Healthcare Information Systems Promotion: From an Improved Management of Telemedicine Processes to Home Healthcare Processes

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ABSTRACT

Crucial advancements in science education and information technology provide promising resources that require many academic disciplines to work together. Innovations of Information Systems (IS) and Technology (IT) offer major potential to improve quality and efficiency of care delivery, enable new forms of healthcare organizations, enhance interactions between patients and healthcare providers, and transform care delivery. Closely linked to the integration into a global world, our work is focusing on electronic health (e-Health). Worldwide, there have been some pilot projects on Telemedicine and e-Health and researchers are working to advance and support e-Health services. Unfortunately, this still suffers from problems of understanding, lack of techniques and legal texts, huge costs, and it is still rarely used especially in Tunisia. Accordingly, fully exploiting the power of IS/IT within the healthcare sector requires overcoming significant challenges. To tackle these issues and following some previous works, our research aims at identifying the main challenges behind home healthcare processes, and to find better ways of improving them through the use of BPM-related technologies. We briefly describe our experience in this kind of processes by presenting our experience with telemedicine processes and the use of Business Process Modeling Notation 2.0 process models. We have tested our telemedicine processes through the Activiti BPMS, which proved its usefulness to enhance the design and therefore the implementation of telemedicine processes. From this experience, we derive the main challenges of using a BPM approach to implement home healthcare processes, and propose also the research questions that can enhance this implementation.

Keywords

E-Health; Telemedicine; Home Healthcare; Information Systems, Business Process; Modeling; Flexibility; Collaboration;

1. Introduction

Electronic Health (e-Health) is defined as the cost-effective and secure use of information technologies and communications techniques in support of health and the related fields, including health-care related services, surveillance, literature, education, knowledge, and research, both at the local site and at a distance [27]. It aims to make personalized medicine possible and affordable in the near future. E-health Information Technologies and Systems ensure huge opportunities in the medical fields. Accordingly, lots of challenges still need to be approved and more studied in order to build reliable, secure, and efficient networks or platforms with great flexibility to maintain agility and competiveness around globalization market.

Telemedicine and e-Health provide appropriate coverage of the information technology advances that offer practitioners, medical centers, and hospitals novel and innovative options for managing patient care. Special emphasis on the quality, cost effectiveness, and access to healthcare is made. They offer crucial tools for home healthcare, remote patient monitoring, and disease management. Telemedicine applications play, nowadays, an increasingly significant role in Healthcare. Telemedicine was introduced by Thomas BIRD in the 70s and designated "A delivery of healthcare and exchange of Healthcare information in a distant way" [26]. Telemedicine is the remote provision of healthcare services through information technology and communication in situations where the health professional and the patient (or two health professionals) are not physically present at the same place [11]. In order to maximize healthcare customer satisfaction (professionals and patients), a better care process management is required.

In this paper, we rely on the approach of Business Process Management (BPM) to identify the main challenges to tackle regarding home healthcare as we have experienced in telemedicine processes, and other researches have also achieved in other health areas.

We have been focused on the design and development of a methodology for teleconsulting and remote diagnosis processes. This includes the modeling of these processes using the Business Process Modeling Notation (BPMN) 2.0, and their corresponding deployment within a Business Process Management System (BPMS), which ensures their proper execution. By analyzing lessons learned in this experience, we identify the main challenges that we will face when adapting our experience to home healthcare processes.

Following the introduction, the remainder of the paper is structured as follows: in section 2 we briefly describe the research fields of e-Health and telemedicine. In section 3 we review the main issues within Healthcare information systems. Section 4 focuses on our registered experience with telemedicine processes. Home Healthcare processes and current challenges are depicted in section 5. We argue that this research field is still emergent and proper solutions would increase the efficiency of this crucial sector. Finally, section 6 summarizes the main conclusions of this research and outlines future work.

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2. E-Health and telemedicine

The involving of Information and Communication Technologies (ICTs) in Healthcare services is the major mechanism to improve efficiency and effectiveness. Nowadays, ICTs are being developed to achieve the integration of heterogeneous systems and the development of intelligent systems to support both clinical and management decisions in healthcare. The exploit of these technologies also improves the quality of patient care and reduces clinical risk.

