CHAPTER 2
LITERATURE SURVEY

2.1 INTRODUCTION

The concepts described below are used as the base for the classification of existing approaches and mechanisms for information integration. This chapter presents a survey on several research and development approaches that have directly or indirectly contributed to the issue of information integration and interoperation mechanisms among autonomous, distributed, heterogeneous systems (Applicable to Healthcare Industry).

Considering the main emphasis of the thesis that addresses the integration of heterogeneous data sources and interoperation among autonomous sites, special emphasis is given to the data distribution, information exchange, and interoperability issues (e.g., to Healthcare Industry).

2.1.1 DBMS architecture

For most of the emerging applications, and considering the enormous improvement in networking and communication protocols, it is
clear that the client/server architecture has become the key issue for application development. However, depending on the type of application, decision has to be taken regarding whether to use a centralized, distributed [1, 2, 3 and 4] or even a federated approach for proper support of the application requirements in term of information management and systems interoperation [5, 6 and 7].

2.1.2 Data Storage/Access

In the area of data mining and Online Analysis Processing (OLAP) are based on the access to catalogs and repositories of data, which are reformatted and prepared for certain analysis tasks [8, 9 and 10].

2.1.3 System interoperation

In this chapter, the main approaches are introduced so far for information exchange and interoperation for different application domains. Therefore, the more complex and higher is the requested level of integration in the application, the more complex and difficult becomes the development process. Some criteria for this interaction involve handling the inter-linking among distributed data over different locations, and the format in which data is going to be exchanged.
However, this is not a simple task since the requirements in terms of information handling are quite different in centralized applications from those that are distributed or federated applications. The interoperation mechanism for exchanging information and services among a set of users/applications within a collaborative community also defines the coupling mechanisms between those systems [11,12,13, and 14]. It is clear that the complexity of the proposed approach for every advanced application depends very much on the specific characteristics of the application and its required level of integration. Furthermore, these approaches are discussed, evaluated, and those that can support some requirements for different applications and better fit the general integration purposes are validated for the general use cases.

Thus, it becomes unrealistic to validate and conclude that one specific and concrete solution can support all types of today’s and forthcoming applications. Some of the applications rely on the use of centralized archived data; others require homogeneous information replicated at different sites, a third type of applications may require runtime generation of information for decision support, and so on. When data is integrated from external sources, it is very important for each system (e.g. data source).
2.2 A TAXONOMY FOR INFORMATION INTEGRATION

There are many classifications and initiatives aiming at the provision of taxonomy for the information integration approaches. In the proposed classification approach, since the main subject of the thesis consists of integrating heterogeneous data from distributed sources, the categorization architecture from the distribution/Integration point of view are addressed. As such, these “category names” might be defined differently in some other publications, since in general there is no common consensus among database researchers on the exact definition of these category names and the database systems they represent.

The main purpose of this classification (and the names that are suggested and associated with each category) is to be able to discuss the common features among a group of systems that follow one general approach [15]. Also this classification of information integration approaches is specifically focused on the main characteristics emphasized in the thesis, namely the design of a flexible environment to support many heterogeneous application domains, as it is the case for instance in scientific and engineering domains, like healthcare environment. Some classifications look to the problem of integration/interoperation from the data access dimension, some others from the
distribution/ centralization dimension, and still some others from their heterogeneity and autonomy dimension [16, 17].

2.3 INTEGRATED SYSTEMS

In the main area of integrating heterogeneous and distributed information sources, the information amalgamation usually indicates similar and clear approach to data monitored by different databases. An important distinction in classifying the different strategies for the manipulation of the data.

In approach data it is not simulated and is confirmed to be up-to-date at query time. In the virtual integration, the data remains at the local/remote sources where it belongs. The study starts with application case on healthcare industry proceeds with general problems & trends in healthcare. This chapter presents a review of the research contributions that constitutes the background to this study. The rest of the chapter will review the details of ICT in Healthcare, problems & challenges in realizing electronic health records, interoperability standards in health informatics.
2.4 APPLICATION CASE: HEALTHCARE INDUSTRY

It allows exploring the acceptance improvement and application strategies and equipment emerging from an amount of informatics-related disciplines in healthcare [18, 19].

As a result, provision of healthcare is increasingly shared between different healthcare and social care institutes. There is a shift from periodic treatment of acute health problems to provision of coordinated services. It emphasizes the optimization of the public health. The economic, political, socio-demographic advances in medicine as well as medical informatics and engineering have moved modern healthcare beyond a largely reactive acute care standard. The continuity of care for those with chronic conditions is provided to enhance the health status of defined populations.

The healthcare costs play major concern for industries that obstructs their abilities to globally compete. Today, the healthcare industries are facing major challenges: increasing costs, unbearable error rates, dissatisfied patients and caregivers. The general motors spent $2 billion on healthcare in 2004 for its employees, retirees and their families. Healthcare costs in developed countries were about 9 % of the
gross domestic product (GDP) - $6 trillion in 2002 estimated to be 9 trillion in 20 It is projected to rise to 6 trillion by 2014 [20, 21].

