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A Case Study on Implementation of Health Data Standards for Smart Healthcare

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***Abstract*— Electronic Health Records (EHR) and other health standards are in use for quite some time now in some of the developed countries. Simultaneously, with the advancement of ICT-based infrastructure for providing smart healthcare services, volume of health data has increased vastly and storage and management of this huge volume ofdata, which also have the other properties of big data, has evolved as a major challenge. The objective of this paper is to investigate whether the presently available EHR standards and other related standards can adequately handle the data, which are generated through a smart healthcare system.**

***Here, we consider some of the well-known EHR standards and related standards, which have been proposed and are commonly used in various countries. These standards are studied in the context of data storage, data representation and data handling. Suitability of these standards is analyzed in terms of different evaluation factors, such as portability, scalability, and interoperability. Moreover, the implementation experiences of these standards are also considered. For this analysis, the authors consulted the survey papers and research papers describing the experiences of the researchers, as well as the users.**

***The paper concludes that in a smart healthcare system various types of data are generated, that include structured data like EHRs, as well as unstructured clinical data of patients, some of which need to be accessed quickly and frequently. Thus, an EHR system should be supplemented with models for representing unstructured data. A suitable ontology is required for designing a storage structure for storing healthcare data.**

Keywords: EHR, Health Data Standards, ICT, Ontology, Data Storage

I. INTRODUCTION

Health records in paper are not preferred any more anywhere for known reasons. The reasons include human errors, no option for interoperability between different care giving service providers, problems related to maintainability, longevity etc. In the recent time, EHRs replaced the paper records and are being used in different parts of the world, so that maintenance and sharing of medical records become easier for caregivers. Privacy and security are also other important requirements, which need to be addressed while managing the health data. Electronic Health Record or EHR contains basic medical details of patients, such as demographic data and medical parameters at different instants of time. In most of the healthcare organizations, EHRs are primarily used for storage, representation and communication of health data. In addition, EHRs also show the relationships between the different components of health data.

Though several important standards of EHR have been proposed during the last few decades, they have not been taken up in a major way in the developing countries. It is understood that one major requirement for these EHR standards is that they need to be defined on the basis of scope, scale and context of health data. Furthermore, with advances of ICT-based healthcare services, there has been substantial growth in computerized processes. These processes require specific definitions of medical terms and such terms are not very generic in respect of usage in different countries. Moreover, storage of health data for optimum performance is also a challenging issue which has not been yet dealt with. In some health data standards, high-level concepts for data storage are proposed. For example, in case of EN13606, file, folder, section etc. are defined. Nevertheless, no study was conducted to understand whether such high-level concepts are useful for capturing, defining and retrieving health data. With the increased use of Internet of Things (IoT) based e-health and m-health applications in healthcare, such as continuous monitoring of patients remotely over the Internet, question arises which data storage formats are suitable for handling smart environments. When most of the smart environments intend to use NoSQL databases, there must be effort to find a suitable technique to map the EHRs and other standards to NoSQL databases.

This paper aims at studying various EHR standards in the light of developing smart healthcare information systems. In the earlier surveys targeting standards of EHR, EHR-S, different perspectives have been focused, including quality of information, intention of usage, satisfaction of user, different factors to influence implementation of EHR, EHR-S etc(Nguyen et al, 2014). On the contrary, in this paper, a study of EHR and other supporting health data standards is undertaken in the context of data storage, data representation and data handling.

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Initially the standards are studied from the resources provided by the standard making bodies and related research papers. In the next step, the usage and feedback from different research studies and white papers related to implementation of these standards are included.

In the next section of this paper, a brief overview of different EHR standards is given. In the third section, evaluation aspects of EHR and EHR-S are discussed. In the fourth section, some experiences of implementation of the standards are described on the basis of some research studies. In the fifth section, a discussion is made based on suitability of the standards for smart environments. In the sixth section, the paper concludes with a discussion to future direction of the work.

II. STANDARDS FOR EHR, EHR-S AND RELATED MEDICAL STANDARDS

The dependencies among the concepts and interpretations at various levels, which form the basis of building health data standards are shownin Figure 1. The aspects and various issues that need to be handled while designing a health data standard are shown in Figure 2.

