

NARRATIVE REVIEW

INTEROPERABILITY STANDARDS IN EHEALTH: REVIEW OF CURRENT METHODS AND FUTURE DIRECTIONS

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ABSTRACT

Since the 80's and 90's, the medical data exchange and storage represented a huge challenge in the evolution and interoperability between different hospitals and health organizations across the world. If in the early years the amount of data to be exchanged and stored was reasonable, nowadays in the heart of the globalization process we discuss about huge amounts of data to be shared from one location to another location, and sometimes across different continents. In this context, it is critical to have clear standards to enforce the format and semantics of the medical data and more than this, to leverage these standards and integrate them inside the latest IT solutions. This article reviews the importance of standards in the context of the interoperability between different medical systems and the way these standards are being developed and researched in EU-based projects such InteropEHRate.

Keywords: eHealth, interoperability, data store

INTRODUCTION

The necessity to have standards when discussing about the medical data exchange was obvious since the early 80's. Different hospitals and organizations had heterogenous meanings and interpretations for the medical terms. On top of this, the format in which this data was exchanged and stored was also specific to each hospital [1].

Since then, it was also quite clear the fact that hospitals and other medical organizations cannot live in their own isolated world and there is a huge benefit in being able to share data and knowledge. In the medical field, the need to spread the information and use it as input in order to derive and enrich it, to be used later on patients' treatment, is more important than in any other domain of expertise [2].

As time passed, different standards emerged and offered a framework to be used by the healthcare ecosystem [3]. Standardization is solving only one piece of the puzzle. The other piece is related to the way these standards are used and implemented, leveraging the IT support. It would be a pity not to take advantage of the booming IT world that was adopted in every other part of our life nowadays [4, 5].

A clear standard for exchanging medical data, combined with a solid IT solution to back up this standard can bring enormous benefits in creating a global ecosystem capable to aggregate health data in a uniform manner and at the same time an ecosystem which can be useful to perform complex analysis on the collected data with the sole purpose of improving the standards of life for patients all around the world [6, 7].

Why are standards important in terms of interoperability?

Interoperability standards are needed to enable proper communication among heterogeneous systems from different hospitals. It is mandatory to create a unique alphabet, that reunite the health data model, across the semantic, syntactic, technical but also organizational platforms [8]. We need to get a clear health care patient report, and this requires sharing and comparing clinical data from multiple sources. The principal effort in achieving this is to work with a ubiquitous shared platform [9, 10].

Health Level Seven (HL7) v2 → HL7 v3 → FHIR evolution during the years

The medical ecosystem was always a rich expertise domain looking to the vast number of terms used and even bigger semantics of this terms.

Taking this into account, when looking to a local or individual clinic there is not an obvious issue in terms of the big amount of data that is process and stored. Instead, in the moment when we think to exchange this data between clinics and organizations, a big issue emerges: in which form should we send and receive the data and what is the semantics of the data? so that we can make sure the information is properly interpreted on the other side.

This problem was highlighted before the 90's and domain experts tried to solve it during the years. The obvious necessity was a standard to be used as a universal language across hospitals and health organizations [11, 12].

In this exact context, HL7 v2 standard appeared in 1989 and evolved during the years. From data model perspective this standard was designed to cover approximately 80% of the medical data from clinics and organizations together with a framework that was flexible enough to offer support for the 20% remaining interval [13, 14]. From technical perspective HL7 v2 messaging protocol is based on strings and delimiters, having as a central characteristic the flexibility to cater for a large number of medical terms.

HL7 v2 with its variations is even today one of the most used and spread medical standard from obvious reasons. Being developed in the 90s the technical implementation specific to the epoch together with the 80/20 design approach ended up not being enough, in the sense that the specific terms used by different hospitals across the world (which should have been covered by the flexibility of the framework inside the 20% slot) became a shortcoming of the standard [13, 14].

Therefore, in 2005, HL7 v3 appeared. This version of the standard was an obvious evolution and the main goal

of it was to increase the core domain of the data model from 80% to at least 90%, and to leverage the technical evolution of the IT domain by using the Extensible Markup Language (XML) format and the Subjective, Objective, Assessment and Plan (SOAP) approach, and consequently enforce a more solid and rigid standard.

From a technical perspective, HL7 v3 is for sure an improvement over its ancestor. The only main problem in the adoption of the new version was the fact that HL7 v2 was already being used at big scale in 2005 and the migration towards HL7 v3 was very costly. Moreover, another adoption issue was that for quite some time the systems of HOs should both cater for HL7 v2 and HL7 v3 (as the 2 versions are not backward compatible) [15]. This aspect is even today the biggest issue and the main reason for which the HL7 v3 is way under HL7 v2 from adoption perspective.

Domain experts noticed this concern and as a result, the Fast Healthcare Interoperability Re-sources (FHIR) standard appeared in the recent years [16].

What FHIR brings new

This is an evolution of the HL7 v3 from technical perspective, leveraging the Representational state transfer (REST) approach which is offering an extra flexibility layer on top of the already existent HL7 v3 advantages [8].

