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PROFESSIONAL PAPER

Data Standards in Tele-radiology

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ABSTRACT

Data standards play an important role to provide interoperability among different system. As other applications of telemedicine, the tele-radiology needs these standards to work properly. In this article, we conducted a review to introduce some data standards about tele-radiology. By searching PUBMED and Google Scholar database, we find more relevant articles about data standards in tele-radiology. Three categories of standards identified, including data interchange, document and terminology standards. Data interchange standards, including those which facilitate the understanding of the format of a massage between systems, such as DICOM and HL7. Document standards, including those which facilitate the contents of a massage, such as DICOM SR and HL7 CDA. And terminology standards, including those which facilitate the understanding of concepts of the domain. Since, the harmonization between different standards are important to meet interoperability, so the more effort is needed to conduct harmonization between tele-radiology standards and other domain.

Key words: standards; data; tele-radiology; radiology; terminology.

1. INTRODUCTION

In the healthcare, the term "data standards" encompasses methods, protocols, terminologies, and specifications for the collection, exchange, storage, and retrieval of information associated with health care applications, including medical records, medications, radiological images, payment and reimbursement, medical devices and monitoring systems, and administrative processes (1, 2). In general terms, the main objective of data standards is to ensure interoperability.

According to HIMSS definition, "interoperability" is the ability of different information technology systems and software applications to communicate, exchange data, and use the information that has been exchanged (3). Interoperability deal with two main concepts: syntax/structure and semantic.

Syntax refers to the structure of a communication, and defines the format of a message. Data interchange standards such as Health Level 7 (Hl7) and DICOM are placed into this level. Semantics is about the meaning of the communication. Terminology standards such as SNOMED and LOINC and document standards such as HL7 Clinical Document Architecture (CDA) are examples (2, 4).

Tele-radiology is the electronic transmission of radiological images, such as X-rays, Computed Tomograms (CT's), and Magnetic Resonance Images (MRI's) across geographical locations for the purposes of interpretation and consultation (5). Tele-radiology faced with radiological imaging data. Hence, the first aspect to consider is the standard that should be used for transmitting image data.

In this article, we review the main standard related to data in radiology, especially at distance.

2. METHODS

Tele-radiology is widely used and is one of the most matured telemedicine applications. In telemedicine, overall, standards have an important role in electronic communication to meet interoperability. In a tele-radiology domain, are the standards were developed? If yes, what standards were developed in tele-radiology? We conduct a formal search in PUBMED and Google scholar database to identify articles which have focused on tele-radiology standards. Articles were published after than 2000. Since, the term "guidelines" have distinct meaning with the term "standards", we do not consider it in our search. The identified data standards categorized as:

- Data interchange standards.
- Document standards.
- Terminology standards.

3. DATA INTERCHANGE STANDARDS

3.1. DICOM

Digital Imaging and Communications in Medicine (DICOM) is the most important standard for transmission of digital images and diagnostic and therapeutic information. DICOM was developed by the cooperation of the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) in 1983. DICOM includes data structures for medical images and associated data, network oriented services for image transfer, medical formats for data exchange, workflow management, consistency and quality of presentation and requirements for conformance of devices and programs (6).

Some aspect of DICOM standards, protocol and services related to tele-radiology including: Web Access to DICOM Objects (WADO), DICOM Modality Work List standard (DMWL), and JPEG 2000 Interactive Protocol (JPIP).

Web Access to DICOM Objects (WADO): WADO is a web view in DICOM and developed in a cooperative effort

of the NEMA and the International Organization for Standardization (ISO). It is a new web service for distribution, access and display of DICOM persistent objects (such as images and reports of medical images) and viewing them through web pages or XML documents and HTTP/HTTPS protocol using a DICOM Unique Identifier (UIDs). This protocol has many advantages, including: It permits an aggregate record of whole information, it is able to be used beyond the limits of the hospital intranet, it decreases costs because there is no need for special software and hardware to view images- only a browser is needed, it achieves multitasking in DICOM services, it provides high quality services because images store to the client PCs on demand, hence broadband problems will decreases (7, 8, 9).

DICOM Modality Work List standard (DMWL): The Modality Work list service was introduced into the DICOM standard in 1996. It provides electronic transmission of patient demographic and study data from Hospital Information Systems (HISs) or Radiology Information Systems (RISs) to the image acquisition modalities such as Computerized Tomography (CT) and Magnetic resonance Imaging (MRI). The main advantages of this service is integrity that is essential for PACS installation and for the successful implementation of an electronic patient record and to decrease typographical errors which there is no need to reenter patient identification data into the modalities (10, 11).