Overviews of ISO 13606 (Catalina et al, 2010), OpenEHR (Transport Standards, 2020), HL7 (RIM, CCD, CDA, FHIR, CIMI) (ISO Part 1, 2008), UMLS (UMLS, 2021) SNOMED CT (5-Step Briefing , 2021), LOINC, ICD are studied in this section.

2.1 ISO 13606 and OpenEHR

ISO 13606 and OpenEHR are similar standards dealing with Electronic Health Records with dual model architecture separating the domain information model and the model of reality. OpenEHR is a wider standard covering every aspect of EHR and EHR-S, whereas ISO 13606 covers only EHR extracts.

ISO 13606 organizes data in COMPOSITIONs, which are optionally contained in a FOLDER hierarchy. These COMPOSITIONs include ENTRYs, which are optionally contained in a SECTION hierarchy and ENTRYs include ELEMENTs, which are optionally organized within a CLUSTER hierarchy.

Both, ISO 13606 and OpenEHR specify Archetypes using the Archetype Definition Language. Archetypes are detailed and domain-specific definitions of clinical concepts in the form of structured and constrained combinations of the entities of the reference model. They also represent health care and application specific concepts. Some examples are blood pressure, examination of the chest, heart rate, etc.

Archetype Definition Language (ADL) provides an abstract syntax, which can be used to express archetypes for any reference model in a standard way. An archetype can include other archetypes and can be used in combination to form templates. Moreover, archetypes are treated as a clinical guide for clinicians (openEHR, 2020).

Every ISO 13606 entity has a similar one defined in OpenEHR, but the opposite does not happen because OpenEHR provides richer data structures and data types (openEHR, 2020).

OpenEHR is an open source standard for Electronic Health Record System (Transport Standards, 2020). OpenEHR platform architecture components are expressed in a combination of UML models and formal language specifications.

The standard was developed for the following purposes: (i) need for a patient-centric, lifelong electronic health record; (ii) integration of different types of data of the patient, emergency and acute care, pathology, radiology, computerized patient-order entry, etc. with the vast body of available knowledge resources --- terminologies, clinical guidelines and computerized libraries; (iii) clinical decision-support to improve patient safety and reduced costs through repeated medical investigations; (iv) access to standards-based computing applications.

The advantage of this standard is that it follows a dual model. It separates the ontology of information from ontology of reality, i.e. available standards. It also separates the information domain from implementation domain and in this way the software components of implementation are kept separate.

OpenEHR contains templates with metadata for medical data that covers the requirements of role, specialization, service. There are templates containing page, documents or reports (Stan et al, 2010). It tries to ensure that origin of data is indicated to maintain legal and ethical issues.

Many researchers consider OpenEHR to be the best optional standard having the widest coverage of the electronic health record domain, using other needed standards, and keeping the option open to be implemented and used and to be modified in future.

The disadvantages include the fact that both, OpenEHR and ISO 13606 cannot be scaled up or down according to scope and country specific coverage.

2.2 HL7 Standard

HL7 is a coordinated message based connection between two systems that allows information to be exchanged reliably between application programs. Many common standards include HL7 for administrative data such as patient demographics. HL7 V2 of 1989 is the most popularly used “inter-operable system”, but it does not meet today's requirement of interoperability issues. In 2005 HL7 V3 emerged with object oriented concepts and the specification of “entities”, “participation”, “acts”, “roles” etc. However, in its endeavour to model the complete medical system, it has become complicated lagging flexibility (Stan et al, 2010).

In this context, it is noted that according to Healthcare Information System Management and Society (HIMMS), there are four types of health data standards --- content, transport, terminology, and privacy and security (HIPAA, 2013). HL7 V2 and CDA are content related standards (HIMSS, 2021). FHIR, DICOM, HL7 are transport related standards (HL7 V2, 2020). LOINC, ICD (ICD-10), SNOMED CT are terminology related standards (HL7 V2,

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2020). Finally, HIPAA (Health Insurance Portability and Accountability Act) privacy rules are followed by different health data security standards (CDA, 2020).

