An eBusiness-based Framework for eHealth Interoperability

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Abstract— **A significant challenge for eHealth systems is the need for interoperability of both the processes of care and the data that is used within those processes. Failures of interoperability can lead to adverse events such as medical or communication errors at the clinical level or inefficient use of services at the organizational or regional level. However interoperability is a multi-faceted concept that must take place at the clinical, organizational and regional levels. Thus we need to look at healthcare interoperability from an overall system perspective. Various eHealth technologies provide the tools to facilitate integration but those tools must be used within a framework that integrates all users of the system across the various levels. This paper presents an eBusiness based framework for eHealth interoperability that maps specific processes and tools and applications to the multiple levels of the healthcare system. The framework can help us focus research and system development efforts to enable eHealth integration.**

Index Terms—**eHealth, interoperability, eBusiness, integration, healthcare system redesign**

I. INTRODUCTION

The term *electronic health* – or *eHealth* – has been coined to describe applications of information and communication technology (ICT) in the health care sector. Typical eHealth solutions are electronic medical records, applications in telemedicine, consumer health services (e.g., personal health records such as Google Health and Microsoft Health Vault), public health surveillance systems, and health decision support systems. Motivated by the assumption that eHealth interoperability will benefit patient care and increase efficiency of health services, developed countries world-wide have invested significant resources in the development of eHealth interoperability infrastructures. Despite benefits of eHealth solutions on the local level [1-4], the progress achieved in making eHealth solutions interoperable is lacking behind expectations in most jurisdictions [1, 2].

Researchers studying barriers and challenges of eHealth interoperability suggest that eHealth interoperability must be viewed as part of a larger context, involving concerted measures on different levels [1]. Compared to the eHealth domain, the ICT supported commerce (eBusiness) has attained a much higher degree of maturity and interoperability to date. This begs the question whether the eHealth sector can learn from these successes in eBusiness.

Avison and Young have pointed out similarities and differences between the two domains of eHealth and eBusiness [2]: Similar to eBusiness, eHealth is process-oriented, product (patient)-centric, and integration-oriented. On the other hand, differences exist in eHealth with respect to disparate management structures (clinical vs. operational), a large variety of different "customers" (e.g., patients, clinicians, payors, researchers, governments, users), a "product-variability" that is many magnitudes higher than in other sectors (i.e., each patient is unique), and the lack of hard metrics to determine overall business success. While Avison and Young admit that the eHealth sector has not done a good job in adopting best practices from other business sectors, they also point out that certain unique characteristics of the health care domain require the development of new approaches that are not available elsewhere [2]. They specifically cite scale and the need for person-to-person interaction as the two most important problem factors.

In this paper, we investigate the question how a modern eBusiness based framework can be used to improve the design and interoperability of eHealth solutions. The eBusiness sector has evolved rapidly over the last decades and generated methodologies, processes and technologies for large-scale knowledge-intensive industries. The Semantic Web and emerging technologies such as Web 2.0 has created opportunities for transforming the web from a document collection repository to a collaborative social space [3]. Web 2.0 and other ubiquitous technologies can support healthcare delivery by creating collaborative communities where patients and medical professionals communicate and exchange data while administrators and policy makers monitor and evaluate healthcare delivery.

However before we can achieve our vision of a collaborative and interoperable healthcare system we suggest there are two key challenges we need to address. First is the need to understand the specific and often complex needs of healthcare delivery to identify where ICTs and emerging technologies such as Web 2.0 can

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improve healthcare delivery. Second is the need to work towards a common interoperable framework for eHealth.

This paper offers a conceptual framework to address those two challenges. The rest of this paper is structured as follows. The next section provides an overview of the state of the eHealth sector today. Section 3 provides an overview about processes, models and methodologies that have been applied successfully in other business sectors. Section 4 investigates an eBusiness-based framework to develop interoperable eHealth solutions. We draw our conclusions in Section 5 and close with a discussion of related work.

