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Keywords

Analyzing, Key, variables, adoption, Process, HL7

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Analyzing the Key Variables in the Adoption Process of HL7

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Abstract

The intention of this paper is to provide an analysis of variables that could affect the adoption of HL7 message standard. Based on the review of 33 cases where HL7 was successfully implemented the authors present relevant evidence related to inherent limitation of HL7. The result from this study indicates that it is necessary to enhance the standard to overcome particular limitations and facilitate the implementation of inter-institutional software interfaces based on HL7.

Keywords:

Health Level Seven, adoption, connectivity and standardization

Introduction

Health Level seven (HL7) consortium was founded in 1986 to research and develop a set of standards for electronic data exchange in the health care domain. The HL7 standard is a structured specification that can be used for interconnection and exchange of health records [1]. HL7 is the most widely used messaging standard for clinical and administrative data exchange among health care applications in the information technology industry [2]. HL7 has established a set of information and message models for the development and implementation of interfaces for communication and transmission of medical data among heterogeneous health information systems [2][3]. The aim of HL7 is to produce standards for a particular health care domain considering the holding of a strict and well-defined framework that ensure consensus, openness and balance of interest, and allow the development of specifications for the implementation of messages model and software interfaces[1].

At the actual level of development, the most intractable barrier for the use of HL7 has been the lack of standards for exchanging fine-grained, highly heterogeneous, structured clinical data among information systems that had been implemented under different platforms [2][3]. Moreover, the additional consideration of specific health information domain and inclusion of new information and communication technology adds levels of complexity to the initial hitch [4]. Therefore, it is necessary to explore the HL7 message standard and its application to different health care domains to establish limitations of HL7 stan-

dard, and to outline alternative courses of action that permit the overcoming of those restrictions [4].

The aim of this paper is to identify advantages and disadvantages of HL7 standard by the analysis of 33 specific cases. It will permit to identify benefits of the use, understand the adoption process and recognize limitation and barriers that should be considered during the implementation of HL7 standard. This will also offer an initial answer to why it is important to consider the development of new set of communication models based on HL7 in order to overcome the new requirement of connectivity and communication for specific application in the health care domain.

Methods

As the main purpose of this research is to identify the key attributes that facilitate or limit the adoption of HL7. The methodology used in this study was based on an analytical generalization [5] based in the analysis of 33 articles related to the use of HL7 during the design and development of software interfaces for electronic health information systems.

Framework

The Technology Acceptance Model (TAM) [6][7] was used as a framework for this analysis. The variables considered for this analysis were: (1) benefits, (2) adoption and (3) barriers. The variable cost was not considered because of the limited information provided by the authors of the studied papers.

Scope

The search was limited to articles published since 2000. The articles selected include implementation experiences in: (1) Electronic Health Records (EHR) Systems, (2) Cardiology Information Systems, (3) Electro Physiology Information Systems, (4) Radiology Information Systems, (5) Administrative, Support and Knowledge Information Systems, (6) Tele-medicine Services, (7) Regional Health Information Systems, and (8) Home Monitoring Health Information Systems.

Search strategy

The search was realized in March 2006 and repeated in July and October 2006. The second and third searches were conducted to include recent cases where HL7 has been used as a framework for the development of commu-

nication interfaces in the health care domain. The following key words were used during the search process: (1) HL7, (2) Health Level Seven, (3) health information standard, (4) interconnectivity, (5) software interfaces and (6) communication. The databases ScienceDirect, Proquest 5000, IEEE Xplore and SpringerLink were used as knowledge sources during the search process due to the immediate access for the authors.

More than 150 articles were identified during the search process. However, only 63 of them were considered for review based on the relevance over the adoption of HL7 in the health care domain. Three elements were considered as relevant to pick up the list of 63 articles: (1) the article presents information related to the development and implementation of software interfaces for data exchange among health care system, (2) the main standard used for the development was HL7, and (3) the information presented by the authors has been obtained during the implementation of projects since the year 2000.

The Table 1 shows the criteria used to select the final list of 33 articles. The scope of these criteria was to narrow the articles selected to those that present the most recent information about HL7 implementation.

