Interoperability in Healthcare
- A focus on the Social Interoperability

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ABSTRACT

Context: Now a days Information technology has become a part of healthcare delivery this makes life much easier for patients and healthcare professionals. The increase in demand for communication among the different health information systems and health professionals has made interoperability complex and whereas interoperability is mainly focused at semantic and technical levels of communication. Yet, the social interoperability, an important part of communication between computerized systems and health professionals, is overlooked.

Objectives: In this study we explore the differences between interoperability and social interoperability. Furthermore investigate the social interoperability in practice and the problems that affect the healthcare.

Methods: We start with the literature survey to learn the definitions of interoperability and social interoperability. Later, case study approach is carried out to investigate the social interoperability in Interoperability. Interviews were also conducted as part of the observations in cases.

Results: The similarities and differences in definitions of interoperability and social interoperability are sorted out from the literature study. Five cases have been investigated to identify the social interoperability in practice. Analyses of these cases have identified some of the major problems for health information systems that do not meet social interoperability.

Conclusions: Interoperability definitions agree that interoperability is undoubtedly important for health data communication, but their goals in achieving interoperability is concerned only about computerized systems and very less focused on social interoperability. The case studies are used to find out the social communication using in health information systems. We realize that the communication between the users and the information systems are quite complex. The developed systems are witnessing the usability difficulties to the healthcare providers that affect the patient care.

Keywords: eHealth, Interoperability, Social Interoperability.

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1 INTRODUCTION

Healthcare is delivered by diagnosing diseases, prescribing medicines, prevention of illness. Doctors, nurses and medical organizations deliver the service to the patients. Most of the communication between patients, caregivers and computers are observed in the care setting. eHealth is the healthcare and delivery process that are supported by electronic and communication technology. Some of the eHealth applications used today are patient information system, ePrescription, lab systems, electronic health records etc. One or more times every eHealth tool (here tool represents a software application) will communicate with other eHealth tools for information exchange. The communication of these tools gave birth to interoperability that should actually make the information exchange easier. eHealth interoperability is the ability of one or more computers and software applications communicate with each other for health information exchange and make use of the information. More communication among the tools makes the communication complex and interoperability challenging. Furthermore, interoperability among the heath information systems is observed majorly at three levels and they are semantic, social, and technical. Semantic is about how two or more tools share information and make use of that information. Technical interoperability is about the technologies and networks used to communicate among those applications. Social interoperability is concerned about the environment and the human processes involved in the information exchange.

In our study we explore through various definitions of interoperability and social interoperability in a focus to find the differences and similarities among those definitions. Furthermore we have observation of some cases from various primary care centers in order to find out how social interoperability is in practice. We apply our findings to figure out the social problems involved in the care environment. Though, technical and semantic interoperability is mostly concerned by the researchers, but here we find, social interoperability (along with the technical and semantic), is also playing important role in healthcare.

The audience of this study can be healthcare professionals, like doctors, nurses and information technology people, Research workers, Academia and all the people who are interested in eHealth.

2 BACKGROUND

2.1 Healthcare and eHealth

Healthcare is realized as the diagnosis of diseases, the treatment for illness, the prevention of disease and the cure in humans. It is delivered by various care providers from medicine, nursing, pharmacy, dentistry and other medical allies. The people, institutions and the resources (used tools, information technologies, etc.) combined together to provide healthcare are the part of the healthcare systems. The healthcare is provided at primary care centers, secondary care centers, hospitals and also in some of the public health centers. The hierarchy of healthcare varies from country to county. For example, in Sweden, primary care centers and county hospitals are responsible for first and second line to provide care. Healthcare has been crossing the organizational borders since long time. The change of place is also one of the important reasons for organizational change. Patients always have a choice to move to different care center and also sometimes doctors give them recommendations to other doctors or hospitals. Earlier times (without the help of information systems), a patient had to transferred from one care center to another along with his/her medical history documents., X-ray's, and other necessary documents in order to present their health status. There are many cases that do not have any medical history and this lack of information about the diseases and problems in accessing the health records will be the biggest challenge to the doctors that may also leads to poor diagnosis.

This trend slowly evolved into electronic process where the health officials started using electronic mails and scanned copies of the patient medical documents. eHealth is a concept where healthcare technology manages and shares health data electronically. eHealth services are introduced for better care of the patient and easy access to patient information. To improve the quality of patient care this physical healthcare system are using electronic process and communication where it is called as eHealth or Electronic Health.

Technologies are used more and more to make daily life easier for human beings. From personal management, entertainment to communication, business almost everywhere we can see the usage of technology. Technology has been introduced to healthcare for a long time. Different types of complex machines and accessories are used everyday to diagnosis, medication and almost in every area in healthcare. Healthcare professional (Ash et al., 2004) addressed that information technology has a very important role to play in healthcare.

eHealth, a comparatively new concept, has been introduced from late 90s (Della, 2001). The basic concept of eHealth is to format health-data (e.g. patient data, pathological report, etc.) in a digital way and to use internet as the communication backbone to share and transfer that health data electronically. Briefly eHealth plays major roles to store and manipulate health data digitally and communicate the data electronically.

According to the World Health Organization (WHO, 2006) and the United Nations (UN) agency for information and communication technologies (ITU), the major eHealth services are -

- Telehealth: Telehealth is the service where the care is provided using telecommunication technology. A simple example can be a conference between two physicians discussing a patient's care through telephone. More complex example can be a videoconference from different places among the care providers.

- Electronic Health Records (EHR): EHR is a collection of patients' data in a digital format that can be shared among other information systems. The information systems used in healthcare often embeds EHR to manage, maintain and share patients' information among each other.

- Healthcare information Systems (HIS): HIS are broadly said as the information systems or the computerized system used in any healthcare settings. According to the environment it is also known as Patient Information System (PIS), Patient Management System (PMS), Hospital Management System (HMS) etc. HIS includes information communication systems, formal medical terminologies and clinical guidelines along with the computers used in the care settings.

- National electronic registries (NER): National electronic registers are used to store patients' information and follow ups to monitor and maintain a patient care. Often they are addressed as National Quality Register (NQR) when they deal with the patients with their specific disease data. There are other registers maintained in the eHealth services, such as, drug register. Drug registers are used to keep the record of available and approved drugs in the country.

- Directories of healthcare professionals and institutions: This directory service is used to enlist the care professionals, their roles and the provider institutions and their

specializations. The directory is helpful to search caregiver information for any particular disease.

- Decision Support Systems (DSS): These systems help the eHealth by providing help in decision making about diagnosis with the help of artificial intelligence. A lot of these systems use ontological analysis to identify probable diseases from a patient's symptoms.

- ePrescription: ePrescriptions are the digitized version of the conventional paper based prescriptions provided by the physicians. ePrescription is very helpful as it does not need to be carried to the pharmacist, instead it is transferred from the physicians computer to the pharmacist's one.

- Computer-assisted imaging: Computer-assisted imaging is used in diagnoses and surgical solutions in healthcare. Digital X-rays, real time surgery images, digital eco-cardiographs etc. are considered as computer-assisted imaging in eHealth.

Apart from these, there are also other eHealth services like Health Knowledge Management, mHealth (mobile health) etc. eHealth playing a major role these days in healthcare. These services are used standalone or combined to improve the care of the patients. It is very common to see a physician is maintaining EHR journal in the HIS and suggesting the medication through ePresctiption. The eHealth services are focused to improve the care by reducing the time and increasing the quality.

As we see the increase in usage of information technology and the communication among the systems lead to eHealth interoperability. Interoperability is one of the important aspects among the implementation of Information and Communication Technology (ICT) tools. These tools are vastly used around the world maintaining and managing health related information to make ease of the overall care giving process. There are various definitions for eHealth interoperability that are defined by different health organizations from different parts of the world. The following set of definitions is from US health organizations. Healthcare Information and Management Systems Society (HIMSS, 2005) is a US not-for-profit organization dedicated to promoting a better understanding of health care information and management systems. The Integration and Interoperability steering committee (I&I), a part of the HIMSS in US, has defined eHealth interoperability for National Health Information Network (NHIN), as the ability of health information systems to work with in and out of the organizational boundaries and should provide effective delivery of healthcare to both

individuals and communities. According to the US organization National Alliance for Health Information Technology (NAHIT, 2005), the consistent, effective and accurate exchange of patient data in order to communicate among health information technology systems, software applications and networks is called interoperability. The US department of health (NAHIT, 2004) defines interoperability as the exchange of patient health information among different clinicians and other authorized health entities with high security and privacy.

Let us see some of the European health organizations on eHealth interoperability. European Commission definition for eHealth interoperability (IDABC, 2004) states that, interoperability is the integration of heterogeneous systems that located at various places, should allow fast and secure access to public health data and patient information. The Telemedicine Alliance (TMA, 2005) describes eHealth interoperability as the objective to allow different people and countries to communicate easily so that the interaction of data among different systems and manufacturers becomes very easy. European Committee for Standardization (CEN, 1999), has defined interoperability as a state, where a specific task should be accomplished between two software applications by accepting data from each other in appropriate manner and without intervention of an extra operator.

2.2 Overview of types of interoperability and their importance

Health Level Seven (HL7) is a Standards Developing Organization (SDO) that provides standards for healthcare interoperability. HL7 is the global authority that defines standards for interoperability of health information technology. More than fifty five (55) countries are members of this group. The organization HL7 (2007) has classified interoperability mainly into three types as, technical interoperability, semantic interoperability and social interoperability. The HL7 group summarized interoperability into different categories in a view to find what to do, when to do, how resources are distributed and which goals are met, to identify the rules to achieve interoperability for any information system. The technical interoperability refers to the used hardware, transmission and reception for the exchange of information. The semantic interoperability focuses on the strategies to maintain the same meanings of the shared information. The social interoperability is the process of making information systems successfully work in the actual environment, this type of interoperability concerns about effectiveness, efficiency, and etc. of an information system in real life practice. This interoperability describes the views and strategies of the stake holders.

2.2.1 Technical Interoperability

According to the study of the HL7 group, the focus of technical interoperability is about the conveyance of data, not its meaning. That means, technical interoperability is about the tools and techniques to transfer data rather than concerning about how the data would be realized. The HL7 group also observed that this type of interoperability is mentioned mostly alone and sometimes with other types of interoperability. The European Interoperability Framework (EIF, 2004), is a recommendation of European Commission (EC), describes, technical interoperability is been concerned at the technical issues, such as, rules and regulations, protocols, open interfaces, interconnection services, data integration and middleware of the computer systems and services. It is mostly focused with the hardware related features, such as, protocols and interfaces. The Healthcare Information and Management Systems Society (HIMSS, 2005) explained that technical interoperability enables transfer of health data maintaining data integrity, safety, security, patient confidentiality and a common degree of quality of service. The Tele-Medicine Alliance (TMA, 2004) observes technical interoperability as the capability to share health data among tools from different manufacturers. They explained the goal as to exchange data using different equipment from multiple vendors in different countries. According to (Hans van der & Anthony, 2008) technical interoperability is related to communication of hardware, software applications and platforms. Tolk et al., (2007) described technical interoperability is achieved in the physical level by establishing communication standards among the connected information systems. This level allows the information systems to exchange data through well-established communication infrastructure, underlying networks and protocols. The Information Standards Board for Health and Social Care (2008) has given a small example to show the technical interoperability. It is about two clinical professional's communication regarding a patient. A doctor can ask for a patient's health record from another doctor regardless their distance using information systems. This communication capability is the result of technical interoperability. If the two professionals are separated then a medium takes place for communication and transferring health data. So, the technical interoperability neutralizes the effect of distance and makes healthcare data sharing possible with the help of hardware, software, networks, and/or many types of technological tools.