Medical reports and x-rays are frequently misplaced, misfiled or missing. Unlike most industries in which Information Technology (IT) has improved quality, efficiency and productivity. A patient's critical medical information is scattered across health records kept in many locations instead of being available at the point of care. The healthcare still operates using primarily paper based records, telephone calls and mails.

These days public patient care is disadvantaged because survival of many hospital information systems (HIS), in form of island solutions or even paper-based systems. The problems regarding care coordination between different caregivers, among caregivers and patients confirming that this remains a problematic issue to this day. There is an increase in awareness of the need for integrated care. The important aspect of integrated care is focused on the cooperation between healthcare providers to jointly provide healthcare services to a patient.

In an interactive environment, there is a need to look at the information sharing amongst healthcare systems. It includes multiple healthcare experts and institutions utilizing ubiquitous computing healthcare environments with technological advances. They moved from
isolated software systems in primary health centers towards solutions which support a continuous medical process. This requires that all relevant patient medical data is available easily for healthcare experts at any time, any place. Healthcare systems have grown rapidly in the last decade. This improves the quality of the healthcare.

i. Heterogeneities in hardware and software solutions that support healthcare applications. Heterogeneities in healthcare applications are typical in any other problem domain, where a variety of platforms, systems, databases and technologies etc exist.

ii. Transmission and teaching of medical knowledge.

Every EHR is unique [22, 23 and 24]. It means that the structure of EHR and the procedures for sharing their information may differ. This becomes an obstacle for distribution of medical records between hospitals.

The key solution to these problems lies on greater reliance of IT:

i. Information sharing for integrated healthcare.

ii. Best practice in medicine.

iii. Prompt in getting investigation results such as lab, radiology images, ECG images, etc.

iv. Manual power is decreased and hence less prone to errors.
v. Improved cost control.

vi. Reduce personnel costs and improves the quality care of patient.

Unfortunate thing is a great number of smaller healthcare providers and clinics are not able to keep up with the changing times. There are rapid changes taking place in the methods of healthcare delivery. It has become practicable for any two distinct healthcare systems to interoperate with the sophisticated means of communication and storage capacity.

Interoperability has become an aching module for in sequence experts as long as the bodies of corporate, government, and educational organizations swap healthcare information. In addition to this doctor do not find time to decipher, request and integrate information provided. Consequently, these problems became hindrances and make the current system inefficient though it is the need of the hour.

Once the required information is sent it is the duty of new healthcare provider to make sense of it and save it to the physical file. The problem one often comes across is, during the exchange of information into a system is quite expensive and time consuming. Hence, the only remedy to this problem is to introduce a system which will allow
healthcare providers to electronically transmit or exchange healthcare data between distinct healthcare systems. The services extended to patients will be charged as the prior health clinic has to prepare and send physical documents of a patient to the desired hospital. The proposed scheme explores a framework for interoperable healthcare systems in general and it attempts to create a successful and workable solution. The general solution of this framework is:

i. Agree on a standard data object structure that will serve as the intermediate among providers.

ii. Create and exchange XML document.

iii. Map this document to the standard data object structure.

IV. Receive and store the XML document.

V. Map XML data to existing relational database.

The patient treatment is improved by exchanging health data with certain health standards between hospitals with the proposed GIE System. The elimination of paper-based records reduces medical errors and healthcare costs.
2.5 GENERAL PROBLEMS OF HEALTHCARE

In reality, this is not satisfied because the resources are scarce, such as efficiency, resources are not rationally utilized, and patient outcomes are not satisfactory. The public health is also degraded because continuity of care can’t be achieved. In reality today, the system is poorly organized, managed and coordinated which seriously degrade the quality of healthcare. Other problems include ineffectiveness, under-utilization (not receive sufficient care), overuse (receive unnecessary services) and highly variable provision of healthcare services [39]. According to the World Health Organization (WHO) and other pertinent literature, the major problems of healthcare system globally in the 21st century have to do with the quality, safety, effectiveness, cost and accessibility/equity [25, 26 27, 28 and 29]. Thus communications play a key role to deliver high quality services.

Regardless of economic and social status, all citizens are seeking for safe, high quality and effective healthcare services at a reasonable cost [30, 31]. Cost of healthcare is on the rise globally. The safety of healthcare system is not even close to what it has to be. A this figure is as much as 15% as of circa 2005 and constantly increasing [44], although major part of this high cost is attributable to essential problems unlikely to be improved by known methods. In developed
countries nearly 10% of GDP is spent for healthcare.

The challenge is to decrease costs while increasing quality, safety and effectiveness [32, 33]. The rest is due to sick planning, bad management, lack of coordination, irrational spending of resources and ineffective processes. These errors broadly happen owing to breakdown of a intended healthcare act to be finished as planned or wrong planning [34, 35]. A nearly 1, 00,000 people die due to preventable medical errors each year [36, 37 and 38].

The common accesses to healthcare services are major challenges. The reasons are related with geographic location, uneven distribution of facilities and resources, lack of health insurance, linguistic and cultural differences.