JPEG 2000 Interactive Protocol (JPIP): JPIP is a client/server standard image streaming protocol and based on the JPEG 2000 standard. JPEG2000 is an ISO/IEC standard and facilitates image streaming. It`s designed for many applications such as compression and transmission of medical images. JPIP allows a client application to request only portions of a JPEG 2000 image that are necessary to fulfill the client's viewing needs. JPIP is a standard that can be combined with XDS-I (will describe later) to enable streaming of medical images directly from the EHR connected imaging sources to image processing workstations. This can be achieved with the use of DICOM Web access to persistent objects (WADO) along with the DICOM JPIP referenced transfer syntax (9, 12, 13, 14).

3.2. HL7 messaging standard

Hl7 is an international, non-for-profit Standards Developing Organization (SDO) formed to exchange, integration, sharing, and retrieval of electronic health information. HL7 develops many standards in the health care domain. Messaging standards are one of the HL7 standards that provide exchanging of clinical data between systems. HL7 version 2.8 messaging standard is the latest update of the version 2 standard that was published in 2014. Message structure is formed by some component, including: delimiters, segments, fields, data types and scape sequences. There are various types of

Figure 1. *Sample of HL7 Delimiter-based messages*

Figure 2. *Sample of HL7 XML-based messages*

HL7 messages, defined to carry different types of patient information; for example, the ADT message type is used for patient administration information. There are two types of message encoding for HL7 2.x version: Delimiter-based Encoding (Figure 1) and XML Encoding (Figure 2) (15).

A Memorandum of Agreement (MOA) written, between HL7 Imaging Integration Work Group (IIWG) and DICOM WG-20. The main goal is to provide a standard for the interoperability between HL7 and DICOM. To achieve this goal following steps are required: Define a common for exchange of order and results, understand the mapping of HL7 trigger events, segments and messages to DICOM event type, use a common model and the mapping to specify HL7 and DICOM messages, explore mechanisms for exchanging images between HL7 systems and DICOM systems and develop HL7/DICOM application profiles to achieve interoperability (16).

3.3. IHE

The Integrating the Healthcare Enterprise (IHE) initiative established with the effort of the Radiological Society of North America (RSNA) and the Healthcare Information and Management System Society (HIMSS) in 1998. The first effort was to clearly define how existing standards (such as HL7 and DICOM) should be used to resolve common information system communication tasks in radiology (17).

IHE is not a standard but is more than a standard (18). It provides its products as profiles. IHE profiles are work flow models of the various business processes that take place in healthcare on a daily basis. These profiles describe "actors" and "transactions." IHE actors are systems or parts of systems that create or process data. Actors interact and share data by means of IHE transactions (19). There are some profiles related to radiology and IT infrastructure. Some of them introduced in (20) are the following:

The Cross Community Access for Imaging (XCA-I) Integration Profile specifies actors and transactions to query and retrieve patient-relevant medical imaging data being held by other communities. A community is defined as a coupling of facilities/enterprises that have agreed to work together using a common set of policies for the purpose of sharing clinical information via an established mechanism. The XCA-I Profile extends the IT Infrastructure XCA Profile.

The Access to Radiology Information (ARI) Integration Profile specifies a number of query transactions, providing access to radiology information, including images and

related reports, in a DICOM format as they were acquired or created. Such access is useful both to the radiology department and to other departments such as pathology, surgery and oncology. Non-radiology information (such as lab reports) may also be accessed if made available in DICOM format.

The Cross Enterprise Document Sharing for Imaging (XDS-I.b) Integration Profile specifies actors and transactions that allow users to share images information across enterprises. This profile depends on the IHE IT Infrastructure Cross-Enterprise Document Sharing (XDS.b) Profile. Cross-Enterprise Document Sharing for Imaging (XDS-I.b) defines the information to be shared such as sets of DICOM instances (including images, evidence documents, and presentation states), diagnostic imaging reports provided in a ready-for-display format.

The Portable Data for Imaging (PDI) Integration Profile specifies actors and transactions that provide for the interchange of imaging-related information on interchange media. The intent of this profile is to provide a reliable interchange of image data and diagnostic reports for import, display or print by a receiving actor. This profile addresses identification of the media content's source and the patient (where appropriate), reconciliation of data during import, and the structure of the media contents. The central elements of the profile are the following:

- Reliable interchange of imaging-related information based on the DICOM standard.
- A Web Content Option that provides guidelines for including web-viewable content on media.
- The Web Content Option addresses the case of media containing both DICOM-encoded objects and objects in XHTML or JPEG derived from these DICOM-encoded objects.