2.2.2 Semantic Interoperability

Semantic interoperability, on the other hand, focuses more on understanding the data rather than only transferring it. The HL7 group summarized semantic interoperability as the way to communicate data in a form that both the sender and receiver information systems will understand the data in exactly the same way. This type of interoperability concerns more about the formulation of data in a standard way so that all other information systems also understand it. HL7 group found that this type of interoperability is mostly mentioned with technical interoperability. According to the European Interoperability Framework (EIF, 2004), semantic interoperability is about ensuring unchanged meaning of the exchanged information, understandable by any other information systems that may be different in type and nature. Semantic interoperability focuses on the interaction among the information systems rather than human factors. So, their vision is different types of applications can understand the shared data. The objective of the semantic interoperability in eHealth is to improvise the communication of medical and health related aspects, both among humans and machines. WHO (2006) suggests that the concept of dictionary (using terminologies that both the information systems can understand same meaning) can be used in order to achieve semantic interoperability. The European Committee for Standardization (CEN/ISS, 2005) stresses that semantic interoperability can be gained using terminologies agreed by both data senders and receivers. They expand the dictionary concept introducing archetypes and template. Archetypes contain the norms and the definitions used in various areas of healthcare. On the other hand, templates are the structures to collect and present the health data. Archetypes are the patterns of behavior. Rossi et al. (2001), a biomedicine researcher, has come up with two kinds of semantic interoperability – *fine grained (detailed data structures and on coded values)* and *coarse grained (basic structures, independent from the particular clinical issues).* Rossi et al., (2005) recommends that research should focus on developing the criteria to define the optimal level of semantic interoperability to achieve *fine grained* from *coarse grained*. Semantic interoperability deals with programing, transmission of the information and makes use of that information. The European Commission, in the semantic interoperability report (2009), gave an example story to show how the semantic interoperability works. A general example is used to demonstrate the semantic interoperability using the two words *last name* and *family name,* which mean the same. Let us assume two different information systems are using these two different terms for storing patient's information. Adapting semantic interoperability makes both of the information systems to understand that these two terms, *last name* and *family name*, mean the same and parse this data same way in both of the systems. The whole process is meaningful,

understood by both the information systems and had no barriers with the language and technologies. Semantic interoperability in eHealth, ensures the common understanding of health data among all the eHealth tools and services with the help of health data content terminologies. So, we can say, semantic interoperability makes different information systems to understand the same meaning of shared data in the application level.

2.2.3 Social Interoperability

To discuss about the social interoperability, Landsbergen and Wolken (2001), mentioned about importance from different domains (economic, political, technical, and organizational) involved in information sharing. They defined social interoperability as the support mechanism to understand the relationship among these domains. Here, they have included a variety of domains and also have given a very general idea about the concerns of social interoperability, but the researchers have not talked more about the relationship between information systems and social interoperability. The HL7 workgroup mentioned social interoperability as an emerging concept for implementing information systems successfully in a real-life environment. This type of interoperability is mostly mentioned along with technical and semantic interoperability in the definitions. Lesh et al., (2007) assessed the medical care environment for the medical device interoperability and they have summarized that social interoperability must address both the technical and community aspects (relationships between the technology and the people) to achieve interoperability. According to their findings, the technical interoperability will ensure the interaction of the medical devices with the other devices and with the people who will use those as well. They added that the social interoperability, along with technical and semantic, must exist among all the stakeholders (doctors, nurses, care professionals) and patients in the technical architecture. According to The Intelligent Information Systems Review (2008) social interoperability is the interoperability that involves the users' activities of the health information systems in exchange of information and clear understanding of the requirements and motivations in the data interchange. However, the data is used to demonstrate a return on investment or value or improvement to the quality of patient care and effectiveness of care coordination (Intelligent Information Systems review, 2008). The users of the health information systems plays a big role by realizing to which level the technical and semantic interoperability is needed for the information systems. So, they (Intelligent Information Systems review, 2008) added that, social interoperability provides a foundation for technical data interchange and semantic consistency fitting into a human or functional workflow that delivers a desired result (Intelligent Information Systems review, 2008). Social interoperability often works with

workflow management where the implemented information projects the same flow as the users conduct process in real life environment. In other way, this type of interoperability deals with features to integrate information systems into real life work settings. HL7 (2007) group primarily identified these features as –

- Explicit user role specification – Identification of the users and their roles to be implemented into the information systems.
- Useful, friendly, and efficient human-machine interface – Interface of the information system should be user friendly, easy to learn and easy to use for the users in the workplace.
- Data presentation/flow supports work setting – Presenting health data in an organized and appropriate way according to the users are important for the information systems.
- Engineered work design – System architecture and the design should be performed well to implement a health information system.
- Proven effectiveness in actual use – The information system should also be proved useful for the users in the actual workplace.

From the point of health information systems, social interoperability focuses mainly on the communication between the users and the information systems. As an example, a health information system may be suitable for one care center but not the other in same type of two primary care centers situated in different locations, if it does not meet the satisfaction of its users. So, we say, social interoperability deals with adopting information systems in the real life work process emphasizing on the communication with the users.

2.2.4 Relationship among the types of interoperability

In the above we mentioned about different types of interoperability in healthcare and eHealth. Technical interoperability is all about the medium that is used by the systems or parties to communicate among them with the help of technology. This support for communicating necessary data from one information system to another in an electronic way is provided by the modern technologies. That is why technical interoperability is achieved by using modern technology in healthcare system where the parties exchange health information in an electronic format accurately and consistently. Semantic interoperability is about not only the medium of communication of information but also a meaningful way where the systems or the parties exchange their information maintaining the meaning and the context. Thus, in eHealth, semantic interoperability covers the basic needs of technical

interoperability and in addition the meaning and the context of the health information exchanged electronically. In healthcare, social interoperability mostly deals with the understanding of the health information that is exchanged among different parties before and/or after it is included in any system. So, social interoperability is achievable by maintaining proper coordination among the patients and the caregivers, so that the health data can be preserved, reasoned in the right way and kept unaltered.

Though for better understanding, interoperability is of three types but they are not totally separable from one another. Social interoperability concerns more about the people, who provide, realize and summarize the health data. Technical interoperability deals with the medium used for physical communication of data and semantic interoperability deals with the common understanding of the shared data by using different strategies, formulation and formation of data. Social interoperability also creates the environment where the semantic and technical interoperability are deployed. We can show the relationship among these three with the help of a Venn diagram (in Figure 1). Technical interoperability only deals about the data communication medium. Semantic interoperability not only concerns about data transmission but also realizing common information from the same sort of transferred data.
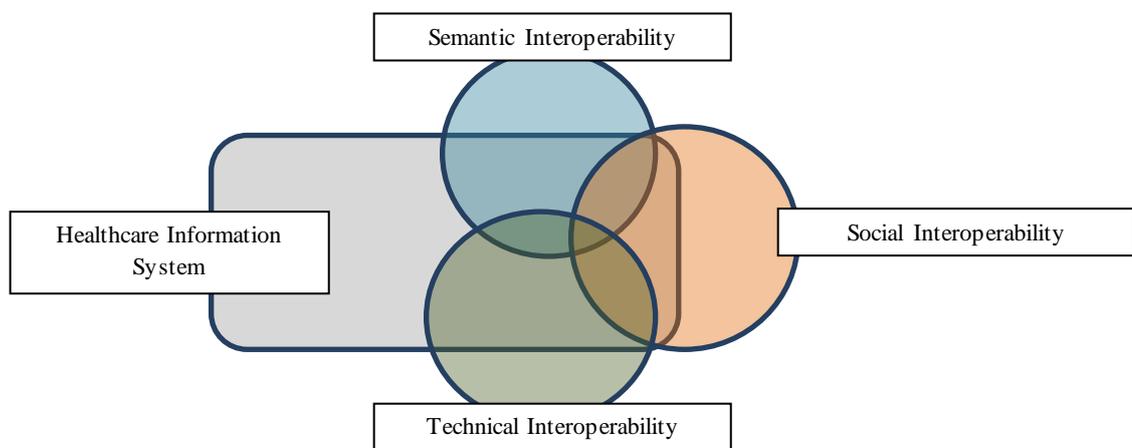
Figure 1: Relationship among different types of interoperability.

So, semantic interoperability can be said as the combination of technical interoperability along with the formation of data that can be realized by both the sender and the receiver. Yet the environment, where all these take place, is the concern of social interoperability. In other words, people are the end users and final beneficiaries of every communication that takes place. So, all these three types should be dealt carefully in order to achieve overall interoperability in any domain. In the picture below, the blue line of interaction shows the

social communication that takes place in healthcare. The semantic and technical interoperability are active during inter-system communication. All these techniques are used as a part of the communication among caregivers and care-receivers where the social interoperability is active.

These three types of interoperability are not separated from each other as we can see. Social interoperability creates the environment and the need in a care setting to exchange and utilize data where semantic interoperability preserves the meaning of it and technical interoperability creates the medium to exchange. Therefore in eHealth, social interoperability leads the environment to adapt to any computerized system satisfying technical and semantic interoperability.
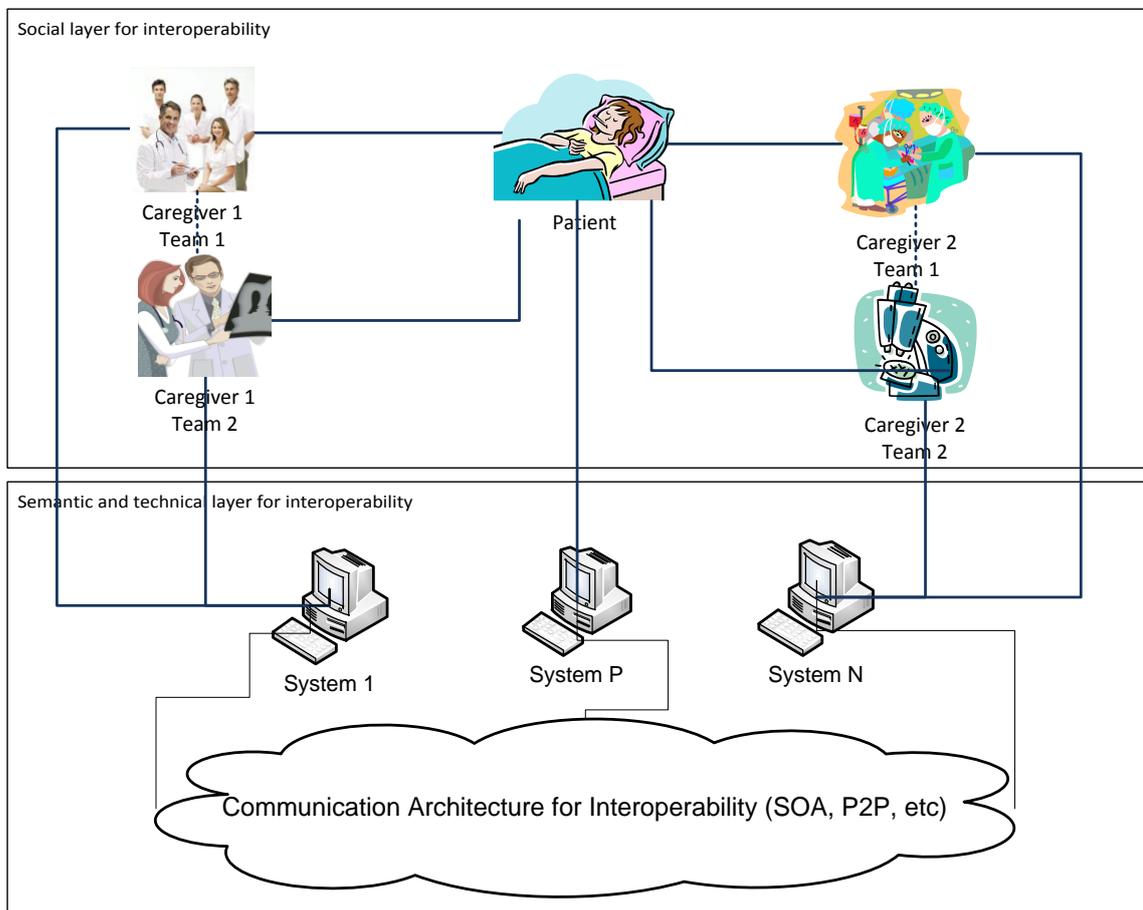
Figure 2: Communication among human and healthcare information system in primary care

In the figure shown above (Figure 2), the blue lines (Social layer for interoperability) show the interactions and the communications of health information among the patients and the caregivers. The interoperability in this domain comes under social context, thus it is addressed as social interoperability.