II. THE STATE OF THE EHEALTH SECTOR TODAY

eHealth infrastructures are developed to various degrees throughout the industrialized world. In contrast to other business sectors, different countries have largely different health care systems and cultures. These factors have an important influence on the development of interoperable eHealth infrastructures. Some countries, such as the U.K., have a national universal health care system and a single entity is charged developing the eHealth infrastructure. Other countries, such as the U.S., lack a universal health care system and eHealth developments are centred on different local initiatives. Again, other countries are positioned between the two extremes, by making health care a jurisdictional matter of individual provinces, but legislating universal health care access for all citizens, e.g, Canada.

Recent studies on the ICT readiness of OECD member states show that the European Union has some of the leading countries with respect to the use of eHealth technologies in primary care. Meyer et al. have found physician eHealth usage rates of 90% and more in nine out of the 27 member countries [1]. This compares to 28% in the U.S. and 23% in Canada [4]. However, even in leading countries such as the U.K., eHealth interoperability remains a problem. Meyer et al. conclude:[1] "*One main area to be tackled concerns the electronic exchange of patient data by networks such as the Internet.*"

Denmark is one of the few countries achieving a relatively high degree of eHealth system interoperability [1]. Danish researchers emphasize that new technologies alone will not solve the semantic interoperability problems. Rather, they stress the importance of collaborative standardization processes, involving representatives of all relevant stakeholder groups [5].

We will discuss standards and implementation as two key issues that are critical for eHealth. We will then discuss those two issues in a case study of Canada's eHealth infrastructure.

A. Standards

Several organizations have been created to develop and evolve interoperability standards for the eHealth industry. Among them are Health Level 7 Inc. (HL7), Continuity of Care Record (CCR), Digital Imaging and Communications in Medicine (DICOM), Clinical Data Interchange Standards Consortium (CDISC), OpenEHR, and the European standardization committee CEN that uses OpenEHR in its standard on Electronic Health Record Communication (ENV 13606). All of these organizations define so-called *information-level* standards, as opposed to *knowledge-level* standards. Information-level standards define data structures and formats to be used for interoperability, however they do not prescribe detailed controlled terminologies to be used for semantic interoperability. There is a common agreement that maintaining information-level standards separately from knowledge-level standards facilitates interoperability, because domain knowledge is subject to a more rapid evolution and update.

Examples for knowledge-level standards (also called clinical coding systems) are the Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT), the International Statistical Classification of Diseases and Related Health Problems (ICD), and Logical Observation Identifiers Names and Codes (LOINC). Recently, SNOMED-CT has received significant international attention and momentum through the founding of the International Health Terminology Standards Development Organisation (IHTSDO).

B. Implementation

The above standards are far too complex and generic to provide a sufficient basis for eHealth interoperability. Their customization and deployment must be guided, managed and evaluated by implementation organizations. Examples for such organizations are the National Board of Health in Denmark, the NHS National Programme for IT in the U.K., Health Canada Infoway in Canada, and cross-national implementation organizations such as EuroRec in Europe and IHE (Integrating the Healthcare Enterprise) internationally.

While specific regional differences exist in the approaches taken by implementation organizations, they also share many common challenges, including the need to:

- *Integrate legacy systems* (i.e., pre-existing systems) of heterogeneous nature,
- *Build ultra large scale systems* [6], i.e., systems of systems,
- *Engage and consult* stakeholders from different disciplines,
- *Negotiate and harmonize requirements* from many different jurisdictions (e.g., states, counties, health authorities),
- *Develop* interoperability standards to facilitate integration of eHealth systems,
- *Assess* and *certify* conformance of eHealth systems with respect to interoperability standards,
- *Evaluate* the effectiveness and benefit of developed eHealth infrastructure components.