The different standards under HL7 are briefly discussed below:

RIM Version 3 develops a single, common reference information model (RIM) that can be used across all products of HL7, enabling the care providers to document the actions taken to treat a patient. Every happening in the RIM is an Act. Acts are procedures, observations, medications etc. Acts are related through Act Relationships, which may be composition, precondition etc. In the RIM, persons, organizations, materials etc. are treated as Entities. Entities play some Roles, such as patient, practitioner. Roles participate in acts and the Participation is defined as the context of an act, such as author, location, etc. RIM integrates health records, provides a mean to match different global systems and adapts to local and regional requirements.

CCD is an XML based standard (Stan et al, 2018). It is particularly useful if the patient has a long history of medical treatment as It provides medical summary of patients.

CDA is a document markup standard for ``clinical documents'' to share health data between care providers and patients. CDA provides an approved standard way to exchange dictated, scanned, or electronic reports of a patient between various health information systems and platforms.

FHIR is a data exchange standard that works between different medical applications (Stan et al, 2010). FHIR welcomes health data that is not specified by FHIR format in files with different extensions, with data by country, culture and domain (Stan et al, 2010).

CIMI – A work group provides clinical information models to provide interoperability of health information. The open source models come with archetype definition languages and archetype modeling languages. There is a core reference model, and some basic data types. they support formal related standards. These models are used for different purposes like : patient care, public health, clinical trials etc. For example, IsoSemantic Model is used for lung cancer problem (Dave, 2016).

CIMI has come up with another model called Common Health Interoperability Model (CHIM) And Practitioner's Guide for HIE interoperability (Dave, 2016).

2.3 Unified Medical Language System (UMLS)

UMLS helps to develop electronic health record systems. The UMLS Knowledge Sources (databases) and associated software tools (programs) are distributed for use by system developers in developing or modifying electronic information systems that create, process, retrieve, integrate, and/or aggregate bio medical and health data and information and research. The knowledge sources work with patient records, scientific literature, guidelines, and public health data (UMLS, 2021).

2.4 SNOMED CT

In (5-Step Briefing , 2021) a comprehensive repository of biomedical terminologies are available. The main components here are concepts, description and relationships.SNOMED CT (5-Step Briefing, 2017)has a standardized way to express “clinical phrases” used by the clinician and enables automatic interpretation. International Health Terminology Standards Development Organization (IHTDSO) maintains the technical design and documentation and main content of the standard. The standard contains set of references, cross maps and historical tables (5-Step Briefing , 2021). It contains body structure, clinical findings, geographic location, pharmaceutical, biological products. The concepts are defined with the help of relationships. It is a support standard for EHR and not EHR in its full form. It needs local and national extension of concepts(5-Step Briefing , 2021).

2.5 LOINC

LOINC is a universal coding system for identifying laboratory and clinical observations, measurements that help to exchange and aggregate electronic health data from many health record systems. This database contains the usual categories of chemistry, hematology, serology, microbiology, toxicology; and categories for drugs and the cell counts, antibiotic susceptibilities etc.(World Health Organisation, 2021) This standard is always needed for implementation of any Electronic Health Record in any scope, but it is not complete.

2.6 ICD

ICD provides international standard diagnostic classification systems and reference terminologies in order to achieve “interoperability”.. It is also a support standard and has many health management purposes and clinical use (World Health Organisation, 2021).

Table 1 summarizes the outcomes of this study.