2.3 Social Interoperability in primary care

Within a healthcare system, primary care is the principal point of consultation for patients. Primary cares depend on the discretion of diseases, locality and care giving professionals. Primary cares can be provided by the professionals, such as, general practitioners, family physicians, nurses, pharmacists, clinical officers etc. As an example, Capio Vårdcentral, a primary care center in Sweden, provides first level of medication. They are mainly serving the people with vaccination and other primary health support. Nurses, general practitioners and clinical officers are working in this center to provide care. After assessing a patient's condition, primary care centers refer the patient to the secondary or tertiary care providers (i.e. specialized care centers, hospitals).

HL7 (2007) explains that, social aspects in healthcare concerns about different aspects of the society (e.g. political, demographic, peoples' nature, economic, etc.). Not all the aspects play role in social interoperability, especially interoperability in eHealth. So, we have been through some cases and tried to identify the social aspects that affect the eHealth and plays role in its interoperability. We also collect information from the local health care centers to identify and understand existing social aspects that can affect the total process of interoperability.

2.3.1 Actors in primary care

Most of the current developments in eHealth interoperability are about the semantic and technical interoperability and the importance of the social interoperability just remains in words rather than action. A system can be developed semantically and technically interoperable by using common standards and common channels, but finally the developed system used by the users in healthcare (providers, patients, etc.).

Interoperability is not only about making different information systems collaborate among each other, but also about the people who are using those information systems. Interoperability is something that should start right from the patients, healthcare providers and stake holders later to the system. According to Alain et al. (2011), the ontological analysis identifies several active actors in healthcare. Three major groups of actors can be seen according to the characteristics of primary care settings. They are -

A1. Patients: people who are in the center of the care. They are active participants in the care process.

A2. Caregivers: healthcare professionals (physicians, nurses, etc.) who provides the care.

A3. Computerized systems: systems that are used to store, share and exchange health data in electronic format.

These actors are involved in exchanging information not only among each other but also among themselves. The definition of semantic and technical interoperability mostly deal with the "system-system" interaction and social interoperability deals with patients and caregivers interaction among each other as well as their communication with the computerized systems.

2.3.2 Communication inside Primary-care

Communications take part among these different actors in the eHealth based healthcare. According to the actors we can classify these communications inside primary care. They are -

- Human–System Communication: the communication between the caregivers and the used computerized system.
  - o Caregiver–System communication: communication with the systems that are used by the caregivers to store, exchange and share patient information.
  - o Patient–System communication: patients also use computerized systems to see their medication and also manage own follow ups. Sometimes, these systems are used for home care as well.

- System–System Communication: different caregivers use different computerized system to manage and maintain patient information and care planning. These systems should be interoperable to share the health data and express the same information for all the systems.

- Human–Human Communication: where information is exchanged among human beings.
  - o Patient–Patient communication: The information, experience and knowledge sharing among the patients. According to Juzwishin (2009), a patient's illness can have positive effects in results if he is able to discuss. Patients can be connected virtually with the help social interoperability tools to enable this facility.

o Patient–Caregiver communication: The communication between the patients and the caregivers.

o Caregiver–Caregiver communication: The communication among multiple healthcare teams in collaborative care.

The importance of interoperability lies inside these communications. The overall interoperability is achieved through adapting of different interoperability types (social, technical and semantic) among these communications.

All these communications are not exactly separated from one another. The process of care starts and ends up with the humans. So in this way, the end users of all sort of communication are the human. The people in healthcare can use different computerized systems or eHealth services to get the benefit of the technology to fasten the care process. The end users of the whole communication are human beings though other communications (i.e. Human-System, System-System) may lie inside. So, all these types of communications are actually related with one another and there is no concrete boundary among them.

2.3.3 Why social interoperability

Better care can be achieved by better communication in healthcare. eHealth technology is introduced for better communication and management of health data in health care. Interoperability is one of the important factors in communication thus it also plays an important role in eHealth. A lot of developments have been done in the sectors of technical and semantic interoperability. In addition, the researchers identified that social interoperability is also important in healthcare. Achieving technical and semantic interoperability increases the quality of the care, but absence of social interoperability in healthcare systems can lead the care to face some difficulties as well. In Capio Vårdcentral, Ronneby, Sweden several computerized systems are used to store, maintain and communicate health data for providing faster and better care. These computerized systems are able to share health data with the other care professionals. So, technologically and semantically these computerized systems are playing role in the care process. In spite of having these modern technologies, supports are sometimes not enough. Instead of having all these support still sometimes the care professionals are using old and traditional methods. The care professionals use these old methods not for their own good but to avoid the technological difficulties because in care time is an important factor. These technological difficulties are arisen mostly in the "Human-Human" and "Human-System" communication

where human is the common actor. Thus, this communication can be improved by achieving social interoperability inside the healthcare setting. Study is needed to find out the practices regarding social interoperability for eHealth in healthcare. Information systems that can achieve social interoperability along with technical and semantic should overcome the difficulties for the care-professionals for using eHealth services in healthcare.

3 PROBLEM DEFINITION AND GOALS

3.1 Problem statement

Interoperability has been defined by various organizations in context of eHealth. National Health Information Network (NHIN) (HIMSS, 2005), the US organization National Alliance for Health Information Technology (NAHIT, 2005), the European Commission (EC, 2005) and the Tele-Medicine Alliance (TMA, 2005) have focused on sharing health data among computerized systems of different organizations in different places maintaining safety and security. According to the types of eHealth interoperability we described, these factors are coming under concern of technical and semantic interoperability. Technical interoperability defines how the data is shared and transferred in a secured way from one information system to another and semantic interoperability deal with how those information systems can understand the shared health data using the help of common linguistics. Yet, there is also another type of eHealth interoperability that defined as social interoperability. Social interoperability more concerns about human beings who are engaged in using the services provided by eHealth. The definitions show that, social interoperability creates the context and make use of the eHealth services in healthcare. Social interoperability also concerns about the relationships among the actors and actions that are done inside a care setting. According to our study social interoperability has a major role between human-human and human-system communication. So, in a primary care setting that use information systems, social interoperability plays a big role but that has been ignored in the definition of eHealth interoperability. So, social interoperability deals with both human beings and the computerized systems concerning about what is the work, who does it and with whom, and how it is done in usual way. Technical interoperability concerns about the technology to use to develop an information system and the strategies that the systems will communicate among each other. Semantic interoperability is about how the information systems will understand the same meaning from the same set of data. Somehow in most of the definitions of interoperability in health care the importance of the human beings in participation with eHealth services are ignored.

Researchers have identified the importance of social interoperability in eHealth through different studies. Lesh et al. (2007) assessed the importance of both technical and community aspects for achieving eHealth interoperability. The Intelligent Information Systems Review (2008) shows that the human processes involved with the health data communication are important for interoperability as a part of social interoperability in eHealth. Landsbergen and

Wolken (2001) has explained social interoperability as a range of political, organizational, economic, social, and technical aspects that affect eHealth services. Edward and Gary (2008) have identified social interoperability as a time consuming process to achieve as it involves the interest from the individuals and the community, and also agree to incorporate. Ellen et al. (2011) and Alain et al. (2011) have shown different practices where several interoperability issues (e.g. ghost charts, missing patient information, handing over patients' care, etc.) have been occurred instead of having eHealth services. The researchers have pointed to the lack of presence of social interoperability behind those issues and placed an open question about the practices of social interoperability in reality. So, in this study we will investigate the practices regarding social interoperability in eHealth and find out any differences with the definitions, if there exists any.

3.2 Aim

Our aim is to explore the differences between the definitions and practices of interoperability in healthcare having a focus with social interoperability.

Interoperability is one of the recent concepts in modern technology and the participation of people in interoperability is getting more focus these days. In this study, we set out goal to explore the concepts and the practices regarding interoperability with a focus of peoples' involvement.

3.3 Objective

Our objectives in this study are identified as -

- Analyze different definitions of interoperability in healthcare.

- Analyze different definitions of social interoperability in eHealth.

- Investigate social interoperability in practice.

- Identify obstacles in real life situations regarding social interoperability.

- Identify major challenges for the information systems to achieve social interoperability.

3.4 Research Questions

We formulated our research questions as -

RQ 1. What are the differences and similarities among different definitions of interoperability?

RQ 2. How social interoperability is been practiced by the information systems in healthcare?

RQ 3. What are the challenges for information systems to achieve social interoperability in healthcare?

4 RESEARCH METHODOLOGY

4.1 Overview

This research is performed using the sequential research process. According to Dawson (2005-06), sequential process is the process where "series of activities are performed one after another". Sharp et al. (2002), has given seven unique sequential steps to continue the research process. Authors identified the broad area of the study as interoperability of information systems in healthcare. The research area is about the social issues (with a focus to the human-technology communications) in achieving interoperability in eHealth systems. There is a brief explanation is given in the background (section 2.1) about the area of the study and the research area. The research process is classified into three different perspectives based on its field, approach and nature of the study (Dawson, 2005-06). The field of this research study is identified from the areas like healthcare, information systems and social studies. According to many earlier studies case study approach was used by various authors, like, (Ellen et al., 2011), (Alain et al., 2011), and (Payam et al., 2011), to investigate and identify social issues of eHealth interoperability in particular problem. Our study will also use case study method to identify the social factors that affect the eHealth interoperability. The survey or experiment approach will not fit this study as case study helps in investigating a particular problem or situation. The investigation process is performed with the help of interviews, observations etc., whereas the experiment is used to investigate the problem under specific and controlled conditions. The Survey method is used to collect large data and it is performed by identifying the samples, designing questionnaires and conducting interviews.

The exploratory nature of the study made authors to choose case study approach. According to Colin (2002), exploratory studies are useful in finding out "what is happening; to seek new insights; to ask questions and to assess phenomena in new light". According to Dawson 2005-6), these kinds of studies can be performed through literature reviews, open questionnaires and interviews where they help in exploring broad areas and ideas, later they can be narrowed down and focused on the specific research.

4.2 Our approach

In the figure below (Figure 3), we have shown our plan to conduct the study. We have started with the literature about eHealth, interoperability and interoperability in eHealth. From the help of study we identified our research area as interoperable healthcare information system in the context of primary care. We further studied about different types of interoperability and how they are addressed and practiced in healthcare. We gathered different scenarios with a focus to understand practices especially regarding social interoperability. We analyzed the cases and also interviewed some healthcare officials of two primary cares in Sweden. We identified some basic problems related with social interoperability after analyzing the cases.

We started with different definitions of interoperability and social interoperability in search for the differences in their concerns. From this study we got to find out that most of the time the definitions talk about semantic or technical interoperability rather than social interoperability along with them. (RQ1. What are the contrasts and similarities among different definitions of interoperability and social interoperability?).

