iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: IX Month of publication: September 2021

DOI: https://doi.org/10.22214/ijraset.2021.38130

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IX Sep 2021- Available at www.ijraset.com

EHR - Interoperability study of HL7 amid the COVID-19 epidemic.

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I. INTRODUCTION

In the realm of medical informatics, interoperability of health-care information systems is a critical issue. It is critical to improve life expectancy, eliminate medical errors, and supply medical personnel with more medical information. To establish interoperability of healthcare information systems, standardised communication is essential [1]. Early in an epidemic, having access to trustworthy and robust epidemiological, medical, and laboratory data is crucial for improving public health decision-making [17].

The use of consistent standards that specify the syntactic and semantic meaning of information contributes to interoperability. Health technology development projects benefit from consistent, implementable standards because they reduce risks, costs, and schedules. Although organizations like HL7 have helped to promote some integration in healthcare, general interoperability has yet to be established. Despite enormous resources expended to far by industry and territorial health programmes around the world, the aim of interoperability in the healthcare industry has remained elusive [3].

II. BACKGROUND

Health level 7 (HL7) is a standard for electronic health information transmission at the application level. Healthcare application vendors follow the HL7 standard when building application interfaces to exchange patient records. The HL7 standard covers most health information exchange requirements, while the Digital Imaging and Communications in Medicine (DICOM) standard handles digital imaging communication. The most well-known version of the HL7 standard is the HL7 V2, that has been widely utilised in the healthcare industry since the early nineties. Two additional HL7 standards include HL7 V3 and HL7 FHIR. With FHIR, HL7 is experimenting with a novel method to standard creation. The FHIR development method takes a gradual, iterative approach to creating a standard that reflects current industry best practices for complex systems architecture. The FHIR development team places a strong emphasis on the end-usability products and suitability for its intended use [3].

III. REVIEW OF LITERATURE

A. *Group 1 – Clinical Document Architecture (CDA) and Continuity of Care Document (CCD) Standards from the HL7 Organization*

Vida et al. [1] highlight how the HL7 CDA and CCD Standards can help to improve the interoperability of healthcare information systems. Their research introduces a control for the Visual Studio.NET 2010 toolbox that can be used for ASP.NET pages and will be utilised to improve interoperability difficulties in the end. It also can display tables and information from many databases and may be linked to a cloud application. Their study outlines a method for improving interoperability between healthcare information systems, which is an important issue in the field of medical informatics.

Dolin et al. [2] also examine the HL7 Clinical Document Architecture (CDA), mentioning that the model for CDA entries was utilised as a starting point for the shared HL7 Clinical Statement model, which is currently developed from it. The capacity of a Clinical Decision Support System (CDSS) to be incorporated into a Health Information System is one of the most important factors in its effectiveness (HIS) [2]. In its second release, HL7-CDA [2] is a standard for the structuring and distribution of clinical documentation. The CDA has been authorized by ANSI and is widely used as a clinical document standard. A CDA document is an XML file that follows the CDA Refined Message Information Model's standard (R-MIM) in the form of an XML schema which is created by of components from the HL7 Reference Information Model (RIM) [2]. To allow interested individuals to understand the final structure of a CDA document, users must create HL7- CDA implementation guidelines, text documents that operate as scenario-standards by restricting the R-MIM to the given scenario. HL7-CDA may currently give entities with partial syntactic and semantic compatibility [2]. HL7 has its own language that provides first-order semantics. In most circumstances, however, it must be supplemented with clinical terminology to offer the needed semantics for a specific scenario [2].