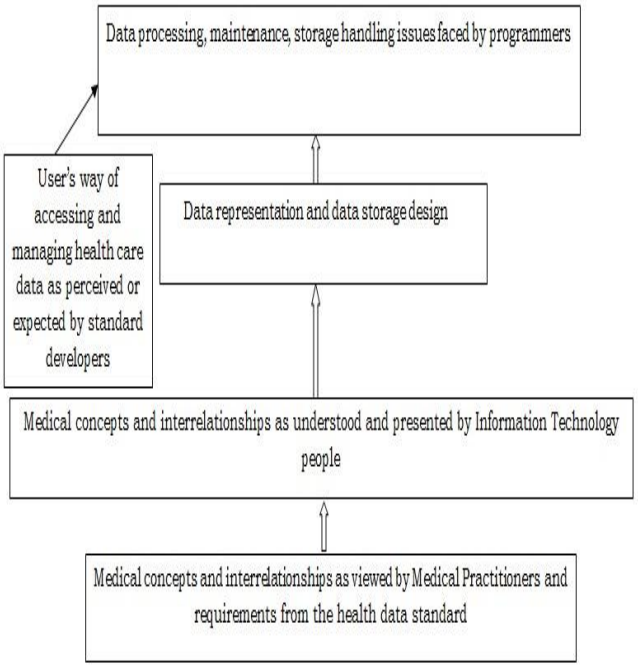

Figure 1. Dependency and basis of health data standard making

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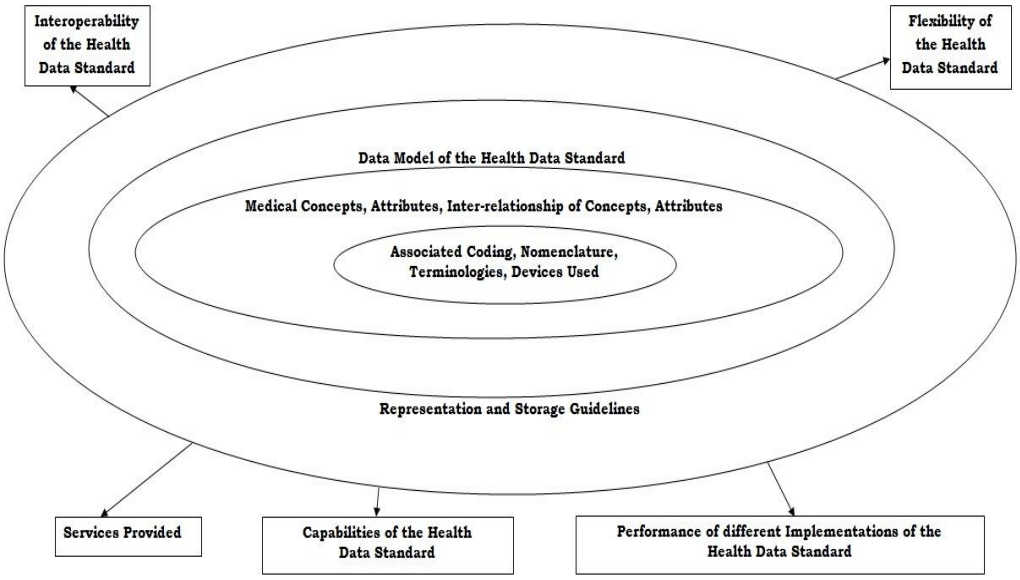

Figure 2. Services provided by the health data standard and the importance of data model

Table 1. Different Health Data Standards, their use, advantages and disadvantages

Name	Significance	Scalability	Flexibility	Interoperability
ISO 13606	Standard for EHR extracts, Follows dual model architecture Archetypes and ADL available.	Scaling down for remote health care, emergency situation is difficult.	Does not specify management of continuous data, storage in cloud.	This standard, in spite of being similar to OpenEHR has trouble to match with it.
OpenEHR	Open Standard for EHR and EHR-S, Wider scope in comparison to ISO 13606, Open to change, update, Archetypes available, though not full proof	Better scalable than ISO 13606 Not enough to manage very simple to very complex situations	At this moment no scope of continuous data. No scale, scope, country or context specific data	It aims to be interoperable but has problems in being interoperable with ISO 13606.
UMLS	Provides knowledge sources, software tools for biomedical, health data, Works with patient records, scientific literature, guidelines, and public health data	Knowledge sources are multi-purpose and not optimized for particular applications	No scope of continuous data or data management in cloud	It is not extensively used and is not known to be very interoperable.
HL7	Standard for communication of medical data between two systems , Can be used for message and communication, Support standard needed for standards of EHR and EHR-S	Quite scalable in comparison to other standards	FHIR keeps country, culture, application specific resources	Consolidated - CCD and FHIR are considered among the most interoperable health data standards (“How health “, 2020).
SNOMED CT	Repository of biomedical terminologies, Has identifier terms, depicts concepts, descriptions and relationships , Support standard	Its conversion from nomenclature to terminologies of ontology is not complete hence not scalable	For the same reason not flexible enough	This standard is not fully ready to be interoperable