To find out the answer of our second research question (RQ2. 1. What are the practices of social interoperability for information systems in healthcare?), we took the answer from our first question, and investigated the current practices regarding social interoperability in healthcare. We collected some cases and observed and analyzed them to understand real life scenarios. In addition, we also interviewed healthcare professionals in two different primary care centers in Sweden and added them as cases.
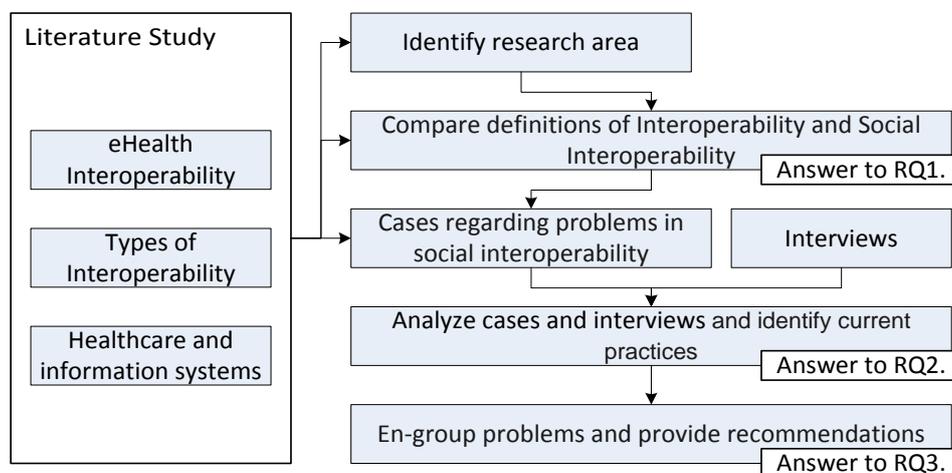
Figure 3: Different phases of the study.

As the answer for last research question (RQ3. What are the problems when information systems do not meet social interoperability in healthcare?), we identified problems from the real life practices realized from the cases and categorized them. In the end we provided our opinions and general recommendation to overcome the problems we identified.

4.3 Literature Review

Literature review by identified key words is used to conduct the literature search. Electronic libraries, conference articles, journals and books are the sources for literature search. The databases, such as, IEEE, ACM, Google Scholar and LIBRIS are also part of the authors' literature search. The total of 70 peer-reviewed abstracts is reviewed to select the suitable articles and 30 were fully read where they are focused on social interoperability, case studies in social interoperability in eHealth. Around 20 eHealth reports from different countries are also reviewed to extract information about the work done on social interoperability (Appendix A). For effective use of time and to learn more about the cases authors' have used interview, observation and document analysis methods. The importance of the social interoperability is investigated with the help of case studies (RQ1). The observations from the case studies help in identifying the impact of social interoperability in eHealth (RQ2).

4.4 Case Study

According to Yin (2003), a case study is used to understand the complexity of social phenomena. The case study gives an opportunity to the researchers to keep hold of the real-life events. We have used case study as research methodology because of the swift changes occurring in the healthcare and IT. Social aspects of the interoperability have become increasingly interesting to the researchers in the recent days where most of the interoperability problems occur between human and systems. Case study gives a chance to explore the issues related to social interoperability in the healthcare practice. The selection of cases is based on the social problems facing by different healthcare centers (Appendix A5). Literature survey is used to identify the articles and papers that have provided several cases about social interoperability problems in practice. Apart from that, we have also conducted observations and interviews at local primary care centers from Ronneby and Karlskrona in Sweden. We have learned more about the practices of doctors and nurses with the computerized health systems. Data collection of the cases is done with the help of literature study, direct observation and interviews. We have observed the healthcare professionals

experience with the computerized systems and tried to understand the difficulties understanding the systems. According to Yin (2003), analysis of the case study is done during the data collection of the case study in the field. Data analysis of the study can be defined by following the three steps: "data reduction, data display, and conclusions drawing and verification" (Miles & Huberman, 1994). Data reduction is a process of simplifying the collected data during interviews or observations. From the cases we have tried to simplify the collected data about the social interoperability practices from the primary care centers. After the simplification of the collected data we have displayed the information about the practices and problems that they are currently facing at the primary care centers. The displayed data is later sent to the doctors and nurses to verify the conclusion of the cases.

4.5 Interviews

Unstructured interviews are chosen for extractions of rich data instead of structured interviews where there is no predefined agenda. The exploratory nature of the study suits unstructured interview because it gives chance to dig deep into the area that gives more information. The selection of interviewees is based on requirements of the case study; In order to find out the practices at primary care centers we have interviewed a doctor and a nurse at each primary care center. As the primary care centers have limited staffs, we are not given much choice to decide the number of doctors and nurses. Still we were given a chance to meet the chief nurses and responsible doctors at the concerned primary centers (Appendix A6). The summery of the interviews are presented in the Appendix B. We have used recorder and also taken notes to record the information and interview with the interviewees' permission. According to the observations of Blaxter et al. (2006), "case study involves the researcher in watching, recording and analyzing events of interest". Authors' observation is recorded in form of notes. Most of the observations is about how the nurses and the doctors are using the health information systems. Analysis of data from all the case studies and the interviews and observations will identify the major social factors that are to be dealt with interoperability in eHealth (RQ3).

5 SOCIAL INTEROPERABILITY

Interoperability is defined by various interoperability workgroups, organizations, and individual researchers. These groups are categorized into European and Non-European countries, whereas the individuals are from different parts of the world. According to (ISO, 2002), interoperability is the ability where two or more systems (here system represents computers, communication devices and software) interact and exchange information with one another. The European Interoperability Framework (2004), defined interoperability as a process of exchanging data among the Information and Communication Technology (ICT) tools that enables sharing of knowledge and information. The European Committee for Standardization (2005) defines interoperability as a state that exists between two applications where they can accept data from each other without an extra operator (human beings). The Non-European nations also have similar definition as the European ones. Healthcare Information and Management Systems Society (HIMSS, 2005) has said, interoperability is about how two or more systems exchange, and later use the health information among them. According to IEEE (2000), exchange of information among two or more systems is called interoperability. According to the individuals, interoperability is seen as the process that leads to the exchange of data internally or externally among the various systems and also reuse of that information. If we closely observe, almost every definition says interoperability is about exchanging data among the different systems, and that exchanged information should be useful. The main focus of the interoperability organizations or individuals is concerned over the systems and their communication whereas the people those who use the systems are being ignored.

5.1 Social interoperability in theories

Social interoperability is the ability that provides a support to human work flow in understanding the technical data exchange and semantic consistency. Landsbergen and Wolken (2001) defines social interoperability as an understanding to economic, political, technical and organizational issues involved with information sharing. The Intelligent Information Systems Review (2008) defines social interoperability as human process involved in exchange of information and understanding the motivation behind the data interchange. Lesh et al., (2007) describes social interoperability as an environment for addressing the technical and community aspects to achieve interoperability. According to the

definition we can see that social interoperability is a property of the communication between the human beings and the information systems, and vice versa. Still, the definitions state that the interoperability is all about the process to exchange of data among different information systems, which means social interoperability is ignored to mention in most of the definitions. All the three types of interoperability are important to make an information system interoperable as the ultimate users of those systems at any end of the communication are the human beings.

Based on social interoperability definitions, we can see that it is a part of the communication structure, whereas interoperability definitions are more concerned about semantic and technical types of interoperability. The similarities among most of the definitions are that all of them talk more about information exchange. The major difference is not all the definitions consider human or social communication factors while defining interoperability. The interoperability of any ICT can be achieved when the three types are taken into account. It is very true that human beings are the end users of the health information systems. If the communication of the systems is highly achieved through semantic and technical then it is partially interoperable. So there is a necessity for serious consideration of human into the interoperability framework and definition.

5.2 Case Studies

We have collected and analyzed different cases to understand the practices of interoperability in communications of health information systems, focusing mainly on social interoperability. The cases are chosen carefully so that they can provide us some real life scenarios. We gone through literatures to select appropriate scenarios and also conducted interviews at two different primary care settings to realize their focus on social interoperability. The cases are from different countries (i.e. Canada, Denmark and Sweden) to realize more about the current practices in some major countries all around the world.

5.2.1 Case 1 (Shadow chart)

Ellen et al. (2011) dealt with this case with a vision to understand the practices regarding "paper based charts" in healthcare. In the study they have observed the communication of *shadow chart*. *Shadow chart* is a chart that is used to write down the patient health data and diagnosis data and it is being circulated in the care center. Each patient has one *shadow chart*

and the same chart is used by all the departments (physicians, nurses, labs etc.). Sometimes clinic has scheduled a date and time for a patient's visit and the patient has showed up in another day. In that situation the authors have found that the ghost charts were absent (as it is hard to trace), and the clinic has faced difficulties accessing patient's record. This difficulty occurred due to the health record department policy where they said "no same day chart pull (during an unscheduled visit of the patient)" except for the emergency department. This departmental policy says that the health chart cannot be accessed and modified simultaneously by multiple departments except the emergency department. The authors observed that in one of the clinics it was common for a patient to travel to another city for some additional laboratory check-ups in one afternoon and visit a specialist on the next morning. They found two results regarding these practices; sometimes the lab results are not going to the clinics prior to the patients, and hence, the lab result is moving slower than the patient. Normally the result should move prior to the patient. The authors also experienced that the test results, specialist reports and some other documents are not updated immediately, and that is why the ghost charts are created to keep those together.

According to American Health Information Management (AHIMA, 2011), several sources suggest that *shadow chart* exists because of the unwieldiness nature and also it cannot be in two places at a time. In another setting the authors observed that the nurses who attend unscheduled telephone queries are maintaining ghost charts as some of the information they require are not considered as a part of medical record.

5.2.1.1 Observation:

The case shows the synchronization issues in communication of health information with records. The issues affect the collaborative care where the care takes place in different settings among different caregivers. The case is dealing with the nature and effect of duplicated paper-based health records, specially said as *shadow charts*. The authors have identified the *shadow charts* as a problematic phenomenon, as it has less tractability, though sometimes these charts are said to be created to provide faster care against synchronous procedure. Amatayakul (2003), Broder (2004) and Kofax Image Products (2011) indicated that sometimes customized local charts are made up when the staff face difficulties in accessing necessary information in the formal chart. According to the observation of this case, paper chats are also produced when it becomes hard to find the information of interest in a multivolume chart. In this case, it is also been observed that the ghost chats were

maintained by the ambulatory care units rather than by the individual care providers. In addition, these charts were considered as the input for their information system.

5.2.2 Case 2 (Ski-hill injury)

This case is about Ski-hill injury. A skier has got injured and the place was one and half mile away from the city hospital. Shortly a ski patrol has appeared. The patrol team has assessed the condition of the skier and sled him to the city and handed him over to an ambulance. The ambulance then has taken him to the local Urgent Care Center. A nurse has attended and an emergency medicine physician has assessed the skier later. The condition of the skier has got worse and then the staff has reassessed him. They have decided to transfer the skier to the hospital in urban area where more healthcare facilities is available. So, the care of the skier has been handed over to an ambulance service during the transport. Again, an emergency medicine physician has accepted and attended the skier at the acute care. The physician has called for an orthopedic specialist for consultation. Later, the condition of the skier has got worse and an on-called surgeon has performed emergency surgery on him. At last, the skier has received acute care, but by that time, information has been communicated by six different jurisdictions and seven times among provider to provider.

The authors (Ellen et al., 2011) have observed this case in order to find out the issues and thus improve the pre-hospital care for the patients. According to their observation, it is really difficult to take field notes during an emergency situation, also any other kind of handhelds are proved not so useful.

5.2.2.1 Observation:

According to JCAHO (2007), handover in care deals with passing of patient-specific information among the caregivers, or team of caregivers, and also transfer of information among healthcare organizations. Pothier et al. (2005) says, "the conservation of patient data is vital to ensure good continuity of care and safe practice" and "errors and omissions made during the handover process may have dangerous consequences". Ye et al. (2007) have recommended the improvements in handovers that include increased information use and the development guidelines to standardize development processes.