Today, even in developed countries, accessibility to healthcare is problematic. Since this information is extremely difficult to acquire, widespread and long-term effects of drugs and treatments or preventive measures can not be assessed. Effectiveness of healthcare can be increased by providing preventive actions and medical services based on best scientific evidence and practical values. Another serious danger happening today is the potential loss of trust and satisfaction for healthcare.
This seriously degrades safety and effectiveness while also inhibiting the change of medical knowledge and proliferation of best-practices. It results in seeking other solutions by patients and families, such as alternative medicine with little or no scientific evidence. Medical knowledge has been estimated to double every six years which poses a big challenge for healthcare workers to stay up-to-date and deliver quality services. High quality and large volumes of data spanning a long period of time are needed to calculate health outcomes of healthcare services and products such as drugs [39].

2.6 TRENDS IN HEALTHCARE

In some cases, patient’s family physician or another healthcare provider might have to intervene with the process. It is obvious that as number of parties and locations increase, the need for effective and high quality HIS is of utmost importance. This is called shared care [40, 41]. There had been important movements in healthcare influenced by HIS.

It can be said that medicine is moving from a single provider/physician to a team of physicians from multiple providers. All are inclined towards alleviating the fundamental problems of healthcare. In order to provide state-of-the-art healthcare services to a patient, a
team of healthcare experts has to act in a coordinated manner. In fact, preventive measures are cheaper, safer, more effective and definitely more ethical. They require long-term follow-up of people, consistent record keeping, good communications infrastructure and surveillance of health threats. So keeping people healthy requires both preventive and treatment aspects of healthcare in harmony for a long time over a number of caregivers.

The current healthcare systems globally are more focused on the latter strategy which is more costly and ineffective. The ultimate goal of medicine is to keep people as healthy as possible by first preventing illnesses and also providing necessary treatment during times of illness. This concept is called the continuity of care and enables the longitudinal provision of healthcare services.

Unlike a healthcare team providing services to an individual cooperatively in shared care, in continuity of care the services provided by different providers are independent and not synchronous. The important aspect is the time-related links between these different health care services. Continuity of care depends on the effective exchange of data and information about the clinical situation, context and services provided to an individual, between different providers [42, 43]. Within
the framework of ethical, professional and legal, rules are defined in CEN EN 13606 and continuity of care record [44].

2.7 BENEFITS OF INFORMATION AND COMMUNICATIONS TECHNOLOGY IN HEALTHCARE

The quality and safety care is also enhanced because of decreased waiting times, better planning and automatic monitoring of certain steps such as medication orders. Although there have been unsuccessful implementations in the past, the evidence shows that health ICT systems help to establish a better healthcare. The fact is that it is hard to review the benefits of healthcare ICT as they are mostly indirect benefits rather than direct which make it difficult to convert into monetary benefits [45].

The uses of information and communications technology (ICT) in healthcare solutions primarily aim to alleviate healthcare problems and seeking for better health.

The ICT greatly enhances the quality and efficiency of healthcare. This mainly results from the ability of providing guideline based services especially preventive measures, enhanced monitoring of health status and surveillance of outcomes, reduction of medication errors and lowering redundancy or irrational use of resources and services. It enables faster transactions which result in direct monetary gains in
terms of faster billing and reimbursement in healthcare [46, 47]. Fast, reliable and timely provision of health information has been demonstrated not only to improve patient care directly but also result in better management and planning activities. It shortens length of hospital stays and improves compliance with treatment guidelines.

Decision support is also seamlessly introduced into daily practice which improves efficiency and appropriateness of medical decisions. By the use of computerized order entry systems, errors can be significantly reduced while at the same they help to decrease costs. It enables standardization practices by decreasing variability of healthcare services by adhering to clinical guidelines and pathways. By means of using electronic communication tools, timeliness and quality of information is enhanced which result in better cooperation of healthcare workers and managers [48].

### 2.7.1 Types and Evolution of Healthcare Information and Communications Technology

The next concept was the Electronic Medical Record (EMR) that had extended functionalities such as the ability to be shared by other providers and possibly used by patients themselves [49]. Before the advent of HIS concept which embraces all types of IS in
healthcare, there were many concepts somewhat confusing. Today healthcare ICT and HIS are used interchangeably for systems consisting of healthcare actors, procedures, software and hardware to perform tasks necessary for providing healthcare services and products. The various case studies of healthcare information technology for effective healthcare information exchange are discussed. Currently, by taking into consideration the importance of preventive medicine, trends like continuity of care and shared care brought about the need for EHR. Now it is called as a hospital wide HIS. By the rapid advance of IT in recent years, they became somewhat more functional and usable with innovative GUIs and alternative human computer interfaces.