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LOINC	Universal coding system for identifying laboratory and clinical observations, measurements , Support standard ,Indispensable for EHR and EHR-S	Scalable within its scope	Flexible within its scope	Works well with other electronic health data standards that use it.
ICD	International standard diagnostic classification of for clinical use. Indispensable for implementation of EHR and EHR-S.	Not applicable	Not applicable	Used by electronic health data standards.

III. EHR AND EHR-S EVALUATION FACTORS

In the contemporary literature, EHRs are evaluated in different dimensions. Evaluation is made on the basis of information quality, perspective of evaluation, which is perception based, quantitative or qualitative, objective data based, effect of dealing with huge amount of data, features found, problems found etc. Another dimension of evaluation can be system quality. Some people are comfortable with the provided user interfaces, while others are not. Sometimes clinicians are not happy entering so much of data instead of treating patients. Lastly, there are factors of service quality, interoperability concerns that include difficulties with its support towards fulfilling urgent requests.

Portability is an important feature for implementation of such standards. Different users have different requirements, expectations and needs that EHR must be able to deliver. Usage of EHR and EHR-S brings changes to documentation practices. The standards receive medium or low response for adoption and usage satisfaction from the users. Organization of the huge volume of data is a key point in influencing information retrieval and usage. Interoperability of the EHR systems within the existing technology infrastructure is also an important issue.

EHR systems are found well integrated. However, communication with the physician within the outside world was difficult. The scope of usage of EHR in mobile health and tele-health are not well explored in many countries. Patients often directly use web portals and believe that they are of great benefit in chronic care management. However, these portals are not integrated with theEHR systems.

IV. IMPLEMENTATION EXPERIENCES OF DIFFERENT STANDARDS

The main aim of ISO 13606 is to communicate patient health record data among EHR systems. However, in this standard, archetype model used to define archetypes is constrained. Reference and Archetype models do not have common classes but the string value property of classes of Reference model is provided in Archetype model. Lozano-Rub et al observes that the link between Archetype Model and Reference Model of ISO 13606 is weak. It is also observed that relational and normalized data source is needed at times for implementing health data standards that is not supported by ISO 13606. R. Lozano-Rub´ et al proposed an ontology based approach to incorporate CEN/ISO 13606 extracts(Lozano et al, 2016).

Inclusion of filtering and other similar processes is not allowed in the available EHR standards, for example in case of the parameters for a diabetic patient. Such processes work well with relational data store. However, a model, like in EHRs, with hierarchies and nested elements is difficult to be represented as relational model, which is primarily designed for data storage.

In an earlier work, Lozano-Rub et al present an information model to implement a simple test application. A number of Archetypes can be merged and reused using this approach(Lozano et al, 2014).

A survey of experiences gathered from design, use and maintenance of SNOMED CT has been carried out in 13 organizations of health care across eight countries through interview of 14 people(Lee et al, 2014). Friedman et al mentioned that in countries with high usage of EHR, very less amount of population health data is available for use(Friedman et al, 2014). One reason for this is that there is lack of federal and governmental support in EHR implementation and usage. Thus, the scope of communication among different health care systems for proper analysis and use of data is very less.

S. El-Sappagh et al(El-Sappaghet al, 2014) have come up with a data model for providing decision support system for diabetes mellitus diagnosis. The data model is based on HL7 RIM, EHR, SNOMED CT standards.