In the case we can see that the first assessment and care of the skier was provided by the ski-patrol team. For assessment, the patrollers note the patient information with the help of a pencil and a waterproof notebook, or a tape, or with pre-printed forms. The authors (Ye et al., 2007) have never observed the forms were filled completely at the field, as the primary concerns of the patrol was to provide fast transfer of the injured person rather than filling up. The authors (Ye et al., 2007) have also mentioned that, many first responders think that health data is used in medical purpose and also the responders do not have in-depth knowledge about how data can be used in other ways (e.g. research in healthcare). It was difficult to identify for the researchers (Ellen et al., 2011) whether it is better to transfer the injured skier as soon as possible, or to perform formal paper works prior to transport. In this case several jurisdictions existed in the pre-hospital care are identified. Some instances show that the front line responders (the ski-patrol) feels that the time used for filling up patients' forms took away time from their first priority, which is the direct care. That is why the patrollers always have to maintain some sort of trade-offs between the documentation and the transfer process of the injured person. These jurisdictions ask for their own data collection in place. It is difficult to diagnose a patient because of the way of collecting data in each jurisdiction. After analyzing on-hill data collection forms the authors (Ellen et al., 2011) have suggested that the practice for documentation can be improved. Sometimes the host of organizations also influences the data collection process at the point of injury. Here the environmental factors also influence a lot in the practice of data collection process.

5.2.3 Case 3 (Collaborative care)

This case deals about the journey of cancer patient in palliative care. In Family Health Team (FHT), a patient is followed by his primary care physician. The physician used the consulting service of the Palliative Pain and Symptom Management Consultation Service (PPSMCS). The condition of the patient was assessed and decided to be suitable for home care. So, the patient was referred to the Community Care Access Center (CCAC), and he was assigned a case manager. The case manager coordinated different cares from different providers (e.g. homecare nurse, social worker, psychologist, etc.). For some symptomatic treatment, the patient often needed to visit his oncologist in the Cancer Center. In need of acute care, the patient also had to visit the hospital. The patient's condition become worse in some weeks and it becomes very difficult for the home care to maintain. Still in a lot of cases, people want to spend the last days of their lives at their homes. The patient's condition get worse during the last few days and his Palliative Performance Scale (PPS) level came

down to 30%. As the condition kept on going worse the "End-of-Life" care process started for him.

5.2.3.1 Observation:

In the case, the palliative care depended on multi-disciplinary team members from FHT, PPSMCS and CCAC. Information is exchanged for collaboration of different team members as well as among different computerized systems.

The physicians at the primary care FHT are the front line caregivers. Here they are playing major roles by consulting with PPSMCS, planning for the care with CCAC and at last delivering it to the patient. The analyses of this case show that the teams need some standard communication tools for on-demand audio video conferencing, sharing health record electronically and accessing data anytime anywhere. Patients who are staying at home also need to participate in such sort of communication tools as well as the tools for assessing own condition. The authors (Kuziemsky & Varpio, 2011) also suggest some technological support in palliative care, such as, electronic systems for the patient and the caregivers, dictation and alert management systems for the physicians, voice enabled technologies and groupware support for conferencing. The systems that are developed for the patients should also consider elderly people and people with special abilities.

Two identified processes by the authors (Kuziemsky & Varpio, 2011) have implications in the social interoperability in healthcare. These are –
- Collaborative care planning
- Patient self-management

A good plan for collaboration can ensure patients palliative care. On the other hand, patient at home should also be aware of assessing his own condition to identify next action of his care. This case also emphasizes that online conferencing tools, electronic health records, and voice enable technologies are also to be useful in collaborative care.

According to Kuziemsky and Varpio (2011), the nature of palliative care, the communication and collaboration among the providers are challenging as they happen in different times. Awareness regarding interoperability of health information, other people, communication channel and data is needed to support collaboration.

5.2.4 Case 4 (Leg-ulcer-would healing center)

Information is gathered from the primary care center for leg-ulcer wound healing at Karlskrona in Blekinge in order to know the practices in eHealth services and to investigate social interoperability issues. The institution is treating the people with their leg ulcer wound healing services. The nurses and the physician are using paper-based forms for registering patient data and taking follow-up information of the patient. The healthcare responsible (nurses and physicians) are also using two systems, one for recording patients' information and the other for communicating with the main hospital. The first paper based form they are using is for registration of the patient with the basic information. Then they are inserting the information to the National Quality Register (NQR) and also to the Patient Management System (PMS). The second form is used for "follow-up" of the patient. They have to update the PMS with the information from the form. The third form is used for discharge summary of the patient and information is updated into two systems, the NQR and also the PMS. The PMS and the NQR are not dealing with the same set of information. Mostly nurses are responsible for collecting patient information and from the patient's home as well. Sometimes the nurses have to visit more than once to fill up patient's information or to correct the information. Every time a patient is visiting different health center a nurse is joined along with the patient to handover the care. Now, the care center officials are planning for another information system that can be used for documenting patient records during field visits. That information system will also be able to communicate with all the other used information system to reduce the redundant works done by the officials.

5.2.4.1 Observation:

Paper based forms are used to take field notes from home visits. Later the information is inserted into the electronic systems (local and the hospital based). This contains large risk of duplication of information also multiple timeslots to handle same set of information of a patient. The health officials identified this issue and that is why they are planning for another electronic system that will contain the electronic version of the paper based forms. According to their vision, the system will check for all necessary data and also communicate with the local register and the patient management system. They feel that using one system capable of communicating with the other systems can reduce their formal desk work and they can provide more time for ensuring care for the patients.

5.2.5 Case 5 (Capio vårdcentral)

The nurses and the general practitioners are using computerized systems to maintain patient information in the Capio vårdcentral in Ronneby. Four or more computerized systems are used in the center, SysteamCross, SVEA, Edos and Wiseweb. SysteamCross is a big monolithic system used in for maintaining patient records for the hospital, SVEA is an internal system used only inside of the clinic to maintain administrative tasks and journals of the patients, Edos is used to help in medication for elderly people and it is used by the Apoteket (medicine store) and Wiseweb system is used for receiving x-ray reports of the patients. Very few paper based forms are used for noting patient information and internal purpose. As an example, when a doctor goes for a home visit for a patient, s/he takes notes in a paper and later inserts all information into the system as soon as he comes back to his office. Sometimes, paper based reports arrive to the clinic from different providers containing different information (e.g. lab report for bacterial infection of a sample). After that, the reports are received and then those are attached to the patient journal. All the papers containing classified patient information are kept inside a secured box and later they are burnt.

In case of emergency, when a person gets suddenly ill in the city at first the ambulance containing paramedics attends the patient and assess the condition. Then they decide to take the patient either to the primary clinic or the hospital. They maintain a paper based form to note the medication support they are providing to the patient and then they give the paper to the clinic if they are bringing the patient to it. Then the doctors give the patient necessary medication, and scan and attach the paper into the patients' medical journal. In case of patient handover, the clinic is supplying the patient with necessary documents that the patient has to carry to the hospital. In other cases of referrals the letters are sent to the hospital regarding the patient and the hospital then contact information about the patient for the medical visit.

SysteamCross is maintaining the patient information in Blekinge. So, whenever a patient comes from another county or country then the hospitals and the clinics have to ask for their health records to the responsible hospital in the patient's home county or country. If the patient is in serious condition, they prioritize the care and go for the remedy depending on what patient says about his own history with diseases. Caregivers are also depending on their own saying and deducting the information based on their experiences when the patients are immigrants with no health record maintained from the beginning. Physicians are depending

on the verbal information about the patient's medication because a lot of times patients do not follow their medication plan exactly.

According to both the nurse and the practitioner, usage of multiple systems is sometimes making the work complex. Both of them agreed at the point that, SysteamCross, used in the hospitals, is not much tuned up for the primary care, whereas primary cares rather need comparatively simpler systems. SysteamCross also has a lot of very useful features that are also helping them in their daily works. Still, both of them said that, around 20% of productivity is lost in a form of time, behind the system. This is making the practitioners to use papers rather than using the system to avoid unnecessary complexity.

5.2.5.1 Observation:

The center is used as the primary medical support for the patients in the commune. Very few paper based forms are been used; as the internal system is quite capable to handle with the processes inside the center. Other paper based information is used personally by the practitioner for deducting necessary part to provide medication to the patients. Yet a strange pattern was found. Though the big monolithic patient management system (designed focusing on the hospital) is capable of fulfilling the needs for electronic communication yet it is found complex and troublesome sometimes for the health officials to use. This complexity is driving the officials to use the traditional way of communication and deduction. As the health officials are always concerned about the delivery of care they sometimes have to combine the system and the traditional way to deliver care easier and faster.

6 RESULT AND ANALYSIS

Definitions hold a lot of importance as the further researches are conducted based on those definitions. As interoperability is an emerging concept, so we have chosen the definitions from the year 2000 and later to understand the goals and the important factors mentioned in those. Several health organizations have defined the interoperability in their own way. Below the collected definitions and their concerns about different types of interoperability are presented.

Organization	Interoperability definitions	Organization overview	Interoperability		
			Tech.	Sem.	Soc.
ISO/IEC (2002:12)	Interoperability refers to the ability of two or more systems (computers, communication devices, networks, software and other information technology components) to interact with one another and exchange information according to a prescribed method in order to achieve predictable results	ISO is the international standards organization and IEC is the International Electrotechnical Commission, the standards organization for all areas of electrotechnology.	X		
European Interoperabilit y Framework (EIF) (2004:5) IDABC	Interoperability means the ability of information and communication technology (ICT) systems and of the business processes they support to exchange data and to enable the sharing of information and knowledge.	The EIF deals with interoperability in the area of eGovernment. It is part of IDABC (Interoperable Delivery of European eGovernment Services to public Administrations, Businesses and Citizens), a European initiative.	X	X	X

CEN/ISSS (2005)	Interoperability is a state which exists between two application entities when, with regard to a specific task, one application entity can accept data from the other and perform that task in an appropriate and satisfactory manner without the need for extra operator intervention. [a clear distinction is made to the terms interface and integration – ed. note]	CEN is the European Committee for Standardization. ISSS is the Information Society Standardization System. Together CEN/ISSS provide standardization services and products.	X	X	
HIMSS (2005)	In the most fundamental sense, interoperability is the ability of two or more systems or their components to exchange information and to use the information that has been exchanged.	HIMSS (Healthcare Information and Management Systems Society) is a US not-for-profit organization dedicated to promoting a better understanding of health care information and management systems.	X	X	
NAHIT (2005)	Interoperability is the ability of different information technology systems, software applications and networks to communicate, to exchange data accurately, effectively and consistently, and to use the information that has been exchanged.	National Alliance for Health Information Technology, a US organization	X	X	
ETSI (2005:1)	Briefly stated interoperability is the linking of systems, networks or services so that they can work together successfully.	ETSI is the European Telecommunications Standards Institute.	X		

Federal Health Architecture (FHA) Interoperability Working Group	For the purpose of this working group interoperability will primarily correspond to the types of architectural elements discussed in the Federal Enterprise Architecture (FEA) Technical Model (TRM) v.1.1 under the Service Interface and Integration (SII) heading, with additions or omissions as deemed necessary by the Working group	Within the US department of health the FHA is one of five Lines of Business (LoB) supporting goal to expand electronic government. The FHA is tasked with creating a consistent federal framework to facilitate communication and collaboration among all health care entities		X	X
TMA (2004:2-1.)	Interoperability in general can be defined as "the state of having sufficient power, skills or resources to mutually or between two entities perform a function or produce an appropriate effect"	The TM Alliance consortium is a partnership between ESA, the WHO (Barcelona office), and the ITU. The successor project to TMA is TMA bridge	X	X	X
European Parliament Source: FIII (2005:2)	Interoperability means the ability of a computer program to communicate and exchange information with other computer programs and mutually to use the information which has been exchanged, including the ability to use, convert or exchange file formats, protocols, schemas, interface information or conventions, so as to permit such a computer program to work with other computer programs and with users in all the ways in which they are intended to interact.	The European Parliament used this definition in the controversial discussion on software patents (June 20, 2005).	X	X	

ATIS Source: qtd .in TMA bridge (2005)	The ability of systems, units or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together.	The Alliance for Telecommunications Industry Solutions (ATIS) is a U.S.-based organization that is committed to rapidly developing and promoting technical and operations standards for the communications and related information technologies industry worldwide using a pragmatic, flexible and open approach.	X		X
IEEE (2000) Qtd, in Morris et.al (2004: 3)	The ability of two or more systems or elements to exchange information and to use the information that has been exchanged. The capability for units of equipment to work together to do useful functions. the capability, promoted but not guaranteed by joint conformance with a given set of standards, that enables heterogeneous equipment, generally built by various vendors, to work together in a network environment. The ability of two or more systems or components to exchange information in a heterogeneous network and use that information.	The IEEE is a US non-profit, technical professional association. The full name is the Institute of Electrical and Electronics Engineers, Inc.	X	X	

Table 1: Definitions of Interoperability (by organizations).