At the same time, the patient becomes part of the healthcare process, having more information about diseases and access to his/her Electronic Health Record (EHR). EHR systems represent the latest evolution of healthcare ICT [23]. An Electronic Health Record is defined by Iakovidis [10] as "digitally stored healthcare information about an individual's lifetime with the purpose of supporting continuity of care, education and research, and ensuring confidentiality at all times". EHR is a mechanism for integrating information and data of patient healthcare collected in both paper files and Electronic Medical Record (EMR) databases by a variety of separate healthcare providers [19].

Moreover, physicians will have more information to deliver a better service, as well as dynamic guidelines to improve healthcare quality and reduce risks. The pharmaceutical industries can get more and more accurate information about drug's effects and supply chain delivery systems. Public health authorities can get more accurate information and develop dashboards to make better decisions. E-health processes are characterized by a high complexity and a large amount of data they have to manage [14].

Among its many solutions, e-health is a challenging domain for process support, allowing for remote care, facilitating patient engagement and contributes to healthcare management. Indeed, it comprises structured and unstructured processes whose support requires a high degree of flexibility [15].

In recent years, there has been a rapid growth of the use of IT in the Health sector. These technologies were introduced to support major restructurings of Health systems around the world. They concerned changes in the process of care and care services offered to the population. The term Telemedicine was defined by Thomas BIRD as "A delivery of Healthcare and exchange of Healthcare information in a distant way" [26]. Telemedicine is the remote provision of Healthcare services through information technology and communication in situations where the Healthcare professional and the patient (or two health professionals) are not physically present at the same place.

Telemedicine provides an important improvement in the supervision of patients. Moreover, it represents the contribution of a new technology that combines a sharing of knowledge between Health professionals, including biological, radiological and ultrasound data. It prevents the transportation of patients between hospitals and allows their monitoring without moving them, promoting dialog between practitioners in charge of these patients in their health problem [18]. Telemedicine is in fact a response to organizational and technical epidemiological (aging population, increasing number of patients with chronic diseases and poly-pathologies), demographic (unequal distribution of professionals in the country), and economic challenges (budgetary constraints) facing the Healthcare system today.

3. Business Process Management in Healthcare - Main Issues

Business Process Management Systems (BPMS) have been considered as one of the main types of Information Systems for the next generation [23]. In order to maintain agility and enhance concurrency, contemporary organizations business processes are becoming more dynamic, distributed and complex. Hence, business processes need to be able to deal and adapt to changes in open business systems environments, such as those arising within healthcare systems. Since the integration of business processes is still majorly done in a static way, it fails in meeting our increasing requirements in term of flexibility, customer orientation and cooperation. Accordingly, the dynamic integration of business processes is becoming more and more mandatory in organizations, but it is much harder to achieve.

Introducing a Business Process Management System in an enterprise can be an opportunity to act directly on these processes and to make a radical change. It has as objective, to reposition the stakeholders, to insure monitoring and control relying on indicators integrated into various parts of the existing Information Systems. Enterprise has always sought to reduce its efforts while producing goods or services. Economists and researchers in management focused on specific issues of the company and its output of capital by improving productivity through the transformation of productivity to industrial production [5]. Given the importance of business processes in the organization, the implementation of an approach based to Business Process Management becomes a required intervention within organizations.

Though current BPMS are established by explicit process models, we still have a main issue which concerns to the fact that sometimes processes cannot be explicitly defined. This is also due to the diversity of tasks and stakeholders (designers, users, managers, etc.) that can compose complex business processes. For instance, the coordination of process model fragments from other different organizations and/or heterogeneous information systems can make it difficult to easily predict and account for all the parameters required to develop a completely specified process model [6]. Moreover, a business process model represents the states of real-world processes at any given time. Hence, flexibility for enhancing business process evolution is becoming a great challenge for BPMS systems that target to reduce the gap between business process models and their real-world executions. Within such systems, manual operations have to manipulate the inputs and outputs of the workflow to adapt to changes in the working environment. These human interventions have an impact on productivity and process execution time. Due to the difficulty to represent reality and reflect its execution, unstructured business processes, like those in the healthcare and banking sectors, are the most affected by this concern.

Within healthcare organizations, we have critical business processes to manage. These can involve the patient, the insurance management or administrative functions. The remote access and automation of healthcare processes represent big challenges to enhance telemedicine processes.