OpenEHRhas been evaluated in terms of its capacity for storing phenotyping algorithms(Papeˇz et al, 2017). In this respect, they found that proper archetype for diabetes was not found in OpenEHR. It also lacks support for natural language representation for medical terms. The required set operations are not supported in OpenEHR. OpenEHRis used in the domain of obstetrics medical records(Almeida et al, 2014), As the OpenEHR records do not fit in relational or columnar data storage systems,the records are exported in tabular formats, like SPSS, R and SQL file structures. It has also been observed that in relational representation, the model cannot deal with situations like birth of twin babies.

Bae et al developed problem oriented CCD to assist theclinicians to view patients' medical records easily. It was

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found that POMR (Problem Oriented Medical Record), which contains a list of problems of a patient, works as an index and better suited for the case bases of this work (Bae et al, 2017)

Problem Oriented medical Record (POMR) (POMR, 2020) format varies from system to system. However, in all cases, the following components are noted: the reason for contact, assessment (made using interview with patient or patient's family members), physical examination, laboratory tests, history. A master problem list is maintained that acts as an index to a structure containing the essential sections. This approach keeps a summary of all problems and encourages continuity of care.

Bosca et al noticed that the implementation guides of health data standards are human readable, but not computer interpretable. Therefore, these guidelines are transferred to executable forms known as Object Constraint language (OCL). Here, the rules are generated from natural rule language for the validation of data instances. In their work, the authors have used ISO 13606, OpenEHR and HL7 CDA (Bosca et al, 2017).

S. El-Sappagh et al(El-Sappaghet al, 2014) proposed a standardized logical model to extract diabetes related data items from EHR. Structure of this record is standardized using RIM. Data fields of the record are refined using common data elements of diabetes diagnosis, and the content is standardized using SNOMED CT.

It is argued that a big portion of the information available in EHR is in textual form and thus NLP and information retrieval are needed(Mart´ınez-Costa et al, 2010), Thus, in this work, random walk technique is used to retrieve information. For this, query is expanded using the concepts and knowledge of UMLS. In this work, headings are identified to build different indices.

A health application is built in Romania (Stan et al, 2018) around libraries of FHIR, which is a data exchange standard in HL7. In this work, it is observed that data must be used and accessed by entities from different geographical regions and related to different medical applications.

Smitset al found that HL7 FHIR and CDA are not fully compliant with each other. The study is made on the basis ofGenOGeg, a real-life use case(Smits et al, 2010).

In the Sharp project, it is observed that the proposed clinical models of CIMI (Clinical Information Modeling Initiative) of HL7 are complex and simpler approaches can be used for implementation of health data applications (Final Report, 2014).

From the above study, the following points are noted:

- EHRs contain raw data, whereas decision support systems (e.g. for diabetes) require the data after filtering and preprocessing.
- Processes related to health data analysis require addition of tables, relations, attributes and data types and these actions are not accepted by people implementing EHR systems.
- Distributed EHR systems use diverse techniques and technologies for data modeling, storage, processing and may use different terminologies.
- Data normalization is an important requirement that will affect the performance of the EHR systems.
- Health data contains mostly text-based data, which needs encoding, restructuring to provide data with improved quality for case bases.
- Problem oriented record approach is better for storage, retrieval and maintenance of health data.
- EHR standards must be flexible and should have support to include all data types.

In a country, where the government offers healthcare services for its people, in absence of a central repository of health records, it is hard to work in a timely manner and take appropriate action when necessary and when health related emergency arises. Infrastructure, which is available in multi-specialty hospitals in urban areas,is scarce in remote or hilly areas, making implementation of full EHR or complete EHR System practically impossible in these areas.