Like the organizations, individual researchers also defined interoperability in different ways.

Researcher(s)	Definition	Interoperability		
		Tech.	Sem.	Soc.
(Kosanke, 2005, p. 4)	Ability of two or more devices to work together in one or more applications.	X		
(Blanc, 2005, p. 2)	Interoperability is defined as the ability of two or more systems or components to exchange information and to use the information that has been exchanged.	X	X	
(Morris, et al., 2004, p. 4)	The ability of a set of communicating entities to (1) exchange specified state data, and (2) operate on that state data according to specified, agreed-upon, operational semantics.	X	X	
(Kasunic & Anderson, 2004, p. 32)	The ability of one services' system to receive and process intelligible information of mutual interest transmitted by another service's system.	X	X	
(Carney, 2004, Slide #3)	Ability to achieve "cooperation" is generally termed "interoperability".	X		
(Berre, et al., 2004, p. 13)	The ability to integrate data, functionality and processes with respect to their semantics.	X	X	X
(Levine, 2003, p. 6)	Operational Interoperability refers to the activities related to the operation of a system in the context of other systems. These activities include: doctrine governing the way the system is used, conventions for how the user interprets information derived from interoperating systems (i.e., the semantics of interoperation), and strategies for training personnel in the use of interoperating systems.	X	X	X
(Clark 2001, p. 2), (Fewell, 2003, p. 2)	The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together.	X		

Miller (2000:2)	To be interoperable one should be actively engaged in the ongoing process of ensuring that the systems, procedures and culture of an organization are managed in such a way as to maximize opportunities for exchange and reuse of information whether internally or externally.	X	X	X

Table 2: Definitions of Interoperability (by researchers).

According to the definitions and their focused types, we find out the frequencies of mentioned types in the definitions of interoperability. The analyzed frequencies are shown in the Table 4.

	Organizations	Individuals	Total
Only Technical	2	4	6
Only Semantic	0	0	0
Only Social	0	0	0
Tech + Sem	5	3	8
Sem + Soc	1	0	1
Tech + Soc	1	0	1
Tech + Sem + Soc	2	3	5

Overall mentioned			
Technical	10 = 2+5+1+2	10 = 4+3+3	20
Semantic	8 = 5+1+2	6 = 3+3	14
Social	4 = 1+1+2	3 = 3	7

Table 3: Frequencies of the types mentioned in the definitions.

After analyzing twenty one (21) different definitions, almost in every definition (in 20 definitions), technical interoperability has been talked about (showed in Table 3). Semantic interoperability is considered in the second place by the definitions. The least mentioned type of interoperability is the social by both the organizations and the researchers.

From the different definitions we have sorted out several similarities and differences among them to find out the answer for first research question (RQ1.).

Similarities	Differences
More focus on achieving technical and semantic interoperability. Technical interoperability is the primary concern, then semantic. Technical and semantic interoperability are presented as a concern of information system while environmental and human factors are under social.	Most of the definitions that concerns about social interoperability are stated more recent than the others.

Table 4: Similarities and differences observed in the definitions of interoperability.

Here, in Table 4, we see that most of the definitions have some similarities. Mostly the importance has been focused on achieving technical and semantic interoperability. Only a few of the definitions mention about organizational and/or human processes, thus the social interoperability, though it is already found that social interoperability is important as the human factors are considered in that.

So, here we can realize that the definitions were more focused on pointing at the technical and semantic rather than the social interoperability. However, social interoperability is also important and mentioned more into the recent definitions; so, we continued looking into some cases to identify the real life practices of social interoperability.

Five cases have been investigated in a view to identify the practices which is also the answer for our second research question (RQ2.). The cases were selected in such a way that they focus on the consequences where social interoperability is not achieved. The reason behind this way of selection is to realize what sort of troubles the health care may get through if the social interoperability goals are not met and/or ignored. From the observed cases and the collected studies we have found the practices mentioned in cases and some obstacles for delivering care properly there.

Case	Observed practices
1	Several information systems are used to store and manage health data of the patients. The information systems are able to share health data among each other. Health officials use paper-based forms to avoid complications in data retrieval.

2	Multiple information systems are used to store and manage health data.
	Paper based forms are used in the field by ski patrol team and later they input the data inside the information system.
	Several jurisdictions are engaged in the process of patient handing over.
	Synchronization in health data sharing among the jurisdictions speeds up the handing over.
3	Number of information systems is used to store and manage health data.
	The information systems are able to share data among themselves.
	Real time collaboration support is important for making care decisions for the patients under palliative care also the patients who are under care of multiple providers/units.
4	Several information systems are used.
	Paper based forms are used to collect initial and follow-up information. Later the data is inserted into the information system.
	Some of the information systems are capable of sharing health data among themselves.
	Officials feel that operational complexity of one particular information system increases workload.
	Sometimes same set of operations are performed on same set of data. It introduces redundancy in tasks in information systems and more time consumption.
5	Multiple health information systems are used.
	Used information systems are able to communicate data among themselves.
	Health officials feel one of the information system is not suitable for primary care and this is causing excess time consumption.
	Sometimes officials are using papers to avoid the data retrieval and communication complications.

Table 5: Observed practices from the cases.

From both the directly observed and collected cases we have analyzed and summarized the problems that led health information system to face obstacles. We have analyzed focusing to the concept of social interoperability. That is why we noted only those obstacles which are related to this study. We used cross case analysis to en-group the problems later into challenges.

Case	Identified problems
1	Physicians faced difficulties to retrieve health data.
	Not enough support to collect data.
	Multiple numbers of health information systems to operate.
	Use of paper based forms though information systems are in use.
	Administrative complexity

2	Difficulties to collect data in the field
	Inadequate data retrieval in emergency
	Confusing emergency procedure
	Incompatible health data during handing over
3	Support for combined decision for the patient was not enough.
	Not enough support to collaborate in real time decision making.
4	Paper based data collection and follow-up forms are still in use instead of having computerized systems.
	Multiple health information systems are used for doing same operations on a same set of date.
5	Non suitable information system made the official uncomfortable and switched to paper based operations.
	Data retrieval and display complications are visible in a particular information system in use.

Table 6: Identified problems in the cases.

According to the features of social interoperability, suggested by HL7, we have grouped the observed problems into several challenges. The challenges are shown in the table below.

Case	Data collection	Data retrieval/display	Real-time collaboration	Emergency Procedure	Handover care	Complication with IS (others)
1	X	X				X (Difficult to choose and handle)
2	X	X		X	X	
3	X		X			
4	X	X				X (No. of IS)
5		X				X (Complex operation)

Table 7: Cases and challanges.

Among the challenges, we can easily see that mostly all the cases faces the issues with data collection and data retrieval/display. So, two of the major challenges for any health information systems can be said as data collection and display mechanism. Along with these, there are other challenges, such as, real-time collaboration support, emergency procedure and

handing over procedures that play important roles directly and indirectly for the health information systems to achieve social interoperability.

7 DISCUSSION

Social interoperability improves the communication where human process is involved. Information systems are been designed and developed to serve the users to save time, save enormous data, communication, and also in a lot more different ways. Interoperability is an important property of the communications of the information systems where not only the other information systems are involved, but also the users play a vital role by making use of it in their actual work. For this reason, the definition of interoperability holds a great significance as the information systems try to adopt interoperability according to the definitions they follow. Nevertheless, in the result we have analyzed, we realize that social interoperability is address less than the other two types in most of the definitions. One possible reason may be that, at the beginning the researchers were focused to connect multiple information systems and share data among them that is coming under the concern of technical interoperability. Gradually researchers started to focus with the standard dictionary so that all the information systems can share the data in such a way that all other information systems can also understand it and that is how the semantic interoperability is achieved. At last it came the concern of the users in the actual work settings there these information systems are been used. Here the relationship among the users and the information systems play a vital role, because, an information system may have the capability to store and share the health data efficiently, but if the users are not comfortable with it, or it fails to prove itself in the actual work setting, then the information system fails to achieve social interoperability though it might have achieved technical and semantic ones. The concepts of the importance of the human factors are comparatively newer than the others in interoperability. So, there is a big chance that the definitions have not yet been improved so much to address the social interoperability.

The cases show different problems related with the healthcare information systems that influence the care delivery process. One of the facts observed in the Case 1 (shadow chart) is the redundancy of the information using paper based shadow charts. Healthcare information systems are been introduced to manage the health data and reduce redundant paper works. However, due to the complex data retrieval procedure the physicians had to use the paper based forms to make the care faster as it is seen in the case of *shadow charts* (Case 1). Shadow charts also returns in the presence of complex interfaces of the information system. Ash et al. (2004), a medical officer and a researcher, identify in their research that computer interfaces can create confusions if the interface does not match with the use context (i.e.

different care professionals need different formation of data and displaying all data regardless the necessity can be annoying). He also identifies that, switching between different screens can be a reason to loose overview of the task.

In the Case 5 (Capio vårdcentral) and Case 4 (Leg-ulcer wound healing), we observed that the health officials are using more than one healthcare information systems at their workplace. These systems are serving specific purposes. Yet, some of the systems are too complex to handle that the officials commented that they are spending more than usual time to operate, and it takes away valuable time for care from them. Using different information systems for the same set of data can be another reason for loosing overview as well. In the observation of Case 5 (Leg-ulcer wound healing), we found the officials are using multiple information systems for the same set of health data (for registering and following up the patients). Incomplete data can also lead to poor care delivery, such as, delayed diagnosis, delayed medication, faulty assessments, redundant data collection, etc. The medium of data collection sometimes are responsible for data management overload.

In the Case 2 (Ski-hill injury), the hill patrol teams use special paper and pen to fill up the forms when they attend the victims in the ski accidents. According to the urgency of the situation and the length of the forms, often they skip the initial paperwork and transfer the patient to a nearby care center. The incomplete initial assessment later leads the diagnosis process a difficult start. In the case of Ski-hill Injury, the complicacy of the entry form finally lead to a troublesome and delayed diagnosis and unintentional incomplete data is one of the reasons along with others. This case shows also some other reasons related with the legislation and management of the human related medical process that interrupted the care process. Proper emergency protocols were clearly not found active in the observation. So, the injured skier was assessed several times by several medical officials. These initial assessments were not reserved in a good manner, so that, it took long time before the skier finally got the accurate diagnosis and treatment. For the skier, handing over care among the different care providers was also identified as a problem, (Ellen et al., 2011). Not only the patient, but also all the assessments and other diagnosis information are shared in the process of handing over care. A major challenge in handing over care is sharing the exact data that is necessary. Different care providers make use of different sets of health data of a patient. Lot of unnecessary data can waste time for the professionals to reason whereas lack of necessary data can lead to faulty or slow diagnosis while handing over. The skier was been handed over among six different jurisdictions before he got the care. Faster handing over provides faster care delivery. Also, proper collaboration is needed in both handing over and general care.