In order to maintain agility at a competitive level, healthcare business processes are subject to frequent changes. To evaluate healthcare processes quality, we cannot disregard the flexibility aspect in the healthcare processes context. Indeed, the collaboration feature between healthcare actors (doctors, nurses, etc.) is a major challenge in telemedicine and home healthcare.

4. Registered experience with Telemedicine Processes

Our experience consisted in adopting the BPM approach for managing telemedicine processes. More precisely, our approach took into consideration the modeling of telemedicine processes with the BPMN 2.0 business process modeling language. Then these models were deployed in a Business Process Management System (BPMS), in order to obtain executable telemedicine processes.

In adopting such approach, our processes were automated and could involve all the concerned actors. We have succeeded to model, deploy and run two healthcare processes: the tele-consulting and the tele-radiology processes.

4.1 Modeling of the tele-consulting process

Tele-consulting process consists in examining a patient or analyzing data about a patient without direct physical interaction via a distant system. Its indications are varied: advice request, diagnosis or therapeutic advice to a colleague, organization of emergency management with guidance and transfer of the patient to the appropriate service, primary care in a place where there is no doctor (ships, aircrafts) [11].

The expected product of tele-consulting is an improvement of the medical decision making process and, consequently, the quality of healthcare offered to patients. In Figure 1, we present the tele-consulting process model according to the BPMN 2.0 standard.

4.2 Modeling of the teleradiology process

This process represents an act of teleradiology performed remotely or through a scheduled activity. It is achieved through continuity of care [17]. It allows a non-radiologist in practice to obtain an interpreting of an imaging study from another doctor. In the diagnosis there will be the involvement of three different actors: a remote radiologist, a local doctor and an electro-radiology technician.

The modeling, implementation and deployment of this process have also been successfully done in the same way as the teleconsulting process. In Figure 2, we present the teleradiology process model according to the BPMN 2.0 standard.

4.3 Main features of Developed prototype

We present in Figure 3 a schema illustrating the way in which actors are involved and the major offered features of the developed prototype. In fact, the administrator starts with the design and modeling of BPMN 2.0 models that will be stored in the BPMS database of telemedicine process models.

After deployment of these models in the Activiti BPMS, the local doctor will start the process by creating an instance that will be completed by another remote doctor. S/he can access to instances of data and give her/his opinion. The expected result of this care process is the preparation of a final report for the patient.

The teleconsulting process designed in Figure 1 was successfully experienced by two doctors. After modeling both telemedicine processes of teleconsulting and teleradiology, we developed a BPM solution in the Activiti BPMS from Alfresco Environment, and also in the Activiti Explorer runtime. The teleconsulting process starts by getting the approval for teleconsultation from the patient. After that the local doctor records clinical information and consent from the patient. This is shown in Figure 4, which illustrates the user interface that enables the interaction between local and remote doctors.

Other interfaces are offered in order to support the interaction between the local and the distant doctors and to allow them collaborating and discussing the considered health case of the patient.

5. From Telemedicine to Home healthcare processes - Current Challenges

Health establishments are required to evaluate, change and improve their processes to better satisfy their customers and offer them more efficient and better services and to integrate the advantages of Information Technologies and Communications that are imposed in all areas. Today we speak about telehealth [1], patient e-record [22], telemedicine [11] and, more generally, medical informatics [3].

The contribution of BPM in the field of healthcare has been confirmed in a previous work [11], through the improvement and implementation of telemedicine processes.

5.1 Home healthcare – an overview

Both aging of population and increasing life expectancy have led to an increase in the number of people with chronic diseases which give rise to functional limitations and disabilities. Patients undergoing treatment for chronic progressive disease or palliative care require a support, which subtracts them, as little as possible, from their home environment. This ensures many reasons of personal comfort [4]. It is for these reasons that many structures of overall care of patients outside the hospital walls have been developed, in recent years. These structures support the concepts of hospitalization at home or home healthcare.

Home healthcare is a system of care provided by skilled practitioners to patients in their homes under the direction of a physician. Home healthcare services include nursing care, physical, occupational, and speech-language therapy, and medical social services [8]. Home healthcare has grown into a vital source of healthcare, especially for older adults, who represent 72% of recipients [9]. It can be defined as the introduction of ICT in the home to support the delivery of healthcare. Homecare providers deliver services at the client's own home. The goals of Home Healthcare services are to help individuals to improve function and live with greater independence; to promote the client's optimal level of wellbeing; and to assist the patient to remain at home, avoiding hospitalization or admission to long-term care institutions [21, 8].