All the internationally accepted standard EHRs and EHR systems work as reference and without them one cannot start preparing any health data application and expect it to be correct and inter operable. These standards are essential in proceeding such work, as health data and health care systems are complicated and these standards can work as knowledge base for IT people with non-medical background. The archetypes effectively support application development. However, though EHRs are complete source of health data(El-Sappagh et al, 2014), the following facts should be considered:

- EHRs do not have consistent structures;therefore, cost or effort is involved to convert them from one standard to the other. Similar situation arises when an application specific data model is proposed and used. Thus, conversion schemes and tools are to be developed with care that provide easy and less time-consuming conversion.
- EHRs are expected to be flexible enough to accommodate various diseases, various applications and ranges of domain specific usage.
- There are varied requirements for application, analysis, analytics, research type of health data processing and all these cannot be managed with one standard of EHR or EHR system. One may be suitable in one case and the other may be suitable in the other cases.
- An internationally accepted EHR or EHR system will be popular and frequently used if it is easily available and becomes comparatively simpler to follow. If the knowledge related to the topic is presented in a hierarchical manner then it is easier to relate to and implement the standards. The question of inter-operability will not be an issue if it is frequently used.
- Such standards must be open to changes and suggestions. The preferable choice of EHR standard and

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EHR system standard need to be tested by using these standards in the most challenging environments or situations.

- In many implementation efforts of EHR systems, there has been a need to define a problem or application specific health data model to manage the specific cases. Many of these health data models follow the standards, which are discussed in this paper. Thus, required changes can be brought to such standards by studying these health data models.
- EHR and EHR system standards depend on some ambiguous concepts and natural language. Thus, the standards sometimes have different perspectives of the same topic. A general ontology of clinical concepts must be used as the basis of all such standards and this ontology will use general medical concepts of care persons.

Figure 3 shows how health data standards can be scaled up or down according to the scope of application, country, coverage using ontology.

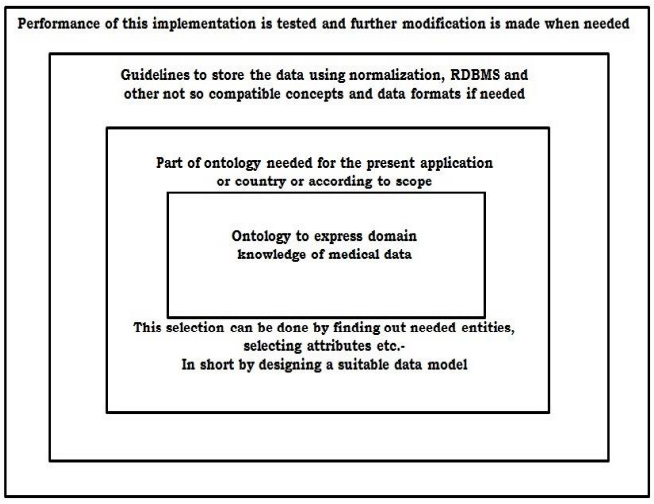

Figure 3. Health data standard may be scaled according to scope of application, coverage using part of ontology

V. DISCUSSION

In this section, we summarize our observations in an attempt to find some solution to the problem of storage and management of health data.

1) Standards are indispensable

Every healthcare application needs to use internationally accepted EHR, EHR-S and some other support standards from the initial design of the application until its implementation.

2) Major Drawback

The standards do not cover everything that are required for implementation of healthcare applications. For example, it does not specify data store design or guide implementation procedure implicitly. Archetypes are not fit to be used in all scopes, scales, contexts and countries.

3) Adaptability

The standards are not designed keeping in mind that the health care application may have to work in a very low scale with limited infrastructure, such as while handling an accident or natural calamity. Sometimes, again the standards are failing where explicit details are needed with respect to a particular medical problem such as diabetes.

4) Difficulties in using the standards

It has been reported extensively in the contemporary literature that health care personnel spend most of their time handling the difficulties of storing health data electronically.

5) Internationally acceptable standards

Similar to the internationally accepted standards in other domains, there must be one standard to be followed everywhere based on the recommendation followed by medical practitioners.

6) Interoperability

Due to the differences in the data models of different standards, there is chance of loss of data or incompleteness in expressing medical data in one standard when converted from another standard.

7) Approval of clinicians

Standards must be understood and agreed upon by the clinicians. Thus, during usage, clinicians must agree with the way they perceive the implementation of the standard. They must come across the clinical terms used every day for treatment purpose.

8) Usage in different situations

The competence of a standard must be tested by using it in as many situations as possible. For example,OpenEHR has the openness to be used repetitively and to be modified and improved.