Table 1 - Selection Criteria

Criteria	Considerations
Version	HL7 v. 2.5 and HL7 v. 3.0
Implementation	Modeling, Implementation of Communication Interfaces, Software, and Web-based software and interface.
Message Format	XML
Publishing Date	Year 2000 and after.
Elements Implemented	HL7 messages, new vocabulary, and model representation based on the Reference Information Model (RIM) and/or Clinical Document Architecture (CDA).

Results

The articles selected were classified into the four implementation categories described in table 1. The analysis was conducted considering the following variables: (1) Benefits/Limitations (performance and time saving, adaptability, and extensibility, modeling and implementation support; (2) Adoption of HL7 in health care; (3) Technical barriers for adoption of HL7

Benefit and limitation of HL7

Performance and time saving

The performance and time saving during the exchange of data is a main decision variable for the adoption of interna-

tional information and communication standards. Moreover, the inclusion of international standards for exchange of information among health information systems, such as HL7, may have a direct and positive impact in the time processing and performance of medical data exchange.

Langer [8] indicated that the implementation of HL7 standard enhances the performance and interoperability of health information systems and diminishes the time required for data exchange and access between hospital units and departments. Moreover, they consider that the incorporation of HL7 messages allows the friendly and easy access to multiple instances of patient's records and clinical information, which permit to enhance the quality of the health care delivery service. Ko et al. [9] agreed that the use of HL7 improves performance and efficiency of connectivity and interoperability among health information systems. However, they pointed out that large implementations, such as integrated institutional web-based application or inter-institutional health information systems, increase the risk of informatics attacks and could provoke loss of robustness, security and flexibility of the systems.

Müller et al. [10] indicated that the implementation of communication standards is a cost factor in modern health care systems. This implies that a better and faster exchange of medical information could ameliorate medical care services. They also agree that HL7 framework, in special the Clinical Document Architecture (CDA), allows the development of efficient and well defined interfaces that enhance the exchange of medical documents in local health information structures and diminishes the time of transference.

In almost all the cases analyzed, the implementation of HL7 has permitted the enhancement of performance and diminution of time during the transaction and data exchange among electronic health information systems. However, the inclusion of security schemes should be considered to ensure the safe delivery of messages and information and overcome possible information threats and loss of robustness of the systems.

Adaptability

Since its beginning HL7 has been developed as a standard for software interface that should be able to connect different and highly heterogeneous software environments. For this reason adaptability has become a keystone attribute that must be accomplished by HL7.

Most of the authors state that HL7 has presented high adaptability to the domains actually included in the standard scope [11][10]. In this sense, the HL7 Reference Information Model (RIM) has been successfully adapted to electronic health records systems, department information system and administrative and financial applications [11]. However, it has presented limited adaptability to nursing information systems, inter-institutional application

and specific health care systems such as general practice and radiology [4]. The Act¹ class of the RIM has been unable to represent nursing activities and the HL7 vocabulary is limited for nursing information [4]. The actual data structure and vocabulary definition is unable to map complete data information for General Practice's information systems [12] and, even though, HL7 has demonstrated excellent performance during the exchange of radiology clinical information, it is still limited for large image exchange [13].

According to Müller et al. [10] CDA can be easily adapted to overcome local health system requirements such as electronic health records systems, decision support systems and knowledge applications [14]. However, some issues, related to adaptability requirements, efforts and cost to meet inter-institutional needs, should be addressed to provide a better support in the implementation of software interfaces for the exchange of clinical document among different actors of the health care domain [15][10]. They also suggested that CDA can be adapted to different inter-institutional scenarios by including additional data structures and vocabulary that allow overcome the two basic limitations: (1) CDA is limited to the scope of HL7 definitions [16] and any additional extension to the data or vocabulary definition is limited to local solutions [10]. Finally, Müller et al. pointed out that the inclusion of CDA permits diminish the cost associate to the exchange of clinical documents and could enhance the delivery of primary and secondary health care services.