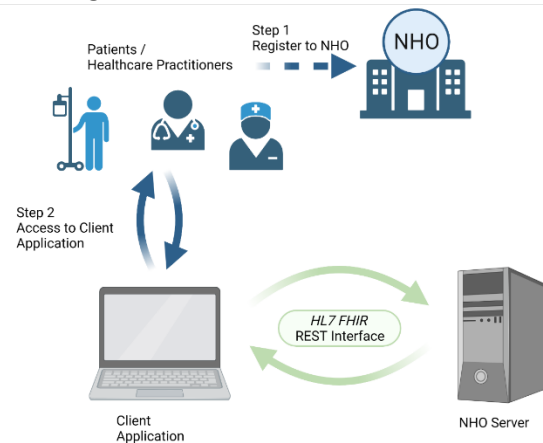


Figure 1 - Illustrates the steps needed to access the HL7 FHIR standards. Step 1: Patients / healthcare practitioners need to register to the National Health Organization (NHO) in order to receive a unique identifier. Step 2: By using a client-side application, health data are being visualized, produced and furthermore they are stored on the NHO server for later access.

Nowadays, if an emerging country wants to leverage the FHIR standard to integrate with the already existent HL7 compliant components the only things they need to put in place are the following [17, 18]: (i) their patients,

health practitioners and organizations need to register to the National Health Organization (NHO) to receive a unique identifier; (ii) use a client-side application (mobile/desktop or browser based) in order to visualize, process and extend the patients' health data by creating and consuming FHIR resources. These data are stored in the central NHO server and are further accessed through the HL7 FHIR REST interface (Figure 1) [19, 20].

FHIR and the development of a healthcare mobile application

The client application can be a country specific application or, ideally, a cross-country application, capable of offering global functionality towards patients and healthcare practitioners across the world. One of the emerging such "client applications" is Andaman 7 [21]. This application is currently used across different healthcare institutions from Europe and the United States and also is being developed and integrated along the InteropEHRate project [22]. The project highlights the importance of interoperability standards to generate significant medical results via sharing and exchanging information between different sites [23].

The data model proposed by FHIR evolves around five pillars: personal information, general health information, diagnostic orders and lab results, medication, and care plan (Figure 2). A user can create, read, update, and delete (CRUD operations) information belonging to the five pillars.

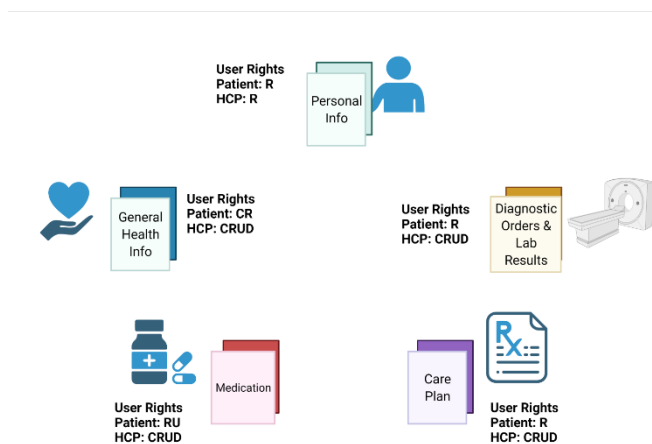


Figure 2 - Presents the data model of the FHIR standard which is based on five pillars (personal information, general health information, diagnostic orders and lab results, medication and care plan). The possible operations are: create (C), read (R), update (U) and delete (D) and each user has certain rights to perform these operations. HCP: Healthcare Professional.

Interoperability Levels

The major paths to interoperability in the healthcare field are represented by: IT, Semantic, Syntactic and Legal interoperability [24].

Technical interoperability refers to the ability of two or more systems to exchange data via different communications channels [25].

Semantic Interoperability involves universal medical terminology and nomenclatures, or more specifically, same terms for same concepts [26]. When referring to etiology, diagnosis and treatment, a common language between different systems is crucial in order to automatically and meaningfully interpret the data and, as a final target, to obtain clinically relevant results. More importantly, without contextual data, the complete meaning in health data, remains ambiguous [27].

Syntactic Interoperability requires the ability of two or more systems to work properly together with data transferred between them by each component. Thus, there are specific format and structure for this information. Most frequently, the syntactic interoperability is ensured by XML or Structured Query Language (SQL standards) (28). Examples of International Standards Development Organizations (SDO) are Health Level Seven International (HL7) and HL7-FHIR version. A model of a general-purpose language is LOINC (Logical Observation Identifiers Names and Codes) [29,30].

Because we discuss about interoperability at a national and international level, it must include policies and laws, to ensure a seamless flow of information between different organizations from different countries.

Conclusion

Interoperability standards play a vital role in the healthcare field. The standards have evolved during the years, each of them with advantages and drawbacks, but there still is an acute need of standardization at a global level when exchanging and storing medical data.

Currently, FHIR represents the standard which has the highest potential in becoming the most used model in the medical expertise field. The potential of FHIR is based on the years of experience gained from the HL7 standard combined with the flexibility from interoperability perspective offered in this moment by the REST protocol and the JavaScript Object Notation (JSON)/XML based for-mats.

Given the increasing interest of the European Union to develop and adopt a patient-centered health data solution (for citizens to gain access to their data and to promote data exchange across Europe when needed) (30), projects such as InteropEHRate become extremely important, by offering a clearer view on the way FHIR

based systems can interoperate with each other, and how they can be integrated in clinical practice.

There is also one more thing to be highlighted in the sense that these standards, transposed in technical solutions can bring a lot of benefits to the medical society with the hard and solid requirement that countries should take part in initiatives like InteropEHRate and try to spread as much as possible these standards to be able to offer a better life to patients all over the world.

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Nowadays, while artificial intelligence is bringing such a drastic change, not having interoperability standards, means remaining mired in a fractured health system and distrusting the real promise of health information technology.

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