4. DOCUMENT STANDARDS

4.1. DICOM SR

The DICOM structured report (DICOM SR) is the standard which designed by DICOM for encoding the imaging diagnostic reports and for exchanging structured data by using the DICOM hierarchical structure, data elements and services. It is the diagnostic report that encodes the interpretation and the impressions of the radiologist. DICOM SR is a structured document that contains text with links to other data such as images, waveforms and spatial or temporal coordinates. SR uses DICOM Patient/Study/Series information model (header), plus hierarchical tree of "Content Items". Content items are a sequence of nodes that are linked together with relationships in a tree form. Each content item is represented by a name/value pair. The name refers to a single "concept name". Any concept name is presented with a coded entry that uses triple encoding attributes and the value of a concept item is values presented in Figure 3. DICOM SR can be easily transformed into another format by using transform engine software and applying transformation rules (21-24). More details on SR discussed by Hussein et al (24).

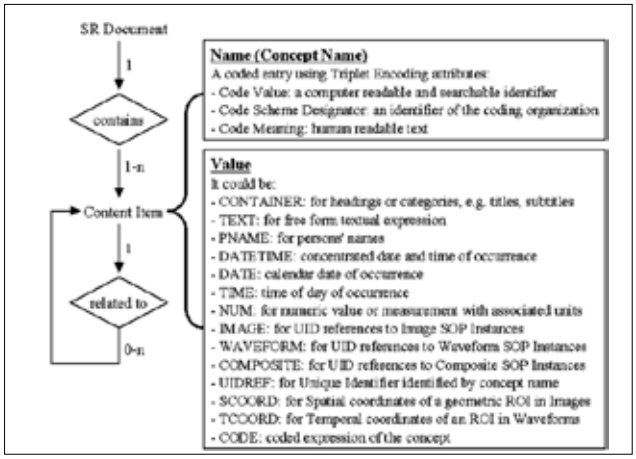

Figure 3. *SR Information Model (from (24))*

4.2. HL7 CDA

HL7 Clinical Document Architecture (CDA), is a document markup standard that uses to exchange clinical documents such as discharge summary and progress note. HL7 CDA is based on HL7 Reference Information Model (RIM) and specifies the structure and semantics of a clinical document. HL7 CDA uses Extensible Markup Language (XML) for encoding the documents. Each HL7 CDA document consists of a header and a body. The CDA header contains the document metadata and provides administrative information about included clinical data. The CDA body contains textual and multimedia data (25). The main components of HL7 CDA illustrated in Figure 4.

```
<ClinicalDocument>
  ... CDA Header ...
  <structuredBody>
    <section>
      <text>(a.k.a. "narrative block")</text>
      <observation>...</observation>
      <substanceAdministration>
        <supply>...</supply>
      </substanceAdministration>
      <observation>
        <externalObservation>...
        </externalObservation>
      </observation>
    </section>
    <section>
       <section>...</section>
    </section>
  </structuredBody>
</ClinicalDocument>
```

Figure 4. *HL7 CDA main components (from (25))*

There are some efforts to mapping DICOM and HL7 CDA. For example DICOM-CDA service is a web service that provides efficient transformation of DICOM objects to CDA XML documents (26). Also, HL7 IIWG and DICOM WG 20 are mapping to exchange of images from DICOM SR to HL7 CDA between imaging information systems and clinical information systems (24).

5. TERMINOLOGY STANDARDS

Any national association of radiology such as ACR and The Canadian Association of Radiology (CAR) issued standards on tele-radiology. Their standards provide some guidelines. These guidelines illustrate that which data are needed to tele-radiology, including: patient name, identification number and date, type of examination, modality, and number of images, image acquisition site, data and time of acquisition and availability for review (5). According to our search there are no

standardized data set in the field. In the following, the most important of terminology standards will be described:

5.1. ACR Index

ACR Index for Radiological Diagnosis (Also called ACR Index), has several features for indexing image-based teaching files. It offers both anatomic and pathologic identifiers. ACR Index codes are decimal numbers. The numeric code before the decimal point is for anatomic location and after the decimal point is for pathologic entity. Although, it was created to be used by human, some activity was done using this terminology using computer applications and web (27, 28).

5.2. RadLex

RadLex is a controlled vocabulary of radiology terms. It was developed by the Radiological Society of North America (RSNA) and created to be used by a computer. RadLex expressed as an ontology that is a representation of a terminology with hierarchical organization and relation between terms. RadLex consists of more than 68000 terms with 15 top level categories in a hierarchy. RadLex encompasses many complex domains, ranging from basic sciences to imaging technologies and acquisition. RadLex also provides a comprehensive and technology-friendly replacement for the ACR Index for Radiological Diagnoses (29-31).

6. CONCLUSION

There are many standards in the other fields that developed as well. It is needed to develop and extend the main standards such as SNOMED and HL7 in the field of tele-radiology. Hence, it seems that a harmonious body is needed to consider the standardization requirements in radiology.

CONFLICT OF INTEREST: NONE DECLARED.

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