In the case of the cancer patient, the researchers (Kuziemsky & Varpio, 2011) identified that collaboration is one of the key factors in decision making of palliative where the patient is under observation of different group of caregivers. Often the care is said to be as patient centric, so all the caregivers have to take collaborative decision for diagnosis or further schedule of treatment.

All the cases represent the real life practices regarding the communication of human beings and health information systems. Technology is been used in healthcare to support the diagnosis, medication, health data transfer, overall the whole care process faster and better in quality. Furthermore, health information systems are making this vision come true. It increases work overload if people use traditional workaround along with the information technology because they have to use the same operation with the same set of data that are redundant. As an example, for some reason, one health official decides to work with shadow charts though there is an information system in use. The healthcare personnel may speed up the medication process for the time being, that is actually necessary for the welfare of the patient, but in the long run, the official has to work later with the information system for that set of data. So, information systems are used to speed up the process but strategic gaps can make them to slow down the process as well. In all the cases, information systems were used to manage health data but still certain situation arouse where these systems were not sufficient enough to support the care process.

From the point of view of communication and interoperability, these information systems may be very efficient to transfer and manage the health data, but also the communication between human and these information systems are playing a major role to define the performance of these information systems. Semantic and technical interoperability ensure data communication among different computerized systems, where social interoperability focuses more into the communication between human and those information systems. An information system may be developed using various techniques to support all sort of communications and data management, but still it will not be useful unless it will be easy to understand by the personnel who are working with those data. So, not only the technical strategies and tools, but also the human begins (the users, how they are interacting, etc.) are important while designing and implementing a health information system. Improved communication among the information systems and the human beings (healthcare personnel and the other users), improve the quality of care and interoperability improves the communication. The problems discussed in the cases occurred in the phase of human and information systems communication that are coming under the concern of social interoperability. Like the mostly used and usual definitions of interoperability, social

interoperability is not been focused sufficient while developing information systems in healthcare. However, this practice of ignoring the importance of social interoperability leads the whole healthcare to face some unwanted troubles as discussed in the cases.

According to the discussion we identified and categorized several challenges, and they are –

a. Data collection and entry – Data entry tools and techniques play important roles in healthcare. Easy to understand interface, and other necessary basic design tools and techniques can be used according to the situation and environment for data collection, retrieval and manipulation. Complete health data is required for any care diagnosis for better performance. Incomplete data can lead to troublesome situations in diagnosis. Care officials should be provided with more technological support and variety range of tools for their work with the data. Handhelds can also be used where the big computing devices cannot be used for data manipulation. Audio/video recorders can also be used to collect data in the field.

b. Data retrieval and display – It is very important to have straightforward time-saving data retrieval procedure to ensure faster care. Structuring data to display is tricky. In the research of (Ash et al., 2004), he has noted that some physicians has reported loss of overview while going back and forth some screens to understand some patients' conditions. In the case of shadow charts (Case 1), one of the identified reasons was complex data retrieval for the physicians (Ellen et al., 2011). Amatyakul (2003) said about the unexpected gap between shadow charts and the electronic medical records that sometimes lead to confusions in decision making.

c. Emergency procedure – In case of emergency the care professionals have to take urgent decisions to provide care to the patients. Procedural complications can delay and harm directly to the care process. Emergency protocols should be easy and flexible enough so that procedural complexity can be skipped at the time of urgency and the care can be provided in a priority to the patient.

d. Real-time collaboration for different group of care providers – In many situations, care is distributed among several units of caregivers. These units need to collaborate to ensure the care of a patient. The decision making process is often complex as many groups of caregivers are involved in the process. So, for ensuring better care, proper communication and coordination is needed among the caregivers. Information systems can apply different communication approach, like same/different time same/different

place, according to the urge of the situation. Comprehensive architecture in interoperability is needed for supporting collaborative care (Alain, 2011). In a technical level, a lot of group-wares are present to support real time collaboration and health information systems also can integrate this technique to achieve real-time collaboration.

e. Handing over care – Transfer of care or handing over is a common process in care. Handing over care involves transfer of the patient and all the necessary information. Lack of provided information during handing over delays the diagnosis process and more time consumption in handover delays the care delivery. Joint Commission on Accreditation of Healthcare Organizations (JCAHO, 2003), has identified standardize handover as a National Safety Goal in Canada. They stated that communication breakdown is responsible for around 70% of all sentinel events. Accreditation Canada (2008), identified "the effectiveness and coordination of communication among care/ service providers and with the recipients of care/service across the continuum" as a patients safety goal, (Ellen et al., 2011).

User feedback is an important matter in case of improving any system. Sometimes the feedbacks of the users of the information systems are overlooked. Mostly in all the cases we discussed earlier, the problems exist for such a long time that the care officials are applying alternative approaches to provide faster care by overcoming unnecessary overloads. These overloads are either from the used information system or from the people's practice. Still, these situations are not taken care of properly in a good manner. In Case 4 and 5 we found that the care officials agree upon the complexity of an information system as the system was not designed with the concern of primary care. In spite of their suggestion, initiatives were not taken to reduce the hassles.

There is a big difference among the theoretical importance and practical implementation of social interoperability. The interoperability is defined as to exchange data among two different systems or components that directly points that interoperability is purely a combination of semantic and technical aspects of the application. However, the social interoperability is a property of the communication between the systems and the human beings, and that is also a part of communication structure. The actual interoperability should be the complete means of communication by exchanging data among the information systems and human beings, so the environment should include social, semantic and technical aspects of any system. Theoretically an information system can be maximum interoperable when the social factors are also taken care of along with semantic and technical, because those developed systems are used by the human users in the care setting.

These issues can be dealt with different approaches regarding both information system and human practices. Some general precautions and practices can become useful to deal with them, such as –

- Information systems should be designed concerning both the limitations and availability of the technologies. Interfaces should be in context, easy to understand and usable. That means the interfaces should be different for different group of care officials, different care-centers, even in different environment according to the necessity. The information systems have to be implemented according to the environmental situation and care settings. The same information system can be used in different environment with the help of different medium.

- Semantically interoperable information systems can reduce communication problems among the connected information systems. It can reduce data redundancy as the health officials do not have to use different systems for the same set of data as the systems will be able to communicate among each other. Two semantically interoperable information systems can share the health data and all the other necessary information and that can reduce working with the same operation with the same data multiple times. As in the Case 4 (Sårvård Center), the officials are sometime using multiple information systems for the same operations with the same set of data. Connected and interoperable information systems can solve this matter by committing the operation in one system and sharing the information with the others.

- Straightforward, transparent and flexible procedure in human practice also ensures faster and quality care delivery. Two of the important situations where this is important are emergency and care handover. Jurisdictions should be transparent and flexible to such extent that the care process for any patient should not be hampered. Balka et. al. (2011), said that defining handover is a semantic problem as different groups of caregiver needs different set of health data and that is why they need to be standardize.

These approaches can be said as too general but they can be further explored and applied according to the situation in a scenario. Ash et al. (2004) have identified that the complexities of healthcare process sometimes slows down the whole care though information systems are best to automate routine works. Introducing computerized information systems not only improve the timing and the quality of care, but the human behind those systems play a vital role in it. This is where comes the social interoperability with the view to bridge a proper communication channel among human beings and the

computerized systems. Continuous research and taking account the feedbacks are very important to achieve social interoperability, and that will make the information technology more worthy in healthcare.

8 VALIDATION OF THE STUDY

8.1 Internal validity threats

According to (Creswell, 2009), "Internal validity threats are experimental procedures, treatments, or experiences of the participants that threaten the researchers' ability to draw correct inferences from the data in an experiment". We had discussions, unstructured interviews and had open ended questions with the personnel from the primary care centers. We have started the interview by explaining the purpose of the study and then interviewees have shared their experience using the health information systems. Based on their explanation about the current practices at primary care centers, we asked questions here and there to know more related to the social interoperability. There is a threat of leading to many questions that may make interviewee uncomfortable with and also chance of going out of scope. We tried to stick to our goal and we asked questions only related to the study. We have chosen nurses and doctors as they are the responsible people from the primary care centers who directly work with the systems. Based on the interviews and observations we collected and analyzed data. To overcome the internal validity threat for this analysis we have sent the data to the interviewed person and got the confirmation that the analyzed data is verified.

8.2 External validity threats

Creswell (2009) says that External Validity Threat arises when gathered data is changed in past or future. In the current study we have dealt with the social interoperability problems at the primary care centers. If decisions are changed in the future then it may affect the study to some extent. We overcome this threat by grouping our results and showing differences between the definitions of interoperability and social interoperability, identifying the current practices at various primary care centers and identifying some of the major problems that are said to be barrier for achieving social interoperability. If some changes occur only necessary parts can be modified accordingly, so that the whole study can still be valid.

8.3 Credibility

According to William (2006), credibility is something that is achieved from the results of the research and trustworthy. Firstly, we have performed literature review where we found reliable resources in order to identify the differences in the interoperability definitions and social interoperability. Secondly, we have conducted observations and interviews with the people from the primary care centers who are the users of computerized health systems. Later, we have validated the analysis by conforming from the interviewed persons.

8.4 Transferability

Transferability is the extent of generalizing the results of the research (Creswell, 2009). Our study is involved in different aspects of social interoperability that has helped us in identifying and showing that the problems make social interoperability challenging. Our study has identified some of the major problems that can be considered as the initial study and will help solving the interoperability issues at primary care centers and later at bigger levels. Even though we have used certain cases in this study, the identified problems are closely similar to many primary care centers. So, our study can help identifying problems at other primary care centers.

8.5 Reliability

This can be one of the basic threats that must be addressed at the early stages of the design of the study. Non-peer reviewed articles and reports are used in the literature study that can be considered as a reliability threat in research. Nevertheless, these articles and reports are published by health organizations who are well recognized developers of health standards and interoperability frameworks. There is not much threat of study being affected in the future. Interviewers (doctors and nurses) are very aware of what they are using as those health systems are part of their daily work. There is no necessity for additional training to the healthcare personnel. The observation was written down and interviews are recorded for data consistency.

9 CONCLUSION

In the study we have found the answers of the research questions in different phases of our study. In other words, we analyzed different definitions of interoperability, and this way we get to know that social interoperability is not been emphasized as much as the others in most the definitions. We investigated some cases from in primary care from different part of the world in a view to identify current practices regarding interoperability and social interoperability in the healthcare sector. After analyzing those situations, we identified some problems in health data communication when social interoperability is not achieved. Sometimes the system is too confusing to assess the patients' medical information where most of the cases the healthcare providers go back to the paper based records. It is also difficult for the healthcare providers to handle the data handovers at the time of emergency and ambulatory services. This problem exists because the developers overlook the people and their main focus would remain on the system. Good policies are needed to show the social interoperability as an important level of eHealth interoperability.

Our first research question is about analyzing different definitions of interoperability and social interoperability (RQ1. What are the differences and similarities among different definitions of interoperability?). As we have identified, most of the researchers defined interoperability as a property of the process for communication among two or more computerized systems using standards and common norms. However, interoperability is not only about the computerized systems as humans also are involved in communicating with the computerized systems and social interoperability concerns about the communications where human beings take parts. As an answer to the first question, we found that all the definitions agree that interoperability is undoubtedly important for health data communication, but their separate goals make them to be concerned about achieving interoperability in different way and as social interoperability is sometimes quite complex to deal with, so that they do not mention enough about it.