C. Case study: Canada's eHealth infrastructure

In Canada, health care services are under provincial (territorial) jurisdiction. At the same time, Canada has federal legislation that guarantees universal access to health care and portability of insurance coverage to all its citizens. In particular the requirement for portability implies the need for pan-Canadian interoperability of eHealth systems. Health Canada Infoway (Infoway for short) has been founded in 2001 as a federal not-for-profit organization to foster the implementation of interoperable eHealth solutions in the different provinces and territories. Infoway estimates that approximately 40,000 distinct systems will need to be integrated in the envisioned pan-Canadian health infrastructure, including existing legacy systems and newly procured components. Infoway's strategy is two-legged, i.e., it acts as a facilitator as well as a strategic investor. In its role as a facilitator, Infoway has developed an architecture blueprint for an interoperable electronic health record (EHR). Infoway has created a set of online collaboration forums and bi-annual face-to-face conferences called the Standards Collaborative with the objective to develop and refine eHealth interoperability standards. In its role as a strategic investor, Infoway has funded 276 eHealth projects in different provinces and territories. Funding is provided primarily to eHeath infrastructure projects, e.g., client registries, provider registries, drug registries, picture archiving and communication systems (PACS), and shared electronic health records, but implementation of point of service systems, e.g., electronic medical record software at the desk of primary care physicians is not directly funded.

Provinces have created their own programs to fund the implementation of point of service systems in primary care, e.g, the Physician Information Technology Office (PITO) in British Columbia or the Physician Office System Program in Alberta. Provincial and federal initiatives are meant to align with each other but interoperability problems have been found [7]. Infoway's total funding to date amounts to $2,1 billion. Certification programs for standards-compliance are available currently only for consumer health products, others are under development. Jointly with academics, Infoway has developed a benefits evaluation framework [8]. The initial version of this framework has been critiqued as being limited to the evaluation of local impact only. An extension to global, system-wide characteristics has been suggested [9].

Infoway's current mandate will end in 2015 and it is undetermined which organization will take over the evolution of the interoperability standards at that point.

III. EBUSINESS PROCESSES, MODELS AND METHODOLOGIES

e-business has evolved differently than eHealth in that e-business evolved from conceptual models to the development of specific technologies. eBusiness is less application centric and instead has focused on models and processes for using ICT to help implement organizational strategy. Trites and Boritz [16] suggest that conducting e-business requires three components: models and strategies, architecture and applications. Models and strategies look at how a business organizes its core business processes to achieve objectives. Merchant, subscription and brokerage are three examples of models. The specific model or combination of models an organization uses help define its e-business strategy. Architecture includes the tools and technologies that provide the backbone for implementing a strategy and include the Internet, enterprise resource planning (ERP) systems, and security and controls. Applications are the specific business processes that are facilitated such as supply chain management, customer relationship management, and business intelligence. We will describe two specific examples of how e-business models have provided value to the business community by providing a means helping organizations define their business model and identify where ICT can support the model.

The first example is supply chain management, which represents the set of processes that integrate suppliers, manufacturers, distributors and retailers as a virtual organization in order to deliver products to a customer. Supply chains rely on process and information interoperability across the entire supply chain process, both internal and external. [14]. A common reference model, the Supply Chain Operations Reference (SCOR) Model, is a planning tool used by organizations to help with the complexity of supply chain management [14].

The SCOR was developed in 1996 by the supply chain council and was not meant to be a technical or vertical (domain specific) level approach but rather a high level business process reference model that can be applied to any company's supply chain information or process flows [17]. The five high level processes of the SCOR model are plan, source, make, deliver and return. The SCOR also contains descriptions of management processes and relationship among the processes, metrics for process management and standard alignment to software functionality. The SCOR model is used to represent a firms specific needs in order to design a supply chain management system (SCMS), which is an information system (IS) architecture for a supply chain that ensures the right information is available for the right process at the right time.

The SCOR also enables the development of metrics and key performance indicators (KPI) based on a company's supply chain [17]. Because the KPIs were developed through a standardized approach they can be used for benchmarking across different organizations [17].

The second example is the value chain, which is the separation of a business into a series of value generating activities [23]. The value chain contains a set of primary activities, which include inbound logistics, operations, outbound logistics, marketing and services, and a set of secondary activities that includes procurement, human resources and technology development. Businesses that are developing technological solutions to support e-business use the value chain to identify where ICTs can support specific business needs.