Hospital automation is one example; in fact it is truly an IS. Health information technology is currently one of the most dynamic sectors in many other countries. Now, steps are being taken to make this vision a reality. The institution centric HIS started to collect structured clinical data from patients and that this data need to be shared with other providers and organizations, a different approach was needed. The administrative part contains functions such as stock and materials management, procurement and so on. A complete and integrated HIS consists of administrative and medical data. Computers have long been used in healthcare for various purposes. The patient-centered Computer based Patient Record (CPR) came into existence [50]. The medical part is
further classified as departmental IS and clinical support systems such as Laboratory Information System (LIS) and Radiology Information System (RIS). It was merely an electronic form of classical paper-based patient record that collected data within a specific provider [51]. The increasing effect of communications technology and its seamless integration with IT resulted in the birth of ICT [52].

It is widely acknowledged that healthcare providers need to access a patient’s key health information during a consultation [53]. Therefore, accessible health records are viewed by the majority of consumers as a natural next step for health information technology [54, 55]. It is truly patient-centric which records all relevant care events from different sources, supports integrated care, longitudinal (covers time-based history of health events and indelible for medico-legal purposes [56]. It supports the common understanding of record keeping for individuals not only at times of illnesses but also during healthy periods.

2.8 THE NEXT GENERATION MEDICINE: ELECTRONIC HEALTH RECORD

EHR is used primarily to support individual patient care and also has many secondary uses in medico-legal events by providing reliable evidence data, quality studies, education and research. It also provides
access to quality health information, public health services. Policy development, health service management and financial services also benefit from EHR. The recommendations of EHR data [57] is given in Table 2.1.

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<th>Table 2.1 Recommendations for EHR Data</th>
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<td>• Patient-centered</td>
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<tr>
<td>i. Comprehensive</td>
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<td>ii. Aggregated</td>
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<td>iii. Organized</td>
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<tr>
<td>Timely</td>
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<td>Structured</td>
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<td>Sharable</td>
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<td>Secure and private</td>
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Another driver is the added complexity of managing highly mobile patients and healthcare experts. Within the ambitious common ICT objectives of the European commission (EU), [58, 59]. EHR standards now provide coherent definitions and technical methods hence are precursors for interoperability [60]. The progress in adopting EHR systems has been slow. The data is generated at each site. The healthcare today is truly a multi-contact system, where patients receive services from different healthcare providers. As a result the patient information is all over the place in various formats.

EHR has become more important. There is a prominent e-Health Action Plan and this plan states clearly that in order to achieve e-Health structure, the road passes through electronic health records and it calls each member state to establish regional and national frameworks.
Patient centered healthcare records have proven to be a superior approach than organization-centered records [61].

This little progress has mostly been in domains of standards development, open source developments and building of vast amounts of knowledge sources to be used in EHR systems. Most governments have identified EHR as the major aid in controlling cost of healthcare while increasing quality, effectiveness and safety. The consequences of this fragmentation are repeated entries of same information, repeated tests, and errors due to not being able to access key information, and evidently high cost and low quality of healthcare.

2.9 BENEFITS OF ELECTRONIC HEALTH RECORD

They reported that some practitioners and health care organizations thought that such EMR and CPR are too expensive to implement and many of them decided to develop their own system. It is almost a complete model of the patient [62]. However with paper-based records, it is physically difficult to apply those rules because people in the wards where file cabinets are can access patient files.

However EHR systems can provide effective and reliable security mechanisms which allow a very fine grained access to the health data.
Current legislations for conducting healthcare have strict rules especially for privacy and confidentiality of medical information.

EHR is mainly applied for setting up patient care records and evaluating the quality of healthcare delivery [63]. Each of these names is given dissimilar shades of meaning in various nations and various healthcare environments. It has similar functionality as EMR or EPR. The same was described by another, while other says that the main role of EPR is to improve teamwork and patient focus [64]. The terms EMR and CPR can be used interchangeably. Several terms are introduced in the literature to describe the electronic patient’s healthcare data such as EHR, Electronic Patient Record (EPR), and Computer Patient Record (CPR) [65, 66]. It is made clear that the EHR record will be built from several EPRs created and stored at different health care sites.

The following discussion will clarify the confusion and agree on the ultimate definitions for EPR and EHR. The key benefits of EHR are accessibility, readability, easy reporting, completeness of data, decision support, supporting preventive medicine, access to external knowledge sources and data analysis [67]. This is mainly because of the definitions provided by those organizations which referred to different terms for the EHR such as the EPR, CPR, and EMR. Possibly the most striking effect of widespread usage of EHR will be on biomedical research [68, 69]. In
each acute care hospital, there would be one EPR per patient and various departments would be able to check as and when they require any information about patient. The concept of electronic EHR has been described with various names, based on the nation and the actual healthcare providing quality care.

The relationship between EHR and EPR is illustrated in Figure It shows that whenever a healthcare consumer visits acute care hospital, mental healthcare, or has some other treatment from the GP or a community service, an EPR is created and reserved. The availability of complete and accurate data. Even though there are differences between EHR and EPR, effectively, these terms describe systems that provide a structured, digitized and secured accessible record [70]. It is understandable that there is a need to determine clearly what EPR means and how it is differentiated from EHR. However, in 1991, IOM published a report, in the definition section of EHR, it is realized that nobody has yet internationally accepted the definition of either the EHR or the EPR [71, 72, 73 and 74]. They are described such as EMR, CMR, and CPR. Some of these benefits have been tested and validated in studies [75]. It comprises of information pertaining to healthcare givers and consumers during episodes of healthcare provided by different healthcare experts from various healthcare institutes [76]. Therefore,
different records about the treatment of the same person in various sites can be created.

