit knowledge, when and where they need it. Subsequently, since EBM also includes clinical expertise, the PSS can facilitate the flow of tacit knowledge. For example, discussion forums and/or CoP can help practitioners to capture and share expertise, know-how, ideas, problems, innovations, talents, and experiences. Since, tacit knowledge is the most valuable source of practitioners "experiential know-how" acquired in critical situations (Abidi et al. 2005), it is vital to facilitate sharing of this knowledge type among clinical teams, particularly when they are not always physically co-located but must exchange their critical experiential knowledge (Abidi et al. 2005). Before we try to support EBM by means of process oriented information systems we must be aware of the challenge related to organization specific consensus. Since the guidelines for good medical practice exist at national, regional, and local level contradictions between the guidelines exist. Hence, based on empirical results a crucial challenge will be to agree on which medical guidelines that should be implemented within the PSS and within an organization. Without an agreement it will be difficult to motivate practitioners to adopt the recommendations that are given by medical guidelines. Likewise, if the patient process is to be improved there also needs to be a consensus among different healthcare providers regarding common practices, (see e.g., Lenz & Reichert, 2007). In addition, an IT-based knowledge repository that is integrated within the PSS can facilitate the sharing, creation and capture of knowledge. However, IT alone is insufficient. To ensure good practice and an efficient use and transfer of knowledge that makes a difference on the quality of care, one must connect people who are willing to share

the deep tacit knowledge they have. Once people start sharing and this becomes a natural part of the organizational culture, enablers like an IT-based knowledge repository can be provided (O´Dell, Grayson & Essaides, 1998).

In conclusion, the results of this research have shown that a process support as the one described in this paper can reshape the practice of EBM, by making *current* and *relevant* medical knowledge available to those how need it and where they need it. The research findings would immensely help the healthcare IT managers and knowledge based system developers to understand the healthcare practitioners' requirements for future IS. Nevertheless, further research is clearly needed, particularly addressing the responsibility for process support systems that cross healthcare organizational boundary. Above all the challenges lie in who would be responsible for the ownership and the quality of the medical knowledge within the PSS and within the IT-based knowledge repository. Moreover, since collaboration between healthcare practitioners and the patient is essential in ensuring proper delivery care, future research should also consider how patients' values, preferences, needs and experiences can be captured through a process support system, so that this information can easily be made available to healthcare practitioners in connection to decision-making.

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