9) Quality of standards

Design of health data standards is at times very generic and at times too specific. Generally, these standards are defined in a very generic manner so that almost all situations can be covered. However sometimes, standards are too specific and applicable to a particular application, to a particular scope and within a particular country.

10)Use of modern technologies

Specifications of all health data standards do not take into account the newer technologies, like cloud, streaming data coming from e-health sensorsetc.Data obtained from a proprietary device capturing health datacannot be reused. However, any health data must be made available for storage and reuse in an acceptable format.

11)Role of ontology

Ontologies are used in EHR and the associated standards. For example:

- ISO 13606 uses ontology for its archetypes(ISO, 2019).

- HL7 V3 Release 1 has privacy and security ontology(HL7, 2020).
- FHIR uses ontology to make its resources shareable and to make validation of data possible. It is also used so that it can be combined with other health related ontologies to build a health care application.
- Several parts of OpenEHR are supposed to have ontological significance. Archetypes can be viewed as different nodes of ontologies One important point to note about standards of medical terminologies like ICDx, LOINC, SNOMED CT is that "all medical terminologies with any structure whatever are ontologies of some kind, whether they think they are or not" (Ontologies, 2007).

Nevertheless,the above ontologies and other available ontologies are not sufficient to cover everything. Ontology is needed to understand health and clinical domain and automatic processing of health data. It is also needed to cover the gaps within a health data standard and among the health data standards. Ontology must include the domain knowledge which may be known to medical practitioners, but is not known to the persons who will providetechnological support to implement the EHR standards.

There is a difference between the ontologies of reality which deal with the "real things and processes" and the ontologies of information which record information related to observations, investigations and reporting (Ontologies, 2007). In order to understand the domain knowledge, ontology of reality is to be studied first. Next, while designing the application that deals with health data, the ontology of information is to be studied and used.

12) Application development

There are various aspects of EHR definition and usage. There is a need to define medical concepts and their interrelationships for data storage, data handling and maintenance issues. There is another aspect that covers the medical terminologies and their interrelationships with synonyms of different standards. The difference between medical terminologies and concepts is how care givers use data and how application developers understand the interrelationships among the different medical concepts, so that the data model and the data storage can be meticulously designed to optimize performance. The third aspect deals with the domain where a general user store, use, modify, access data (image file, lab report etc.) everyday. There is another perspective that deals with how programmers will process such data. The interrelationships among the different representations of the different aspects are to be defined.

13) Inter relation between ontology and information model

Ontology uses open world concept and it is the repository of information. Information model that is used to develop an application uses closed world concept. It needs a theoretical knowledge repository like ontology. HL7, ISO 13606, OpenEHR, all have reference information models. However, these information models need to be improved to bridge the gap between the above mentioned domains.

VI. CONCLUSION

Medical data is vast, complicated and sensitive. Covering the entire medical domain is a dynamic and iterative process. Standards should also be available for mass usage, so that they can be tested to examine their capacity, problems etc.

In this paper, different health data standards and experiences of implementing the standards have been studied. It is concluded that a global health data standard should be able to adapt to scale, scope and countries. Such a health data standard must be able to manage normalized data sources and related application programs. It must also work with sensed streaming data, cloud, and other modern technologies. The paper also puts emphasis on the use of ontology to capture the domain knowledge in order to support the health data standards. Further, effort must be given to come up with one acceptable standard as in most technological domains, or the conversion from one standard to another standard must be simple and lossless.

There must be a balance between the level of generality and the level of details covered. This is because medical concepts and terminologies are not easily available or graspable to people belonging to technical domain or for computer processes. Complete infrastructure for care processes may not be available at the time of medical emergency and in remote places.

There are differences in the treatment approaches and health care processes conducted in different countries(as highlighted in (WHO, 2021)..each institution/country have different needs and requirements.). This knowledge must be used meticulously in future to design, develop and update standards and maintain interoperability of different standards.

Our future work focuses on developing an ontology-based data model that will be flexible, portable and scalable to support ICT-based remote healthcare delivery services.

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