IV. ADOPTING AN EBUSINESS APPROACH TO EEALTH

Although Avison and Young state that adopting an e-business approaches such as ERP systems or SCOR models in the healthcare does not sufficiently solve all identified problems [2], we suggest that the eHealth agenda can benefit from research in e-business. Specifically a healthcare equivalent of the SCOR model would help eHealth research by focusing attention on common eHealth processes that occur across different levels of care and the interoperability that is needed to connect those processes and levels. Further, a healthcare equivalent to the value chain would enable us to identify where specific ICTs can provide value for the different eHealth processes. The argument can be made that eBusiness is successful because much of the initial research was on understanding the process level (such as a supply chain) and then developing ICTs to support those processes, whereas eHealth has largely taken the opposite approach. Ironically enough whereas eHealth tends to be viewed more from the perspective of individual technologies e-business has the opposite problem as [15] suggest that there is little known about the integration of supply chains and ICTs.

Avison and Young believe the business enterprise is too small of a building block for a healthcare framework and instead they suggest a national context would be a better starting point [2]. However we believe that approach is also problematic as it may develop high-level solutions that neglect the reality of heterogeneous legacy ICT systems and the different organizational structures existing in different health care jurisdictions. Individual healthcare enterprises have their own level of complexity and that differs according to the centres, services and patient populations where care is provided. A pure top-down approach will not have the required level of granularity for implementation into the hospitals and clinics to support front line care.

Rather we suggest an eHealth framework must be focused on interoperability and process support across the entire eHealth spectrum that includes the individual patient and provider level (micro level), multi organizational or team based level (meso level), and performance management and population health level (macro level). Although ICTs currently exist to support individual processes at each level such as patient portals, group decision support systems, and business intelligence tools, the different ICTs have largely been developed as individual technologies and not integrated services. Developing an eHealth reference framework will enable us to look at healthcare delivery as a seamless set of services where ICTs provide specific services but are still part of an overall integrated framework.

Fig. 1 shows our eHealth framework. The top of fig. 1 identifies different needs that the healthcare system must support or deliver. The different needs include healthcare services such as patient and population health services but also supplementary healthcare processes such as education, research and program or policy development. The bottom part of fig 1 shows the eHealth framework itself. The framework contains three basic components or ‘pillars’: the healthcare system, interoperability infrastructure, and tools and applications. Each component is described below.

A. Healthcare System

The need for a revised and integrated healthcare system has been widely articulated, perhaps most clearly in the 2001 study ‘Crossing the Quality Chasm: A New Healthcare System for the 21st Century’ that identified deficiencies in the healthcare system including car being overly complex and uncoordinated, and operating as silos with incomplete sharing of information and processes [21]. Healthcare system redesign includes applying eHealth applications to support development of care teams and coordination and delivery of care across different services and locations. One particular need is the linkage of the micro, meso and macro levels of the system, Although the three levels of the healthcare system have traditionally been viewed separately (i.e. the patient, organizational or population level) the emergence of disease outbreaks and other healthcare crisis have raised attention to the need for integration between the levels. For example the 2003 SARS and 2009 Swine flu outbreaks have shown that effective management of such outbreaks requires integration of clinical and population health levels. Policy that is implemented at the population level is instantiated by individual patient cases. We need to be able to integrate individual patient data to assess healthcare delivery at the population level. Further, after Hurricane Katrina struck New Orleans in 2005 they realized that poor coordination of medical services hindered the delivery of care to those that needed it [19]. Again, a lack of patient-population integration prevented the timely response to the crisis. Aside from the need for integration at times of crisis it is also necessary for evaluation of day-to-day care delivery. Poor integration also makes it difficult to evaluate the healthcare system as evaluation metrics are often developed at the population level and are difficult to scale down to the patient level.

The healthcare system component of our framework uses patient care as the common point of reference because healthcare delivery originates at the patient level. We represent patient care at three levels of granularity. The micro level is individual patients and care providers. The meso level is many micro level participants rolled up such as at the organizational or team level, and the macro level is the government or health authority level. Patient care is presented as being either upstream or downstream. Upstream is the individual patient level such as the patient record of an individual patient. Downstream is the aggregation of multiple patients at the population health level.