With an increasing aging population that desires to maintain their independent living, the need for smart and cost effective, in-home healthcare technology to replace existing homecare givers becomes critical. Smart Home is a residence that is equipped with technology installed as an integral part of the infrastructure to facilitate monitoring of residents, or promote independence and increase residents' quality of life [7]. As technology advances, smart home applications are being developed worldwide. Smart home aims to offer self-management-style health and safety services to its inhabitants (e.g. Self-health monitoring and medical self-measurements). While the patients will be self-managed for most of the time, the smart home is always connected to a back-end medical institution (e.g., hospital) where doctors are continuously informed about the situation of the smart home inhabitant. Also, through technologies such as game consoles, the

inhabitant can be encouraged to practice regular exercise, weight control, and a diet suitable for their chronic condition [2].

Delivering automated, intelligent health care at home requires smart devices that are aware of their context and therefore able to assimilate information to support care decisions. Sensors distributed throughout the home will help to provide this context, since each sensor will acquire information regarding a patient's physiology, as well as environmental factors that influence their state of health [25]. In home healthcare, technology provides many opportunities to improve communication with patients, to provide patients with accurate information, to educate them about their medications, and to monitor medication regimes.

In many cases, home healthcare allows for a person to be discharged earlier from a hospital, reduces hospital admissions and assists with a more rapid recovery. In addition, it is usually less expensive, more convenient, and just as effective as care from a hospital or skilled nursing facility [24].

5.2 Main social and technological challenges

It is a general premise that ICT can address these challenges and enhances home healthcare services. In fact, advances in telecommunications have the potential to support Healthcare delivery and education. The use of ICT can lead to a fundamental redesign of home healthcare processes based on the use and integration of electronic communication at all levels [7].

Nevertheless, obtaining success in healthcare in a home-based environment is more complicated than simply modifying the physical environment of the home to fit activity and healthcare needs. We can, therefore, identify two main types of challenges regarding the improvement of home healthcare through the use of ICT: social challenges and technological challenges.

5.2.1 Social challenges

5.2.1.1 Paradigm shift

There must be a fundamental paradigm shift with regard to the importance of the home environment in promoting activity, health, and healthcare. To compound the problem, changes must occur in a number of different and mutually exclusive systems that are not particularly aware of the role of the environment in supporting activity and health needs or of each other [20];

5.2.1.2 Funding limitations

Large geographic distances make health services often more costly for rural patients. Besides that, fully equipped smart homes are still a myriad worldwide, and especially in poorer countries;

5.2.1.3 Clinical workforce distribution

Health professional human resources are already limited for the intense in-site/hospital workload. Administrators may be reluctant in considering that home healthcare processes may decrease this workload, and may consider it as an additional workload for their professionals, not releasing them for home healthcare;

5.2.1.4 Collaboration between involved actors in home healthcare

Involved actors in the framework of home healthcare are multiple (coordinating doctor, treating doctor, nursing staff, etc.). This is ensured when an efficient collaboration is established. It is therefore important to maintain this collaboration through adverse home healthcare conditions such as poor communication facilities or lack of trained professionals that are used to work with each other. Moreover, home healthcare processes must also allow for this kind of collaboration in corresponding process models.

5.2.1.5 Elder ICT adoption rate

Being elder patients the main target of home healthcare, ICT adoption by these is still at a very basic level, with a distant gap between what smart homes can provide in terms of technology and the real effective use of this technology for home healthcare.

5.2.2 Technological challenges:

5.2.2.1 Internet reach

The permanent or intermittent lack of internet connection mainly within rural sites significantly hampers home healthcare, especially when remote teleconsulting is needed, or real-time data synchronization is crucial for providing better decision making for in loco or remote physicians;

5.2.2.2 Distributing home healthcare process tasks between different devices at different places

Within home healthcare processes, some task status must be updated from home environments where Internet or computing devices may not be available. Therefore, health professionals must be able to use mobile devices to previously load patient and process information, asynchronously update it at the patients' homes, and then upload it to a central (BPMS) system within a healthcare organization (e.g. hospital);

5.2.2.3 Unpredictable process behavior

As with many healthcare procedures, home healthcare processes cannot be fully predicted and, hence, precisely defined upfront. Modeling languages and BPMSs must be able to accommodate flexibility and changes in these processes, due to unexpected exceptions occurred (for instance: patient reaction to treatment not expected; lack of communication means; need to skip or repeat some procedure, etc.).