The second research question leads us to know more about some scenarios from current world where communication has face troubles when social interoperability was not achieved in a sufficient manner (RQ2. How social interoperability is been practiced by information systems in healthcare?). We went through the cases to know about how the social communication is done using information systems in healthcare. We realized this communication between the users and the information systems are quite complex. The cases

show that there are systems existing to overcome the paper based forms but the issues still remain in health record exchange. The developed systems are witnessing the usability difficulties to the healthcare providers that affect the patient care. Sometimes the system is too complex and a lot of operations have to be done to access a patient's medical information where most of the cases the healthcare providers go back to the paper based records deal with the care temporary by skipping the use of computerized system. It is also difficult for the healthcare providers to handle the data handovers at the time of emergency and ambulatory services. The healthcare providers often miss health data of the patients when they try to skip the operations of a computerized system that they think is the best for the time of emergency. Nevertheless, all these facts affect the whole care giving process in long term activity. All these problems mentioned above occurred due to not taking of social interoperability while designing and developing information systems. Most of the interoperable designs are about using protocols, standardization and technologies So, in answer to the research question, it is not easy to say directly what the practices are but we surely identified that in a lot of communication scenarios, social interoperability is not given importance as much as it should be given to avoid unwanted situations.

The last research question is about identifying the problems after analyzing the cases (RQ3. What are the challenges for information systems to achieve social interoperability in healthcare?). We identified some challenges when the information systems lacks with social interoperability in a healthcare settings. In a brief way, the identified challenging areas are -

a. Data collection and entry: Data collection procedure, collection medium and entry interfaces directly and indirectly impacts on the data completeness in healthcare. Inappropriate medium and complex interfaces sometimes are looked as a burden when they consume more time than usual. So, sometimes not all the data collection procedures are followed and that creates incomplete health data that affect the care process in the long run.

b. Data retrieval and display: Data retrieval procedures and display structures affects the data reasoning and presentation to the care providers. Difficult and troublesome data retrieval processes can lead the officials to workaround that is not the intention for using the information systems. As an example, these workarounds sometimes lead the officials to use old traditional procedures that were later substituted by the modern information systems.

c. Emergency procedure: Complex emergency procedures with multiple jurisdictions can sometimes consume valuable time in case of emergency. Incompleteness of health data due to emergency can delay the diagnosis that affects the care for a patient.

d. Real-time collaboration for different group of care providers: In the concept of patient centric care, real time collaboration and decision making among multiple group of providers plays a major role. Most of the care providers use information systems to manage and share health data. So, the information systems also should support real time collaboration among multiple providers, or else it becomes a hybrid of automation and manual operation that becomes hard to manage later.

e. Handing over care: Handing over care is considered as one of the important processes, as not only patient but also all health data is shared and overall the care is transferred from one provider to another. The process is not as simple as it sounds, as the care is transferred with all the information, so the latest provider should realize and understand all the current data and reasoning of the medication as well.

In the whole study, we have come up with the answers of all research questions. Our focus was to explore social interoperability in healthcare, so our answers are also identified mostly from the point of view of social interoperability. Overall, we investigated and identified that though social interoperability is not been given importance in the definitions and also in implementing information systems but it is important, and ignoring social interoperability is like ignoring human participation in the process of communication that can create complex situations to deal with. So, in different context and situation, the need for social interoperability may vary but its importance cannot be ignored for the sake of health data and the care for patient.

10 FUTURE WORK

The current research is focused on problems and social aspects of social interoperability in eHealth interoperability. Based on our study, we suggest that there is a big scope for future work. Firstly, a study can be done in order to develop standards for social interoperability. According to our knowledge, there is no particular standard for social interoperability, it would be an interesting part for many researchers to think about. Secondly, it will be a good study to develop an architecture that includes the social aspects in interoperability. Later, the architecture can be used for implementing ICT tools. Apart from these, there are many other necessary things, such as, political, ethical, legal issues and policies that play an important role in decision making of ICT implementation. It is never easy to deal with the political issues, but if those political issues are not taken care then the social interoperability is hard to achieve. There would be lot more focus necessary on social interoperability, it could be on either *human-human* or *system-system* interaction. More user-friendly systems are to be developed and the training of those developed systems is also very important.

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APPENDIX A: LITERATURE STUDY

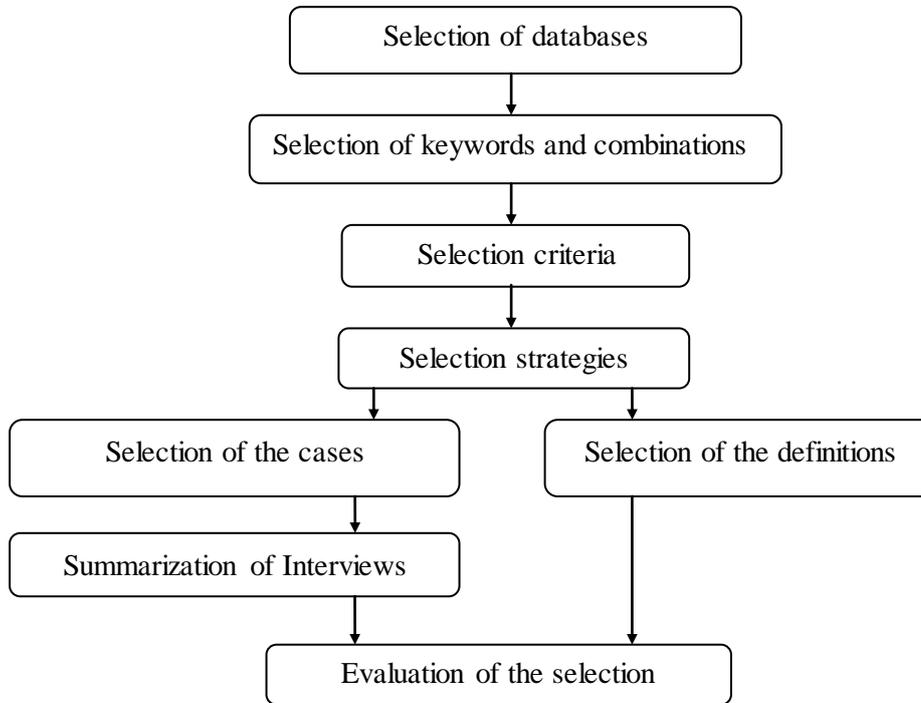Here is the flow of our literature study and we explained each and every part in later sections.

Figure 4: Strategy of the literature study.

A1. Selection of databases

We have used BTH library system as appropriate database for search. Then, we prioritized the available databases that are relevant to our research area. Our research study belongs to two different fields' computer science and healthcare but we are more focused into computer science because as we are more interested with information technology in healthcare. Finally we have chosen the following technical contents of databases related to computing. They are IEEE Xplore, Springer link, ACM Digital Library, Wiley Online Library and Google Scholar.

A2. Selection of keywords and combinations

We defined our search keywords based on our queries. We have used different combinations of keywords to search in the chosen databases. List of chosen keywords are given below:

I. eHealth

II. Interoperability

III. Definitions of interoperability

IV. Social Interoperability

V. Semantic Interoperability

VI. Technical Interoperability

VII. Social issues

VIII. Health information systems

IX. Social factors

X. Case studies

XI. Healthcare

XII. (I) in (V)

XIII. (I) AND (II)

XIV. (I) AND (III)

XV. (II) AND (VII)

XVI. (VI) of (III)

XVII. (VIII) AND ((IV) OR (V))

XVIII. (III) AND (IV)

XIX. (I) AND (VII)

XX. (I) AND (VIII)

XXI. (I) in (IV)

XXII. (I) AND (V)

XXIII. (IV) AND (X) AND (XI)

A3. Selection criteria

We have used the combination of keywords to search through the databases that we have selected. As a result we found relevant articles to our research questions. eHealth interoperability and interoperability in healthcare systems is one of the popular research area in the current days. Social interoperability, a part of eHealth interoperability, can be

practically seen as an issue since the health care professionals started using computers. We have also conducted search for case studies that can show the importance of social interoperability in the recent days. To support our research study we have focused on recent researches so by considering these factors we have excluded the articles, papers and reports before the year 1999. The overall publications are in English so we have easy understanding of the articles and reports. We have filtered all the articles based on the title and abstract. If these two are appropriate we further went through the introduction and the conclusion. The thorough reading of the introduction and conclusion gave us an idea to go further with the text.

A4. Selection strategies

In the earlier phase of the study, we went through the titles; based on the titles we read abstracts and conclusions from the articles and papers. Then the relevant material is chosen and analyzed to answer our research questions. We selected our papers based on definitions for interoperability and different types of interoperability. We have later selected the papers that contain the case studies to learn more about the current practices in social interoperability.

A5. Selection of the cases

This study contains three cases that are taken from the literature study. The cases are searched by using the keywords cases in social interoperability in healthcare. Various case studies are found during search but they are filtered based on the latest year. The selected cases are from year 2011 and they are very relevant to our study of social interoperability. Apart from that, the other cases are from primary care centers that are also significant in our study.

A6. Selection of Interviewees

The interviewees are selected from the primary care centers as the case studies are performed at primary care centers. We have given chance to meet senior nurse and senior doctor at each primary care center. We have explained the purpose of the study and so we are asked to meet those responsible. The selected nurses and doctors are the people who use the health

information systems at those primary care centers. Even though we had no much choice to decide the number of interviewees but we have got the chance to meet the right people. The number of people is limited because the staff at primary care centers is less.

A7. Evaluation of the selection

Finally we have assessed the selection of articles, papers and reports by evaluating the introduction, cases, analysis and conclusions.

APPENDIX B: SUMMERY OF THE INTERVIEWS

B1. Capio Vårdcentral, Ronneby, Sweden.

Interviewees:

Per-Erik Thorell (Chief controller, Nurse)

Fredrik Östberg (General practitioner)

Major health information systems in use:

SVEA: The local system used the officials to manage and store information about patients and the care.

Edos: Used for scheduling medication for elderly people. This information can be accessed be the apotekets (medicine stores) as a form of ePrescription.

Wiseweb: Used to share the x-ray reports.

Daily works:

The primary care center takes care of the general health issues of the inhabitants in the area. Their specializations are providing first line care for gynecology, orthopedics, diabetes, family healthcare, elderly care, vaccination, and general wounds. After assessing the physicians refer the patient to the other specialized care centers or county hospital if necessary.

Advantages of the health information systems:

The officials are very comfortable working with the health information systems in their daily professional life. The officials mostly use SVEA for managing patient data. According to them, it is fast, reliable, easy to learn and easy to use. Another important

Drawbacks:

The officials are a little uncomfortable with the SysteamCross. According to them, it is a big system, really helpful and useful with a lot of functionalities, but it is difficult to learn and get used to. It is comparatively slow to operate. The officials sometimes are using papers to avoid additional time consumed by the application. The officials also feel that SysteamCross is somehow not suitable for primary care as in primary care they have to deal with less processes than a hospital. So, more numbers of unnecessary functionalities are also sometimes creating confusion to operate the system.

B2. Blekinge wound care center, Lyckeby, Sweden.

Interviewees:

Rut Frank Öien (Register manager for the national quality register RUT (Register Ulcer Treatment), General practitioner)

Lars Midbøe (Project co-ordinater, SALAR, Nurse)

Major health information systems in use:

NQR: National Quality Register for monitoring the start and completion of wound care of the patient.

SysteamCross: Used for maintaining patient data.

Daily works:

The wound care center takes care of the leg ulcer patients' diagnosis and treatment. They are specialized in providing care to the leg ulcer patients'. They perform regular checkups and treatment at the care center.

Advantages of the health information systems:

The officials are currently using paper based forms to note down patient information. Later the data is entered into two systems National Quality Register (NQR) and SysteamCross. NQR contains the leg ulcer patients' data whereas SysteamCross is used to maintain all patient data. Paper based forms are used at both care center and at field work. The paper based forms are quiet easy to note down and they can be carried everywhere. They are planning to get a new health information system that can remove the paper based forms and also directly connects the data with NQR and SysteamCross.

Drawbacks:

The officials are doing repeated work by feeding the field data into NQR and SysteamCross. This paper based forms are easy to use but difficult to preserve. The data may be lost and unsecured. The process is very time consuming and sometimes chances of missing the data.