The EPR can imply different things to different people at different countries. EHR has implications in all aspects of security for patient records.

Figure 2.1: Relationship between EPR and EHR

2.10 PROBLEMS & CHALLENGES IN REALIZING ELECTRONIC HEALTH RECORD

This not only makes design and implementation hard but also causes maintenance to be even harder. The study handles the complexity by adding an additional layer of modeling for domain knowledge, on top of information modeling [77, 78]. It has also been observed that the clinicians do a significant role in the quality content and usability of EHR systems.
The data in EHR come from a number of different sources, layout and formats [79]. So the EHR not only has to be able to add or modify knowledge but also make it usable by incorporating into its functionality and workflows. The current situation with HIS and EHR is still organization-centered and episodic meaning they contain information from a patient’s visit for a health issue rather than a full history of the patient.

However depicts that the maxim for EHR is community-based and patient-centered used in shared care. It is believed that this caused by unjustified balance between effort and benefit of EHR systems. It should also be noted that HIS and specifically EHR systems are usually built from scratch rather than using tested and proven software components. The success of EHR projects does not seem encouraging at all; according to, 9 out of 255 projects had failed. As the nature handles complexity by dividing into subcomponents and layers, in development of EHRs, separation of concerns and also separation of domain knowledge from underlying information and data is a new promising approach and a brand new challenge.

The experience with many different approaches to model and implement EHR has proven to be problematic. The EHR has to accommodate individuals’ biologic, sociologic and psychological
complexities within its structure. Not only there are difficulties with data capture and representation, but care provision requires access to and utilization of best available knowledge.

The main bottleneck is the reluctance of physicians for data entry because of anticipated time-loss while typing, limited coverage and concerns with physician-patient encounter. One critical success factor is properly designing business processes and informing people before introduction of EHR. This necessitates that the EHR be very flexible. This low success rate has also been attributed to non disciplined development process of EHR, so it is recommended to employ rigid software engineering principles.

2.10.1 Barriers to Implement Electronic Health Record

To understand why the adoption rate of EHR has been low, Author surveyed experts at nearly 3000 group practices nationwide [80]. As shown in Table 2.2 barriers to EHR adoption are identified. The promise of EHRs being able to transform medical practice saving lives, money, and time has been around for some time, but the fulfillment of this promise in real-world applications has remained elusive due to many factors. EHRs are currently used by 12% of physicians and 11% of hospitals nationwide. Industry and government have promoted EHRs as
a means of controlling costs and improving patient care.

In fact, the Obama administration has set an agenda that includes making the immediate investments necessary to ensure that within five years, all of America’s medical records are computerized. Among the most frequently cited are cost of implementation, privacy and security [81]. While the universal nationwide adoption of electronic health records is highly unlikely within five years, governmental, technical and industry impetus for adoption is high, which will continue to drive EHRs into the hands of medical providers. While overcoming these factors is necessary to the successful implementation of any EHR system, they are hardly sufficient.

Table 2.2: Barriers to EHR Adoption

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<th>Barrier</th>
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<td></td>
<td>Practices with EHRs</td>
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<tr>
<td>Lack of support from practice physicians</td>
<td>3.32</td>
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<tr>
<td>Lack of capital resources to invest in an EHR</td>
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<tr>
<td>Concern about physicians’ ability to input into the EHR</td>
<td>3.18</td>
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<td>Concern about loss of productivity during transition to EHR</td>
<td>3.04</td>
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<tr>
<td>Available EHR software does not meet the practice’s needs</td>
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<tr>
<td>Lack of support from practice clinical staff</td>
<td>2.73</td>
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<tr>
<td>Insufficient time to select, install and implement EHR</td>
<td>2.70</td>
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<tr>
<td>Practice staff doesn’t have skills to use EHR</td>
<td>2.65</td>
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<tr>
<td>Lack of support from practice administration</td>
<td>2.43</td>
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<tr>
<td>Security and privacy concerns</td>
<td>2.31</td>
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Usability is rarely mentioned by name as a barrier to EHR adoption by respondents at these group practices; yet, two of the top five barriers to implementation are related to the usability of EHRs (items 3 and 4). And while implementation costs are important barriers to practitioners, some of the other popularly cited reasons for lack of adoption security, privacy, and systems integration are outranked by usability and productivity concerns [82]. Due to an influence of EU Action plan for eHealth and National Strategy for eHealth, the current direction of research is pointed towards achieving interoperability of eHealth tools and services [83, 84]. Usability issues are also a factor in why EHR implementations fail.