5.3 Research path

Since the growing interest in modeling and execution approaches of business processes and the main challenges today meeting the medicine and hospitalization, we will try in future works to answer following questions:

- Which mechanisms/language approaches must be adopted for the modeling of home healthcare processes?

- How can we take into consideration the flexibility of home healthcare process models in order to allow for changes during the execution phase?

- Through our modeling, how can we favor collaboration between involved actors, even in adverse technological and social conditions?

6. Conclusion and future works

Information Systems integration in Healthcare field include the introduction of several stakeholders whom can more easily and efficiently communicate in spite of geographic distance. Our research focuses on the design and development of a methodology deploying tele-consulting and remote diagnosis processes through a Business Process Management System (BPMS). This ensures the automation of these processes based on BPMN 2.0 models. Our methodology has been tested by tele-consulting actors (patient, local and distant doctor) and proved to be enactable with improved satisfaction. It authorizes the remote access to patient data and efficient contribution of remote doctor. Indeed, it ensures the automation of telemedicine-based healthcare processes.

We are now exploring home healthcare processes and discovering the impact of other new and innovative technologies in healthcare.

In such processes we are sometimes unable to predict the way in which the execution will be oriented and some of the consequences of actors' decisions are unintended. Particularly, we are actually focusing on providing some mechanisms to enhance flexibility and collaboration in within this kind of processes.