Bicer et al. [17] discussed about the necessity to develop message exchange frameworks that provide support semantic interoperability between different versions of HL7 message standard. This is one of the most common problems during the exchange of data between software interfaces developed under both version 2.x and version 3 of HL7.

In conclusion, HL7 has few adaptability issues for health information domains such as electronic health record, administrative and financial systems, and departmental information systems. However, due to limitations in the referential data representation and vocabulary, HL7 has restrictions that have to be considered for implementing health information systems in particular domains such as nursing system, general practice and inter-institutional application.

Modeling, extensibility and implementation support

HL7 allows the incorporation of information structures and extension to the vocabulary and messages specifications. Moreover, the information model and vocabulary should be adapted during the process of software implementation to achieve local needs [4][11]. However, those extensions are limited in exchange of information among different health providers [10].

According to Fernandez and Sorgente [14], the ad hoc variation of the HL7 Unified Modeling Language (UML) is incompatible with existing standards. Moreover, the HL7 documentation is wide and complex making it difficult to understand. In addition, entities, roles and associations had been represented and structured for implementation not for abstract representation, e.g. roles are job descriptions without security specifications and associations that do not have names or semantic values. Indeed, they had been replaced by separate class representations. Moreover, to add extend class representations HL7 uses arbitrary names based on prefixes of the original classes and not stereotypes as usual in UML representations. In general, HL7 artifacts do not completely follow the UML patterns and software engineering rulers. This issue makes the standard unnecessarily complex for the elaboration of model representations and model extensions.

The RIM provides explicit semantic and lexical representations of messages and fields. Additionally, it facilitates the data integration among health care applications, providing structural information models and a health base vocabulary [14]. Moreover, the RIM facilitates the mapping process over basic health care informational representations and model [20]. However, these representations are relatively limited if the standard is applied to some particular health care domains such as nursing systems [4], general practice's information systems [12] or radiology information systems [21].

The HL7 CDA gives a framework for design and interoperability of clinical documents [20]. Furthermore, the CDA provides support and representation for messages based on text, image, sound and multimedia contents, and allows the enhancement of vocabulary and information structure to reach particular requirement. However, it does not provide guides or recommendation for the development of structural or vocabulary extensions and most of the representations require adjustment and modification to local needs [22]. Additionally, any local extension to the model, vocabulary or documents structures must be considered as optional data or field during the interchange of data among health care providers [4]. This implies that, due to the message definition, some relevant information could not be interpreted by the destination node.

Lebak, Yao and Warren [23] suggest that HL7 should provide a better support for large scale system implementations that consider interconnection among different actors of the health care. It implies the consideration of a framework that includes support for the development and deployment of integrated, interconnected and secure software interfaces. [23], the integration of electronic health records, and provides a wide set of elements that support the modeling and implementation of robust inter-institutional software interfaces based on HL7 standard [15].

In Summary, the had hoc UML model representation used by HL7 artifacts do not follow the object oriented standards, this makes more complex the standard for develop-

¹ The RIN Act class is used to represent intentional acts that are performed to benefit the patient and associated clinical activity.

ers and increases the time and cost associated to the development of HL7 message interfaces. HL7 provides extensibility capabilities. However, extensions of HL7 standard are limited to local implementation. Moreover, inter-institutional implementations, such as Regional Health Information Systems, should consider this limitation to include homogenized message structures and message interpretations.

Adoption of HL7 in health care

The use and adoption of HL7 allows the implementation of integrated health care systems. In addition, HL7 provides a native and robust interoperability framework for software development and deployment. Moreover, HL7-CDA reduces the cost of moving existing documents to new standards [10] and enhances the work flow between health information systems. For these reasons most authors explicitly agree that HL7 is a recommended and required standard for information exchange among health care applications. However, the adoption of HL7 should consider several issues that should be addressed to the implementation plan. Some of them are adoption limitation over ad hoc UML modeling of HL7 [18], complexity of the implementation over large information systems, high cost, restrictions of vocabulary and the consideration of other communication standards that provide better support over specific domain, e.g. The Digital Imaging and Communications in Medicine (DICOM) for radiology exchange of information [13].