For accessibility and empowering the citizens, each eHealth tool and service has to be tailored according to each patient’s individual requirements [85, 86]. When inspecting this table, some interesting observations emerge. Thirty-five percent of those physicians listed specific EHR usability issues, the most common of which were: problems with screen navigation, no access to secondary functions, and concerns that data will be lost [87]. Certainly, well-known factors like security and cost are cited as key factors, but theme usability floats near the top. The primary care physicians were asked to list reasons why they did not use the EHRs available to them.
2.11 STANDARDIZATION

Healthcare service is contributed by multiple careers at different times at various locations. Data standardization assists in protecting and promoting population health through early detection of abnormal patterns. It supports reuse of data, improves the efficiency of healthcare services and avoids errors by reducing duplicated efforts in data entry. Data standardization is the basis for accurate and efficient communication.

It facilitates comparability of data and interoperability of systems for data captured at applications built on different platforms. Data standards ensure information is interpreted by all users with the same understanding:

i  the data content.

ii the terminologies that are used to represent the data.

iii how data are transmitted across various platforms/applications and

iv how knowledge, e.g. clinical guidelines, protocols, decision support rules, are represented in the health information system.
Approaches are used in the same way despite of the vendors. The basic elements for data sharing require standardization in the areas of identification, record structure, terminology, messaging and knowledge representation. Thus, there must be a common view between participants for real connections to arise. Each of it has its own electronic based system, rather than a considerable single mainframe. In order to ease medical errors and labor costs which are caused by surplus data entry, there is a request to setup and improve connection among those systems. Typically, EHR system consists of a variety of independent distributed healthcare sites.

This sort of information needs to be exchanged among healthcare givers in a modern-day healthcare organization. The competence of patient records is to create and store patient related data regarding facts such as medical problems, diagnoses, patient demographic history and their results, such as Electrocardiography (ECG), urine test or blood test taken by a specific physician [88].

The EHRs will be constructed and continuously updated from the contribution of one or many patient records created and stored at different healthcare sites such as acute hospitals, community and social services. The main problem about introducing EHRs for local, national or at global platform is the high number of diverse possessors, different
standardized interfaces information systems such as (EDIFACT, HL7, DICOM, etc. LOINC, SNOMED, ICD-10) or different hybrid approaches such as (openEHR, CEN 13606), which possibly needs to be integrated. Standards are the main factors for the implementation of any EHR as it will guarantee the same interface; data element. Concisely, in order to make EHR interoperable and universally understood, there is a need to stick on to standards.

Health informatics standardization falls into four categories:

i. The structure and content standard set up provides clear descriptions to the data elements to be collected and included in the EHR system. This level also specifies the type, the width and the content of data to be collected in each data field.

ii. The terminological standard defines common definitions for medical terms to encourage consistent descriptions of an individual’s condition in the EHR. This standard is truly a challenging task as medical vocabulary can even differ between physicians working in the same organization.

iii. Communication standard supports EDI via establishing a format and sequence of data during electronic transmission process between two or more independent systems.
iv. Security standard is to protect health care data from illegal access and destruction.

They are engaged in presenting guidelines to support standardization for EHR, such as: ISO/TC 215, CEN/TC251, HL7, openEHR, IHE, DICOM, ANSI, etc. There are numerous government agencies, voluntary groups, and medical associations to address the interoperability standards for EHR.

2.11.1 Electronic Health Record Standardization

Standards are created for many technical and clinical domains; EHRs use both technical and clinical standards. EHR vendors have been implementing some standards, but have had a great deal of variation in their implementation methods, which results in systems that cannot interoperate. A standard is established by consensus and approved by a recognized body that provides rules, guidelines for activities.
2.11.1.1 Current Status of Electronic Health Record

Standardization

The great concern is the missing standardization across the diverse health care sector community; it is because of the wider benefits from electronic health solutions will appear at a greater scale. This is concerned with, technical and syntactical as well as semantic interoperability; it does not mention issues which arise at the organizational, lawful and policy levels. However, the growing number of remote solutions without information exchange and interoperability is of growing distress. After over a period of time it lacks of EU wide standards in the areas of the proper identification, collection, coding, classification, and exchange of clinical and administrative information [89]. It is regionally networked or countrywide implemented EHR systems.

Activities in various member states planned to develop, implement and run national electronic health infrastructures and the massive problems they all have encountered giving vibrant authentication to the need for faster, more focused and integrated standards development at EU level. EHR systems contribute to the delay of stand-alone. EHR applications are available in an increasing number of organizations such as GPs offices, laboratories and hospitals. This does not apply within a single healthcare giver [90]. Once it becomes possible to seamlessly
networked hospitals, rehabilitation facilities, doctors in private practices, social care and the many other players such as public health, insurance companies, teaching and research at the local, regional and national level.