B. Interoperability Infrastructure

A necessary prerequisite for interoperability in eHealth and eBusiness alike is the sharing of data, information and knowledge. This area has received the largest amount of attention and effort to date. Organizations such as HL7 have been working for over two decades on the development of eHealth data interoperability standards. Still, the goal of obtaining such a shared standard with

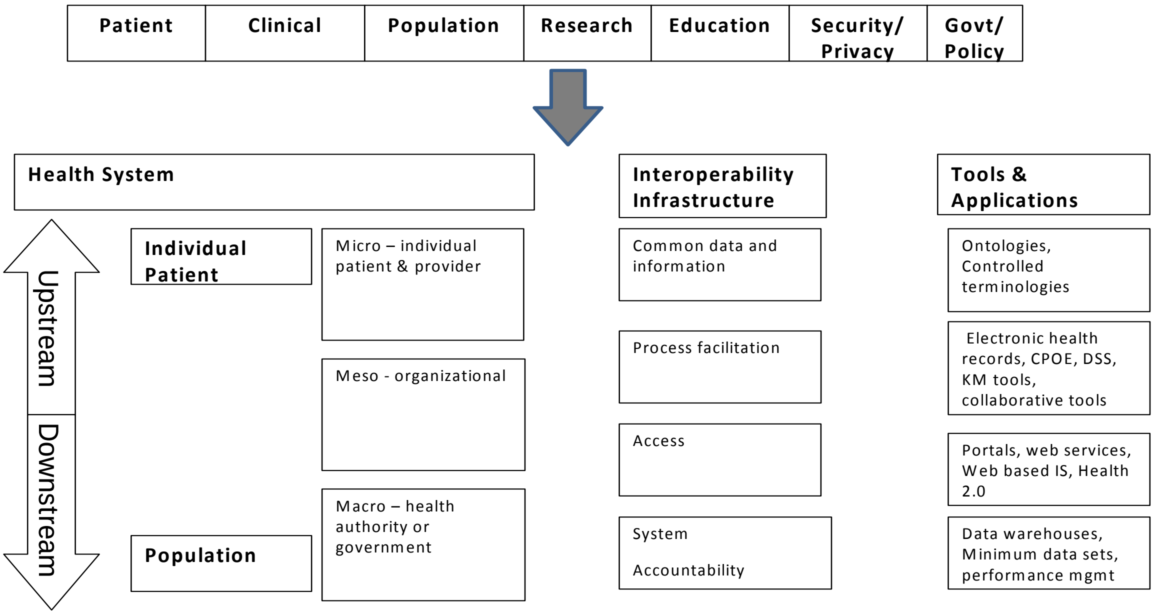

Figure 1. e-business inspired eHealth interoperability framework

broad implementation has not yet been attained. We argue that one reason for this failure has been a lack of separation of concerns when dealing with interoperability problems. For example much of HL7's work has concentrated on defining standard *messages* to be exchanged between eHealth systems. The notion of *messages*, however, effectively intermixes data and standards. Realizing a problem, HL7 has attempted to remedy this situation by introducing a major paradigm shift since version 3 of its standard (released in 2005). HL7 v.3 is based on a shared reference information model (RIM) that is independent of particular application in message-based systems.

Another problem is the lack of separating between notions of data, information and knowledge, respectively. The term *information* is commonly defined as "data in context", while *knowledge* is generated through "applications of information". Distinguishing these concepts is important for interoperability. Smith and Ceusters criticize the HL7 RIM as incoherent for failing to do so: "*Rather than distinguishing the two tasks, of information model and reference ontology, and addressing them in separation, the RIM seeks to tackle both simultaneously, through ambiguous use of language.*" [10]

Less effort has been invested in the three other components in the interoperability infrastructure column in Fig. 1. While eBusiness has a long history of process modeling, management and optimization [11], process definitions in health care have traditionally had the objective of formulating best-practice guidelines [12] and with no or little reference to eHealth system interoperability.