Technical barriers for adoption of HL7

HL7 provides a wide range of guidelines and specification for implementation of data structures and messages for software interfaces among health informatics applications [2]. Instead, HL7 has several technical limitations related to information model specifications, message definitions, document structures and vocabulary applied to specific health care domains.

First, according to the definitions of HL7 standard, the message should contain a basic set of fields, which must hold the critical information required for exchange; additional information should be provided using the optional fields [1]. This fact does not represent a real inconvenience for local implementations [22][11]. However, this issue could increase the costs and efforts required during the development and deployment of HL7 messages for inter-institutional applications [10].

Second, the RIM has presented issues during the data mapping and development of messages in some health care domains [4][12][20]. According to Danko et al. [4], the RIM class Act is unable to represent complete model structures for nursing information systems. Moreover, they suggested the additional attributes to the RIM-Act class and the enhancement of the HL7 vocabulary to include nursing information. Furthermore, these limitations also affect the development of software solutions in other domains such as general practice [12], and the exchange of referral and discharge letters [11].

Thirdly, the CDA has been developed to provide a framework for document representation and message elaboration based on HL7 standards. However, the CDA framework is in a development stage. This implies that CDA does not provide a complete data representation for some specific health domains or local requirements [11]. Moreover, limitations of HL7 vocabulary and data structure make necessary the development of local solutions, which are not totally compatibles for inter-institutional information exchange [4][11]. In addition, actual vendor's software does not provide complete support for integration of certain external data, and local implementations are restricted to internal needs [10]. These issues add levels of complexity to the development process and increase the cost if implement HL7-CDA messages interfaces over inter-institutional health information systems.

Finally, additional limitations are related the cost and time required for implementation and the complexity of the existent HL7 artifacts [13]. The implementation of HL7 messages based on CDA over XML requires an important amount of time and cost of development. In addition, the deployment of large health information system makes the development and implementation process highly difficult and requires additional resources [14].

In conclusion, HL7 has provided a helpful framework for developing and implementing health information messages interfaces. However, there still exist some issues to address in order to improve the standard.

Discussion

This paper has presented an analysis based on HL7, both version 2.5 and version 3.0, implementations experiences over different health care domains since the year 2000. Those experiences ratified that HL7 provides a wide range of capabilities for the enhancement of message communication among health information systems. However, those experiences also had made manifest that HL7 has structural and technical limitation that could make difficult the adoption process. Those limitations are related to the message modeling and implementation, data structure representation and vocabulary presented in the RIM and CDA.

HL7 standard provides a basic framework for message modeling and implementing. However, in most of the cases analyzed the authors recommend to update the standard to overcome local needs. Furthermore, it is necessary to consider the development of a framework that provides guidelines for the development of inter-institutional message solutions. Additionally, it is also necessary to develop a message exchange framework that enhances the compatibility between version 2.x and version 3.0 HL7 messages.

Both the RIM and CDA have been implemented and used to enhance the data, information and document exchange among local and inter-institutional health information systems. At the local level both provide a framework for message design and extensibility implementation, and system deployment [1][10]. However, the data definition and vocabulary incorporated to the HL7 standard is limited to

the existing in the RIM and CDA definition [20][10][19]. Moreover, the existing data and vocabulary definitions limit the mapping of data and generation of messages. These limitations can be overcome by incorporating extensions to the models and vocabulary at the local level. Nevertheless, it is important to consider that according to the HL7 message standards [1][4], extensions must be considered optional attributes or optional values during the exchange of messages. These issues increase the complexity and cost of the development and implementation of health information software solution at inter-institutional level.

Conclusion

HL7 has demonstrated to be an important advance in the development of health information software for medical data exchange. However, the implementation of HL7 in specific cases, requires the development of new information models, message model and vocabulary that allows the implementation of those interfaces [4][12][13]. Moreover, the development of communication interfaces on specific scenarios would permit to enhance the actual information structure of HL7 standard. On the other hand, the definition and specification of HL7 message information models, for specific health domain software, allows the implementation of robust software interfaces. These interfaces would enhance the information exchange and interoperability among different local and inter-institutional health care software applications.

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