B. Group 2 – Integrating the Healthcare Enterprise (IHE)

Pambrun & Noumeir [11] demonstrated the features and design of a web application for evaluating healthcare interoperability using the HL7 standard v3. Using the Integrating the Healthcare Enterprise (IHE) technological framework, the software examines the technical, semantic, and functional interoperability of patient identifiers and demographic enquiries in their research. Patient Demographic Query (PDQ) integration profiles and the IT Infrastructure Patient Identifier Cross-Reference (PIX) and were IHE's first foray into the HL7 v3 standard. Interoperability testing can include assessing peers' capacity to converse and exchange information, assessing peer group' ability to decode and gather information from efficaciously exchanged messages, and checking peers' ability to respond to the information extracted by converting data in their processes or affecting successive work process behaviour [11].

According to Gebase et al., [12] the IHE environment is a heterogeneous environment built for exchanging various message types in an environment. Multiple messaging protocols are used in this setting. The IHE Gazelle project aims to create a testing framework for automating integrated test scenario testing. The Gazelle framework takes the actor-based testing approach and applies it to a diverse environment. The test engine, which orchestrates message exchanges among the various messaging systems, is at the heart of the Gazelle test system [12]. The Upper-Lower Tester is a typical method of evaluating health-care systems. An Upper Tester resides above the application being evaluated and uses its application's user interface—possibly an application programming interface (API)—along with a Lower Tester that functions as a peer program and drives the testing. The Upper-Lower Tester approach can be used to do conformance testing; however, it does not scale well in situations with several applications or that require multiple systems to be evaluated at the same time [12].

C. Group 3 – Refined Message Information Models (R-MIM)

Researchers, healthcare experts, industrial groups, and the public have all benefited from the development of HL7-based tools. These instruments are made to perform specialised functions. The following are a few of these tools: R-MIM Designer is a graphics programme that helps you create HL7 static information models [9]. From XML expressions in an HMD, the V3 Generator generates HL7 artefacts such as dynamic schema, HTML table displays, fixed schema, and MIF files for static models, data formats, and terminologies. The HL7 v2 and v3 Mapping Tool is an Eclipse-based semantic mapping and data conversion application that supports HL7 v2 and v3 extensions. It enables you to convert, map, and test HL7 v2 or v3 to a variety of formats as well as to one another [9].

Kilic and Dogac [18] examine the interoperability of EHR structure and content, and demonstrate how archetypes, R-MIM derivations, and semantic tools can be used to map clinical assertions from two different EHR standards generated from the same RIM to each other. Since an R-MIM still has a limited number of classes for some domains, such as clinical statements, archetypes are used to represent more specific semantics by confining the R-MIM classes. As a result, prefabricated semantic restrictions can be used to map a source idea to a target concept [18].

IV. DISCUSSION

We can see from the above literature study that each of the three groups emphasises the interoperability of HL7 standards to improve the EHR. We can still distinguish between each group's research. Group 1 explores the solutions for enhancing interoperability between healthcare information systems and HL7-CDA delivering entities with partial syntactic and semantic compatibility, which is a key topic in the field of medical informatics. On the other hand, in their research using the Integrating the Healthcare Enterprise (IHE) technical architecture, Group 2 focuses on functional interoperability of patient identification, demographic enquiries and conformance testing of HL7 standards. Finally, Group 3 concentrates on graphics programme interoperability, which aids in the creation of HL7 static information models. In terms of the Reference Information Model (RIM) and R-MIM, we can see commonalities between Group 1 and Group 3 studies.

The arious groups have focused on components of HL7 standards and attempted to overcome interoperability difficulties inside the EHR, which can be useful during these unprecedented COVID-19 circumstances. Interoperability norms frequently have uncertainty in their specifications, which can lead to application variations. To guarantee that data is shared correctly, it's critical to test for compliance and interoperability. There are various standards for each level of interoperability in the EHR sector, as well as the fact that healthcare situations are significantly more complicated, the issue becomes more difficult. The new comprehensive test framework mentioned by the various groups enables stakeholders to conduct conformance and interoperability testing for their goods using HL7 specific standards.

V. RELATED WORK

Several publications discuss how HL7 v3 outperforms HL7 v2 in terms of semantic interoperability and model-driven characteristics. They do, however, mention the difficulty of developing v3 messages and the high expense of communicating them.