Similarly, eHealth system architectures have largely emerged as ad-hoc connected peer-to-peer systems with little conceptual research and architectural planning and management. This approach has been recognized for its lack of scalability [6] and its inability to support critical functions. For example, it took several days for a major national eHealth information system in the U.K. to recover in 2006. Many similar incidents have been reported and indicate that the eHealth sector has yet to learn from eBusiness common architectural practices of putting in place effective business continuity plans.

process concerns (see second component in the Interoperability column in Fig. 1). Messages contain data, but they also have a process-dependent purpose and role. Failure to separate these two concerns has significantly complicated the development of interoperability

Another lesson the eHealth sector can learn from eBusiness is the importance of a system-wide accountability structure. Implementation and management of interoperability requires accountability and assurance that all relevant actors "play by the rules". eHealth interoperability projects are often impeded by unclear reporting and accountability structures among multiple jurisdictions. As an example, consider Canada's diverse provincial initiatives on developing eHealth solutions for the primary care sector, on the one hand, and Health Canada Infoway's shared Electronic Health Record initiative, on the other hand. Both projects are essential for a functioning eHealth value chain, but there is limited accountability between them.

C. Tools and Applications

This column of our reference framework aligns the aforementioned interoperability concerns with tools and applications developed in eBusiness and eHealth. Common data and information can be achieved by leveraging controlled terminologies and using conceptual models such as ontologies to promote common understanding of the healthcare domain. Controlled clinical coding systems introduced in section II such as SNOMED need to be incorporated into eHealth tools and applications where applicable. Since the formation of the International Health Terminology Standards Development Organization in 2007 there has been a concerted effort to use SNOMED as the terminology standard for EHRs. Ontological engineering can be a valuable tool for developing models of different healthcare domains to support the sharing and integration of data and processes. However we must ensure that existing ontologies such as upper level ontologies are the basis for ontology design in order to promote reusability and integration. Data, information and knowledge interoperability can be supported by ontology definition languages developed in the Semantic Web community, e.g., OWL, RDF, DAML. Formal reasoning systems like description logics will help with the maintenance and evolution of complex ontologies. Ontological engineering should use existing development methodologies such as On-To-Knowledge and METHONTOLOGY [18] to ensure that ontologies are designed using good engineering principles.

On the process facilitation level, progress has been made with respect to designing and evaluating specific eHealth applications, including EHRs, Clinical Physician Order Entry Systems (CPOE), and Clinical Decision Support-Systems (CDSS). What is needed is to integrate the different eHealth applications to the specific needs of health care**.** It is perhaps unfortunate that we refer to eHealth applications by a particular process such as a decision support or order entry system. A 2005 systematic review by Kawamota identified context, computerized access, supporting information and adaptation with workflow as the factors most needed for a CDSS to be successful [20]. From that perspective although decision support is the objective of the system it is as much about the overall fit of the CDSS to context and workflow that will determine its success.

Although eHealth applications are often designed to support micro level clinical tasks there is a need for research on how to design ICTs to support team-based tasks at the meso level. It has been described how EHR frameworks and standards tend to focus on individual provider needs as opposed to the needs of team based care [20]. As more healthcare is provided via teams we need to ensure that eHealth tools and applications are designed to support teams. For example teams are frequently separated by time and space and thus we need to develop collaborative tools that provide an interoperability bridge for teams. Emerging Technologies such as Web 2.0 with its emphasis on collaborative support will be a useful application for supporting collaboration across multiple settings and providers [13].

Access is perhaps the most important component of the framework as it is the means of getting eHealth applications out to those who need it. Access needs to be considered from multiple perspectives as it can include provide accessing to data, healthcare services or research evidence. Access can be achieved by drawing on tools and applications such as web portals, and the development of web services and service-oriented architectures. Standard protocols such as XML and other web services languages enable access across different settings. As more patient care is provided in mobile locations such as patient's homes there will be a need to design mobile tools to provide access to required functionality. Mobile (M)-health will become increasingly important in the forthcoming years and thus mobile tools will need to provide the required functionality and have the requisite level of security.

System Accountability will need to leverage tools such as data warehouses, minimum data sets and performance management tools. Currently much of system accountability is done passively. Data is mined and reviewed for congruence with national and provincial standards long after the care has been provided. Thus accountability and required systems change occur after the fact. In an integrated eHealth system we will be better able to integrate micro and meso level data to allow us to do timely macro level system accountability. We will also be able to take systems and policy changes arising from macro level analysis and incorporate them into micro and meso care delivery in an expedited manner.