2.12 HEALTH LEVEL 7 STANDARD

Other areas of interest include the structure and content of clinical documents and decision support recently. Its specifications are mostly for application-level messaging (7th of OSI layers) among HIS. It is an U.HL7", founded in 1987, is a not for profit standards developing institute. Third version of HL7 is still aimed primarily at defining application messages, but now uses a well defined information model, the Reference Information Model (RIM) [91]. Health Level Seven, Inc. However the main goal of HL7 before version 0 was to standardize messaging between HIS and achieve data exchange, not to develop EHR standards. A based ANSI-accredited health information standards development organization. Thus there is no guarantee for interoperability when using HL7 v.x because there is no well defined underlying information model. The process ends with forming Hierarchical Message Definitions (HMD) and then generated message schemas are represented as XML documents. While assembling messages, the content schemas are derived by a restriction process starting from the RIM, further constrained by Domain Information Model (DIM).
2.13 INTEROPERABILITY

Shortly the term means achievability of integration, how much effort that is required to achieve integration between two or more systems. There are, however, some parts of interoperability which are left out in that breakdown, namely connection and process interoperability. It is the basis for all of the other concepts discussed below. The most common division is into structural, syntactic and semantic interoperability [92, 93].

Interoperability is a complex concept which cannot be managed as one problem only it is therefore very common to break it down into sub concepts. See the illustration in Figure 2.2 for an overview of the breakdown of interoperability.

Figure 2.2: Breakdown of interoperability
The subsequent chapters discuss the definition of all of the above mentioned types of interoperability in varying depth, focusing on information interoperability. This thesis focused on structural, syntactic and semantic interoperability which, as can be seen above, can be assembled under the concept information interoperability.

2.13.1 Connection Interoperability

All that is needed is a functioning network connection, which thanks to the standard of TCP/IP and the emergence of Internet is easy both to setup and maintain. Connection interoperability describes how well the physical connection of data operates.

2.13.2 Information Interoperability

Information interoperability can be divided into structural, syntactic and semantic interoperability.

2.13.2.1 Structural Interoperability

Structural interoperability is not always discussed when approaching the problems of interoperability as solutions to it already
exists, or is implemented automatically when dealing with syntactic and semantic interoperability.

Structural interoperability describes the level of agreement on the data format, focusing on each separate data string (e.g., other definitions sometimes used for it are morphological interoperability and data format interoperability. Structural data integration involves re-formatting data structures to homogeneous data structures, which is often done by having a component which can take several heterogeneous data structures and transform them into a specific format.

### 2.13.2.2 Syntactic Interoperability

There are many approaches to dealing with syntactic interoperability. It describes the level of agreement of the syntax/schema of the information system [94, 95]. Syntactic interoperability describes the level of which different systems. One area of discussion in this subject is using some kind of unified language, often a combination of RDF, XML, XML schemas and XSL [96].

Using a wrapper involves use of a strategy to hide the internal data structure model and transform contents to a uniform data structure model. The systems must be able to communicate; they must
be able to speak a common language. The issues related to syntactic interoperability appears at the application-level of the system. Other approaches are wrappers and use of web services [97].

2.13.2.3 Semantic Interoperability

Semantic interoperability is by far the most discussed, and the most problematic, part of information system interoperability [98]. Some of them are listed below:

i Solvability of data heterogeneity.

ii Presence of commonly accepted meaning for data.

iii Data meaning interoperability.

iv Ability of participating system domains to understand the meaning and use of terminology from different domains.

v The ability to operate on information according to agreed-upon semantics [99].

The ideal pair of information systems to integrate regarding semantic interoperability uses the same meaning for the same data at the same abstraction level modeled in the same way. Sharing information is an essential feature of communicating with colleagues and patients about the delivery of healthcare [100]. What must be done is to reach
some kind of mutual meaning and understanding with appropriate mappings between similar concepts.

This is however never the situation as an information system is an interpretation of a reality, and interpretations may, and nearly always do, vary widely. This is not easily accomplished as one cannot use predefined mappings between related concepts as the same concept may have several different meanings in different contexts.

i. A failure to have ability to access healthcare information.

ii. A failure to have reliable healthcare information.

iii. A failure to apply healthcare information.

Interoperability enhances expediency by allowing health care givers to share patients’ medical history, laboratory results, and other significant data in an opportunity and in an accurate manner. The lack of instant access to patient health information is the cause of 1/5th of medical errors and other drawbacks occur from the deficiency of connectivity. Similar problem occurs for medications, which can differ with another to cause life caution through medication conflicts. All relevant data would be shared between healthcare experts in the same or in different institutions. The infrastructure of interoperable healthcare figure is shown in Appendix. Since healthcare experts are autonomous
and work regularly. The connected and unconnected systems would be synchronized and interoperable.

It resulted in extra cost as well as, danger, and pain. Currently, interoperable EHRs will achieve high efficiency, quality healthcare. Interoperable system assists not only the consumers who travel between different regions but also guarantees consistency of quality healthcare service provided. Interoperability offers consumers with more privacy via preventing the unauthorized users from accessing and tracking healthcare givers who view patient health information for quality care.

The advantages of the interoperability system will cover both consumers and healthcare givers, which can be classified into improved practicality, privacy, access, and quality of health care. Interoperability system may reduce the time that consumers and givers should spend during filling out medical application forms, which influence both cost and expediency. The lack in accessing vital health information fragments and shared knowledge can produce duplicate clinical tests to be arranged. In the same way, interoperable system enhances stability of healthcare when service provided is conducted between multiple healthcare givers, specifically for consumers with persistent illness. The meaning that healthcare data is collected and stored into an electronic holding place called data repository.
2.13.3 Interoperable Patient Information Systems

If healthcare systems continue to work without interoperability, then there will be no change and as IT strategist discussed, there will still be a gap among patients/citizens, healthcare organizations and municipalities. Interoperable patient information systems will not only allow sharing of patient data and information but also caregivers can share their expertise. IT strategist thinks that there is not much resistance in health care organizations to introduce interoperable healthcare systems. Everyone was afraid of getting online banking services because they were afraid that anyone can see my account details.