The following are some examples of relevant work in the realm of HL7, interoperability and testing:

1) In terms of the cross-domain information paradigm, data type specification, and top-down development approach of v3, Mead [6] compares v2 with v3.
2) Emerging technologies such as Enterprise Service Bus (ESB), service-oriented architecture and web services are becoming more prevalent to connect old healthcare systems [4]-[5].
3) The Testing Business Process, Application, Transport, and Network Layers (TestBATN) framework is used to test all layers of the interoperability stack for HL7-based systems. The TestBATN framework handles all tiers of the interoperability stack, it may beutilised to capture the testing needs of IHE integration profiles [13].
4) Using the HL7 v2 standard Liu et al. [5] shows an effort to build interoperability in between a hospital information system (HIS) and DICOM-based photo archiving and communication system (PACS). They propose a DICOM and HL7 v2 information sharing gateway.
5) Mirth is an open-source healthcare message integration engine developed by WebReach Inc. [7]. Mirth sends and receives, processes, and transforms messages from HL7 v2 to archive formats using a client-server and enterprise service bus architecture.
6) The limitations of connecting historical healthcare information systems utilising the standardized HL7 v3 message development model is discussed by Sartipi and Yarmand [8]. They show that a Clinical Decision Support System (CDSS) and a specialist's EMR may communicate semantically.
7) TAMMP converts high-level medical scenarios into HL7 v3 messages [10].
8) The European Telecommunications Standard Institute's (ETSI) Testing and Test Control Notation (TTCN) standard is one of the first and most successful works on test automation [14].
9) The OASIS IIC ebXML test platform was created to help with ebXML conformance and interoperability evaluation [15].
10) The OASIS IIC ebXML test methodology is improved by the OASIS event-driven test scripting language (eTSL), which addresses various levels of the interoperability stack, such as messaging infrastructure, message choreographies, and business document standards [16].

VI. CONCLUSION

EHR offers access to a patient's pertinent diagnostic information regardless of the point of access's geographic location or the institution where the data was initially acquired. EHR implementation is predicted to improve care quality by allowing access to all relevant information at the time of diagnostic decision-making; it is also expected to increase the efficacy and efficiency of the whole healthcare system by increasing productivity and eliminating test duplication. Because HER necessitates interoperability between a variety of heterogeneous distributed systems, standards are necessary to assure technological interoperability. The design of a framework for implementing standards is necessary for semantic and functional compatibility. The Integrating the Healthcare Enterprise (IHE) effort was born because of this. IHE uses a mechanism in which healthcare providers identify major interoperability issues, and healthcare manufacturers and information technology specialists agree on a solution for every highlighted interoperable challenge based on established standards [11]. HL7 standards can be used to deliver universal EHR that enable international health data interoperability and build a future where anyone can securely obtain and use the appropriate healthcare information wherever and whenever they need it.

Abbreviations	
EHR	electronic health record
EMR	electronic medical record
HIS	hospital information system
CDSS	clinical decision support system
HL7	health level seven
HL7 V2	health level seven version 2
HL7 V3	health level seven version 3
FHIR	fast health interoperability resource

MIF	model interchange format
IHE	integrating the healthcare enterprise
HIS	health information system
XML	extensible markup language
API	application programming interface
CDA	clinical document architecture
CCD	continuity of care document
RIM	reference information model
R-MIM	refined message information model
HTTP	hyper-text transfer protocol
DICOM	digital imaging and communications in medicine
PACS	photo archiving and communication system
PDQ	patient demographic query
PIX	patient identifier cross-reference
ESB	enterprise service bus
ebXML	electronic business using extensible markup language
IIC	interoperability and conformance
ETSI	the European telecommunications standard institute
TTCN	testing and test control notation
TestBATN	the testing business process, application, transport, and network layers
TAMMP	tool-assisted message mapping process
eTSL	event-driven test scripting language

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