Interoperability Within E-Health Arena

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Abstract: Integrated care approach and the broader view on a patient's care is something that today's healthcare systems thrive for. Medical information collected from many disparate sources, accessed by authorized users through Electronic healthcare record (EHR) is enabling technology behind. This article gives overview of different interoperability aspects related to data exchange and maps it to usual healthcare business processes. It also comments HL7 CDA being one of today's widely used standards for clinical documents exchange. One concrete approach to Personal Healthcare Record (PHR) to EHR integration using HL7 Continuity of Care Document (CCD) is described.

1 INTRODUCTION

The fact that ICT systems can bring a lot of benefits to all stakeholders within healthcare system is well known (Dobrev, 2009). However, successful implementation and proper introduction of such ICT systems in existing healthcare environment is long and expensive process. Many countries can't increase efficiency in healthcare sector through ICT system introduction. One of three main reasons for this is lack of commonly defined and consistently implemented standards (OECD 2010). Without common standards, one of the biggest advantages introduced by ICT systems in healthcare, which is access to comprehensive and high quality patient medical information in any time or place, remains unsolvable puzzle. Due to the fact that medical data originates from many disparate sources, efficient sharing across organizations, administrative domains or even countries is of utmost importance. Interoperability of implemented ICT systems plays vital role in achieving this goal.

Stroetmann et al. (2009) defined interoperability in healthcare context "as the ability, facilitated by ICT applications and systems: to exchange, understand and act on citizens/patients and other health-related information and knowledge; among linguistically and culturally disparate health professionals, patients and other actors and organizations; within and across health system jurisdictions in a collaborative manner."

In order to meet these requirements, all interoperability aspects, namely legal, organizational, technical (eHealth Governance Initiative, 2010) and semantic (EN13606 Association, 2015) must be addressed (Kovac, 2014). A real life interoperability issues are showed in the example that follows.

Ana is a 22 years old female without any chronic disease. On January 23rd she woke up and felt pain in right side of abdomen. She decided to book an appointment with Dr. Henry Levin, her general physician through the patient portal.

On the date of the scheduled appointment Ana went to the polyclinic to see Dr. Levin. Admission

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office staff (AO staff) checked if there were any previous visits of Ana in the system using her identity card. AO staff found general data about her in the system (from her previous visits to the same polyclinic.

Since Ana had set access right level for her medical data to "ask patient consent each time" through the patient portal, AO staff couldn't access medical data and asked Ana to provide consent. Ana refused to provide a consent and signed the document stating that only dr. Levin can access her medical data.

Dr. Levin was logged in to his Hospital Information System (HIS) and chose to review Ana's electronic medical record (EMR). He decided to check her physical status immediately, opened a new case in the system and invited Ana to step into his office.

Even before physician saw the patient, number of interoperability issues had emerged. The first one was legal - who is the owner of medical information: patient or the physician who generated it; how the access rights are managed; can patient choose which part of medical record will be accessible to medical staff. The second issue is of organizational nature. Healthcare institution might have one central reception, one reception per clinic or completely distributed one. Reception process might be completely administrative where no medical information is needed or it can include triage, taking anamnesis and status in which case access to previous medical information is mandatory.

Dr. Levin noted Ana's anamnesis, physical status and result of his observation in the system and issued several requests for laboratory tests and additional consultations from the surgeon and gynecologist.

Unless Dr. Levin understands the data within Ana's electronic medical record (EMR) in the same way that all those users who put information into EMR have wanted, the whole concept of EMR is missed. Having information in free text form is definitely better than having nothing but medical data stored in a structured format can be used for automatic alerting on drug-drug interactions, provision of drug-diagnose contraindications, automatic suggestion of applicable clinical practice guidelines (CPG), automatic reporting, reducing administrative work etc. How clinical documents are structured, what coding systems are used, whether the same or different codes for the same notions are used, are only part of semantic interoperability aspect than needs to be taken care of.

Laboratory order was available through the Laboratory Information System (LIS) at the same moment Dr. Levin sent it through HIS.

Since completely new information system (LIS) appeared in storyboard, technical interoperability issue emerged. Legal aspect returned and became even harder to address since laboratory personnel actually did have Ana in their care but never met her. Ana didn't give consent to all personnel within hospital to access her medical record so important information that might affect laboratory results was not available for laboratory staff. Since physician and laboratory technician / biochemistry engineer were of different specializations and were using different applications, there must not be any misunderstanding of what test were requested and what results were sent back. Did all healthcare professionals use same coding list or at least some mapping engine (terminology server) existed?

The storyboard ends here since majority of interoperability issue types within one healthcare institution were already mentioned although only three steps were exercised: admission, first examination, and referral to laboratory/consultation. In practice, stakeholders within same institution can efficiently share data because they use the same application or some proprietary integration is done if multiple applications exist. But if Ana were urgently referred to another hospital because of suspected acute appendicitis she would be admitted to the hospital with different internal processes, different specialization and HIS from another vendor. These two healthcare institutions were connected only through national infrastructure if it existed. This means that if integrated care is to be supported, proprietary integration that is possible within one institution has to be properly handled through solving all the interoperability issues mentioned above.