V. CONSUMER-DRIVEN INTEROPERABILITY

eHealth system design has traditionally focused on the needs of health care providers. Few classical medical informatics textbooks contain chapters on consumer needs [23]. In terms of our interoperability framework, traditional eHealth systems have focused on the meso and marcro levels, while neglecting the micro level. With the increasing availability of the Internet and advanced Web-based application paradigms, this situation is shifting to a more patient-centred focus. This trend has given rise to the emerging field of *Consumer Health Informatics* (CHI), which has been defined as "*the branch of medical informatics that analyses consumers' needs for information; studies and implements methods of making information accessible to consumers; and models and integrates consumers' preferences into medical information systems*" [22]. CHI has driven the development of a new class of eHealth applications, extending the health services supply chain directly to patients, including applications for self-management of diseases, preventive care services, decision support, personal health records, and different forms of telemedicine.

We expect that the move to CHI will play a major role in enabling and driving eHealth interoperability, analogously to the role that B2C (Business to Customer) applications have played in the eBusiness domain. Popular "killer apps" such as eBay and Amazon have initially emerged as B2C and even C2C (Customer to Customer) applications and have since had an important function in furthering eBusiness interoperability on a global level, including B2B (Business to Business) value chains. CHI applications such as Google Health, Microsoft HealthVault and other emerging systems may become a similar "killer app" for eHealth interoperability. Along with this increasing patient-centric focus will come a fundamental shift in power that will blur the traditional boundaries of health service providers and consumers. Similarly to how eBay and Amazon have blurred traditional notions of customers and vendors, Web 2.0 technologies such as social networks may empower patients to support each other with decision-support, health prevention, disease management and recovery. Professional health care providers and health care organizations will increasingly move into the role as partners and facilitators rather than as the single source of health information and services.

In order for this vision to succeed, we need to develop an interoperability infrastructure that takes this emerging consumer-health focus into account, on all level shown in Fig. 1.

- On the data and information level, we need to incorporate standards that are accessible to laypersons. This may include aspects such as (1) the adoption of consumer-oriented terminologies, while mapping them to clinical codes, and (2) the adoption of an archetype-centric paradigm of modeling information content in a modular and reusable fashion, as apposed to the traditional message-centric paradigm.
- On the process level, we need to incorporate patients as full partners in the health care domain, integrating them not only at the receiving end of the value chain, but also as value generators.
- On the access level, we need to provide mechanisms that enable secure and dependable sharing of health information between consumers and providers while ensuring that privacy and accuracy is preserved. Emerging technologies such as Web 2.0 will be a key driver of increased accessibility.
- Finally, at the system and accountability level, we have to devise mechanisms that ensure the quality of consumer-oriented eHealth systems and the dependability of the services they provide. Schemes for compensating eHealth caregivers for their services need to be developed.

VI. CONCLUSIONS

This paper presented an interoperability framework for eHealth systems design that bridges the micro, meso and macro levels of care delivery. Our framework draws upon supply chain management and the SCOR model. The framework also described the specific interoperability infrastructure needs and how tools and applications can provide those needs.

The key message from our framework is that interoperability must take place across all three levels of the healthcare system. There is little to be gained in debating about whether a healthcare framework should be developed top down or bottom up. In fact we suggest such discussions go against the very principles of integration and interoperability. Instead we need to look at the healthcare system as one integrated system that is supported by different levels of interoperability. As we incorporate data and information into eHealth applications we need to leverage existing standards both for terminology and for data exchange. That common data and information must then be used as the basis for developing tools and applications to support clinical tasks such as EHRs, CDSS and CPOE as well as performance management and data warehouse applications to support system accountability. Further, we need to move way from developing disparate eHealth applications to support specific needs and instead we must view eHealth development as a set of integrated services. To achieve that objective we need to leverage the ubiquitous and collaborative functionality of Health 2.0 to design integrated online communities of eHealth applications that are available anytime and anywhere.

Finally, eHealth applications developed to support micro level care delivery must roll up into meso (team) level applications and macro (population health and policy) level applications. Overall, we must look at eHealth from less of a technology centric view and instead view it in terms of the specific needs of the users of the system including the individual patient and provider (upstream) and the health authority and government (downstream). Only then will we be able to develop ICTs that provide value to the eHealth users.

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