As discussed earlier in this study, interoperability is something which is emphasized much in National eHealth Strategy for eHealth. But today, almost everyone uses it and they are much more secure than in the past. For legal issues like who should see my health record and who should not, people’s fear is similar to one when online banking services were introduced. He also added that 10% of emergency cases occur due to this lack of sharing of patient’s medical history. From this, it is clear that interoperability will not only help in providing better eHealth services to citizens but also it will bridge this gap between all four
stakeholders. This is very much helpful in a case where a citizen moves out of a county.

For instance, a patient moves from HOSPITAL 1 to HOSPITAL 2 and he gets sick, the general physician or even a nurse could share data from his general physician or nurse. Health care organizations and providers believe that interoperable healthcare systems will reduce this rate. For example it is not possible for a patient to see his own medical data in another hospital except where they are registered.

This must be made sure by interoperable healthcare systems to allow customize the view of data of a particular patient so that unwanted data could be disallowed from being displayed to unauthorized persons. So eHealth records would also be secure in the same way, let’s hope. This is rather good because a vast majority of citizens also demand greater sharing of their medical record as mentioned by strategy maker, 98% Swedish population wants it. This makes the advantages two fold.

According to project assistant, current problem in developing countries is that a patient can’t see his/her medical data from one institution to another even in same city. The interoperability is central to the idea of building smart, efficient and effective eHealth applications and services. Strategy maker raised a challenge very correctly that not
every patient will want to share his/her complete medical data. It means that there will be legislation involved to restrict unwanted data sharing. One of the challenges is to make patient data and record about his/her medical history accessible at national level.

2.13.4 Electronic Health Record Interoperability

It is surprising that health records are not always being available at a point of clinical care, particularly in large institutions. The second part holds a basic information model for symbolizing and connecting the model occasions.

Number of standards already exist to deal with the EHR architecture and interoperability functions, such as CEN EN 13606 EHRcom [101], HL7 CDA [102], the ISO/TC215 Working Group1 [103], open EHR [104]. The third part will include models reflecting a diversity of clinical requirements. A similar proportion of staff time is committed to handling patient data in primary care. However they are readily portable. They revealed on the significance of database elements that stored at GP site to facilitate valuable information sharing [105].

The researcher pointed out that EPRs are increasingly being used as an instrument to standardize healthcare patient records which is not
achievable with the paper based records [106, 107]. A published research contribution reveals that there is a awful need for standardizing EHR as well as interoperability standards [108, 109]. An acute hospital gathers and process information, almost exclusively through paper systems. Patient healthcare data is shared between healthcare locations in the UK using aggregated and non-aggregated schema for extraction of patient data, which are stored in general practitioner (GP) database.

The term standardization comprises of EHRs structure, content and the way of exchanging them; it will assist and improve the connection between health care givers at distributed sectors, sharing of data between distributed EHR systems, and support daily medical work [110].

Many programs have been introduced for accomplishing the interoperability; current EHRs are simply not set with data items in order to share them between different healthcare institutes. There is an aspiration to create international standards through which EHR can be shared among different healthcare organizations nationally and worldwide. This consists of five parts. Although there is strong wish to achieve a common standard for EHRs, the existence of numerous standards will move all the complication and cost of margining EHRs.
The fourth and fifth parts are the strategy for adapting the part 3 and 4 subsequently. Currently, there is a working group to modify this standard to address interoperable EHRs. The prototype needed more work in order to encompass all the required aspects to achieve an absolute EHR standard.

2.13.5 Roadblocks to Interoperable Healthcare System

It includes a need to update, replacements, and changes in software, hardware, and procedures as standards and training are sophisticated. Thus, cooperative work would become impossible. Any professional entity whether it is a business firm or any should interact with each other with a motto of cooperative work so as to perform certain functions. Interoperability is prominent feature as it does not have self-contained units of work.

Implementation of interoperable healthcare system may give rise to various challenges: Organizations that deal with EHR systems have financial motivations to act against each other [111]. However, by introducing EHR standards, pressure will be increased on these companies to support their consumers connected systems quickly and simply in an unprecedented way.
However, standardization is the major step required for sharing and classifying healthcare data with respect to quality and proficiency. This kind of work culture is called cooperative work. The computing systems become more heterogeneous as computing technology becomes more advanced [112].

2.13.6.2 Healthcare Providers

This category includes healthcare experts, belonging to a variety of professions. Unfortunately, very few have all the necessary and appropriate skills in computer science and technology; or the necessary time to dedicate resources to tackle interoperability problems or participate actively in standardization of medical informatics and standards.