2 E-HEALTH BLOCKS

2.1 Electronic Medical Record

While introducing ICT into the healthcare institutions, system Purchasers (not the users themselves) often prioritize administrative over medical processes. True value of information systems / applications in healthcare provision processes is proper management of medical information. Therefore medical documentation module should be the core of every application within general practitioner and specialist practice

application or hospital information system. This core component is called electronic medical record (EMR). In simple terms, EMR is a digital version of the paper charts in clinician offices, clinics, and hospitals (Health information technology, 2015). Market today witnesses thousands of EMR systems. Unfortunately lack of standards led to the situation where most of them are implemented on different information models that are followed by the completely different graphical user interfaces, different ways how data entry is supported and completely different application logic.

2.2 Electronic Healthcare Record

Today's healthcare challenges are numerous and there is myriad of ways how healthcare authorities try to address them. One important tendency in coping with these issues is shift towards so called integrated care. The core of such an approach is broader view on a patient's care. This requires boundaries among multiple EMR's to vanish and much more data about the patient made accessible than it is collected in any single healthcare provider's office. The solution for this is electronic healthcare record (EHR).

EHR contains information generated by all the clinicians involved in a patient's care process, with all these clinicians having also access to it. EHR also shares information with other health care providers, such as laboratories and pharmacies. EHR should be pervasive and follow patients – to the specialist, the hospital, pharmacy, the nursing home, within or out of the country (Health information technology, 2015). Secondary use of information stored in EHR, namely education, research, public health needs etc. is as equally important as its primary continuity of care purpose.

2.3 Personal Healthcare Record

The implementation of different eHealth services brings numerous benefits to the patients even when they do not use the service directly. Example is any service that saves time for the physician, allowing him to spend more time with patients. Nevertheless, final touch on the national eHealth system would be direct patient empowerment where patient portals and personal health records (PHR) play vital role. Personal health records contain the same types of information as EHR – diagnoses, medications, immunizations, family medical histories, and provider contact information, but are designed to be set up, accessed, and managed by patients. Patients can use PHR to maintain and manage their health information in a private, secure, and confidential environment. PHR can include information from a variety of sources including clinicians, home monitoring devices, and patients themselves (Health information technology, 2015).

3 STANDARDIZATION

In order to efficiently use medical information throughout healthcare system, it has to be stored and exchanged in a standardized way. EMR, EHR and PHR in their essence are about documenting different facts. If document is intended for personal use only, than words, grammar and rules are not so important. But if document is intended for use by other persons, all of this must be well defined and collectively accepted. Otherwise, document will be at least partly incomprehensible or what is even worse wrongly understood. In the world of semantic interoperability notion grammar refers to reference model, words/dictionary are codes/coding system and phrases/rules are clinical models, archetypes or templates.

In that sense openEHR and HL7 Clinical Document Architecture (CDA) are two of the most promising standards for storing clinical information and medical documents exchange respectively. Integrating the Healthcare Enterprise (IHE) initiative is the most prominent way to achieve out-of-the-box interoperability at least in specific use cases.

3.1 HL7 CDA

The HL7 CDA is a document markup standard that specifies the structure and semantics of "clinical documents" for the purpose of exchange. A clinical document is a documentation of clinical observations and services, with the following characteristics: persistence, stewardship, potential for authentication, context, wholeness and human readability. A CDA document is defined as a complete information object that can include text, images, sounds, and other multimedia content.

HL7 CDA standard proved to be too generic. In order to refine it, content templates are introduced. One of the most widely known content templates is Continuity of Care Document (CCD). CCD is specification on how to constraint HL7 CDA in accordance with requirements set forward in Standard Specification for Continuity of Care Record (CCR). The CCR is a core data set of the most relevant administrative, demographic, and

clinical information facts about a patient's healthcare, covering one or more healthcare encounters (Health Level Seven International, 2007). It provides a means for one healthcare practitioner, system, or setting to aggregate all of the pertinent data about a patient and forward it to another practitioner, system, or setting to support the continuity of care. The primary use case for the CCR is to provide a snapshot in time containing the pertinent clinical, demographic, and administrative data for a specific patient.

Although templates obviously refine underlying standards, one obvious weakness emerges – too many different templates defined by different organizations/vendors/health authorities. Even after content is defined with content standard and refined and constrained with standard templates, overlapping terminologies issue remains. Very representative example is HL7 CDA representation of observation of 108 mg/dL glucose in the plasma of a patient, which is measured in a laboratory setting. There are more alternatives how to exchange this fact within CCD document.

Alternative 1 is that plasma glucose measurement procedure is exercised (SNOMED CT code 119958019) and there was an observation of blood glucose status (SNOMED CT code 405176005), with the actual observed value, which is 108 mg/dL glucose. Alternative 2 is that laboratory test procedure is exercised (SNOMED CT code 15220000), and there was an observation of glucose in serum or plasma (LOINC code 2345-7), with the actual observed value, which is 108 mg/dL glucose.