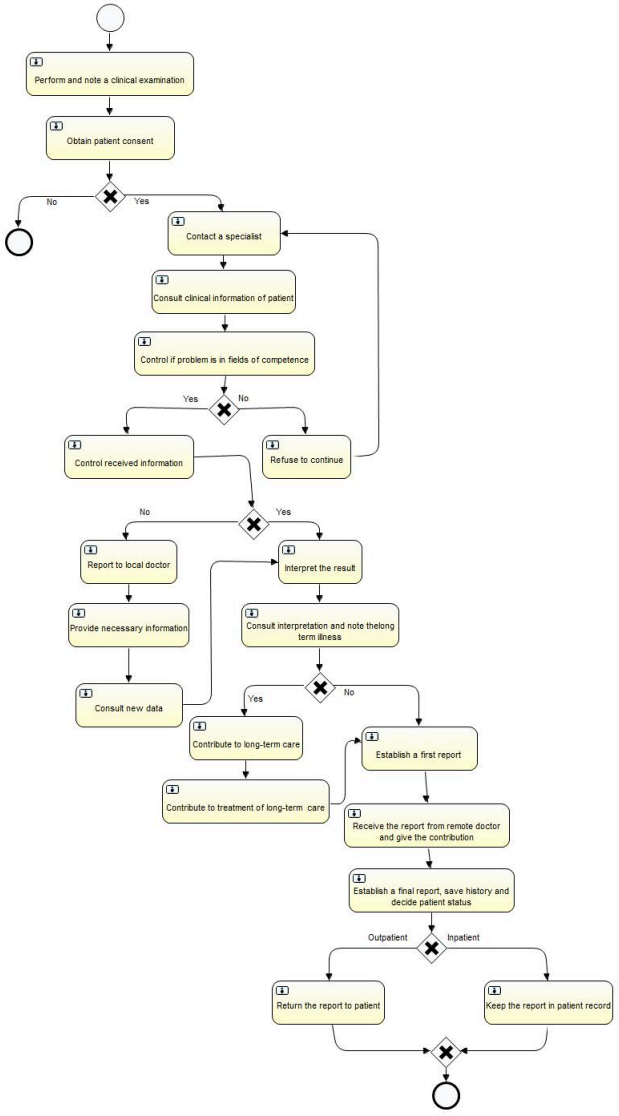

Figure 1, Tele-consulting process model according to the BPMN 2.0 standard

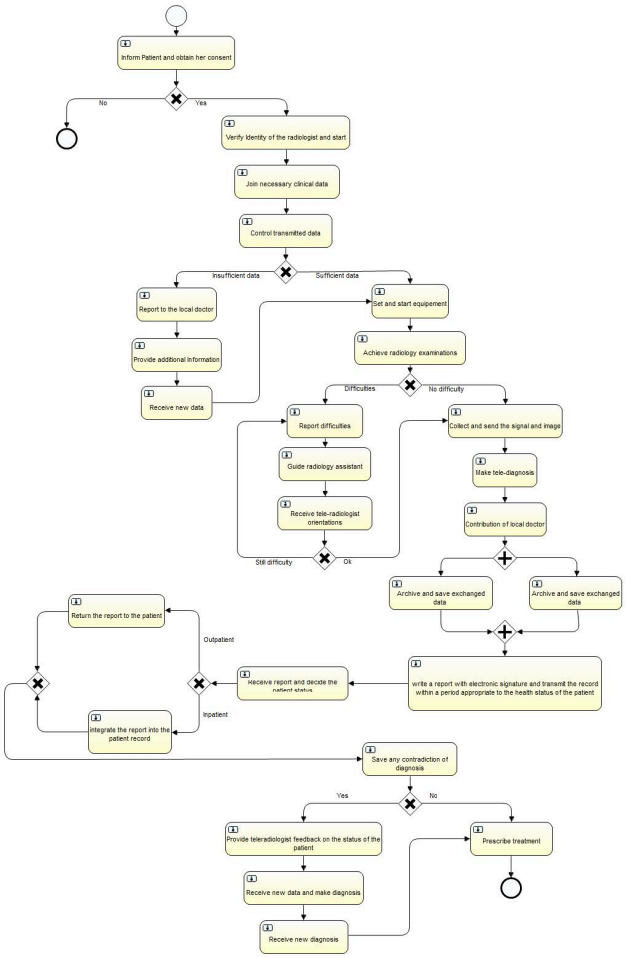

Figure 2, Teleradiology process model according to the BPMN 2.0 standard

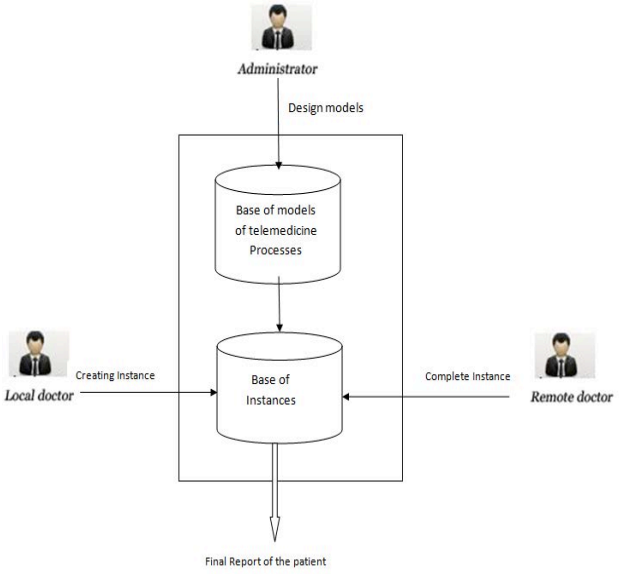

Figure 3, Features of developed prototype

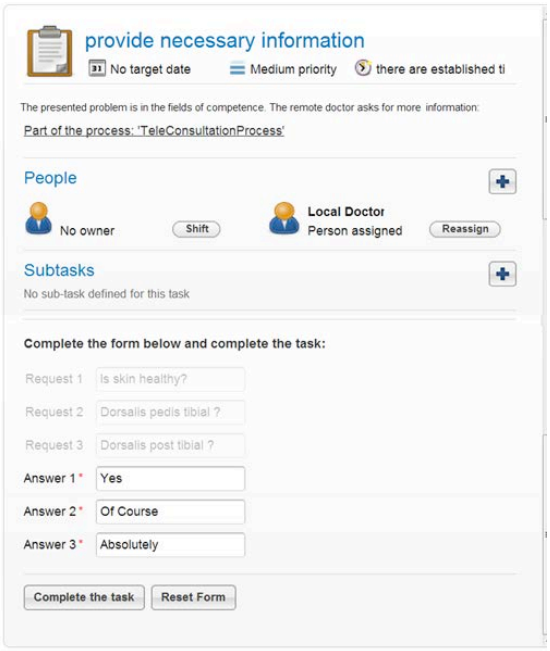

Figure 4 Interaction between doctors

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