Although different coding systems and different structure is used, the same medical information is represented and communicated in both instances. So in spite of the fact that communicating applications are capable of using CCD template, interoperability is achieved only partially. When different terminology systems are used in the same structure, it is necessary to semantically mediate them for interoperation. Some of the repositories with mapping information are Unified Medical Language System (UMLS) and Metathesaurus and BioPortal.

There are examples of successful eHealth systems that do not use international terminologies. National information system in Croatia (CEZIH) does not use nor SNOMED CT or LOINC. Local coding systems are defined by professional associations. Since there is national consensus about coding lists used, interoperability on national level is achieved and Croatian eHealth system is perceived as one of the best in Europe.

4 INTEROPERABILITY

The practical approach to solving interoperability problem is one of the goals of project “Information and communication technology for generic and energy-efficient communication solutions with application in e-/m-health” (ICTGEN). In scope of this project we will demonstrate integration of PHR with EHR using HL7 Continuity of Care Document (CCD). Simulation environment, consisting of PHR and EHR, was created at Faculty of Electrical Engineering and Computing. As an EHR system openEMR solution based on openEHR reference model is hosted and adapted to specific needs of the ICTGEN project. Project partner, Ericsson Nikola Tesla d.d. provided their own solution for PHR, Ericsson Mobile Health (EMH).

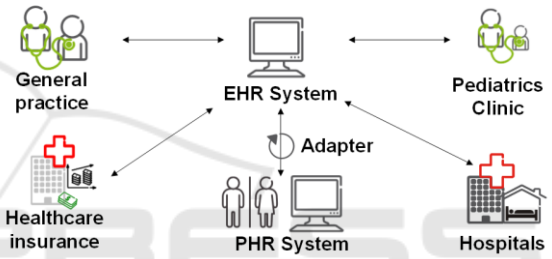

Figure 1: EHR-PHR integration within ICTGEN project.

EMH is one of the numerous PHR solutions offered on the market and its focus is on managing patient's record. Depending on the role, users can access and manage their medical data. EMH provides external access to specific data through Medical Node (MN) API in custom format. Without standardized format of data exchange, integration with any other ICT solution requires system modifications or additional integration components.

First step to solving this interoperability issue was thorough analysis of exchanged medical data format and HL7 Continuity of Care Document (Health Level Seven International, 2007). The analysis lead to classification of medical data into matching categories which were mapped to corresponding CCD elements in the next step. This mapping model was implemented as an adapter component connected to MN API. Since lot of data from PHR is not suitable for EHR, only EHR to PHR communication is implemented. After PHR client is authenticated and authorized for data access, adapter on PHR side receives data from EHR

formatted as CCD document. That allows multiple PHR solutions capable of importing CCD to be integrated with EHR. In this project, specific adapter is built and information from CCD document is extracted and stored within EMH database. In that sense EMH is upgraded into interoperable PHR solution capable of importing patient summaries in CCD format presumed limited subset of medical information is exchanged. Although this might seem like unacceptable limitation it is in fact the only realistic way to achieve interoperability. With more than 600.000 concepts within SNOMED CT, it would be illusion to build application that can interpret any of these in the right context. Our approach is to start small and expand adapter making it capable to process more medical information.

5 CONCLUSION

Retrieving all relevant information, utilizing other experiences, exercising team work and looking on things from different perspectives are all aspects of providing high quality healthcare service. Communication is foundation for all of this. The necessary precondition however, is that sender and receiver of information are capable of exchanging it and understanding it in the same way. This is the essence of interoperability. Healthcare, being one of the most complex human domains, poses similarly complex interoperability issues. It actually requires from the participants speaking different complex languages to use one common grammar, words from the same dictionary, to use same phrases or to find one translator that knows all the languages. Neither of this is realistic, especially in short term. Therefore different healthcare interoperability standards and initiatives are introduced but for the time being solution is far away. HL7 CDA without templates is too generic to assure true interoperability. It only allows that clinical documents can be exchanged with appropriate amount of metadata. What's within these documents is not so important to this standard. Templates and constraints narrow this uncertainty a little bit. But even with CCD as one template, same thing can still be expressed in more than one way which makes it very hard for applications to communicate among each other. Nevertheless, ICTGEN project, confirmed that for well-defined subsets, medical information can be efficiently exchanged between different applications like EHR and PHR.

But the main interoperability issue as we see it, is the fact that healthcare professionals does not use same dictionaries (or terminologies / coding list), nor they use the same words (codes) for same events. SNOMED CT as maybe the most comprehensive terminology today is not available in all languages. Mappings to other terminologies are not available at all or are not complete. Process of introducing terminology like SNOMED CT into healthcare system of one country is very long and expensive. Still it does not guarantee that same event will be described with the same code by different healthcare professionals. Until this is solved, no structure, no clinical document definition, no knowledge model (archetype) will bring true interoperability.

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