Health Data Exchange Standard Review: Health Level 7 Version 2

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In an ideal world, every patient would have a single source of truth for their healthcare data. Whether their care was received at a hospital, an immunization clinic, or their primary care provider's office, all their data would funnel into a single system. This system would then be accessible to everyone in the patient's circle of care, including the patient. In our current healthcare landscape, this remains a significant challenge. Interoperability, as defined by the Institute of Electrical and Electronics Engineers, is "the ability of two or more systems or components to exchange information and to use the information that has been exchanged (1991, p. 14). Health Level 7 Version 2 (HL7 V2) is a health data exchange standard created to allow interoperability between healthcare systems, and it is argued to be the most widely used standard in the world (HL7 International, n.d.-b). This report explores the positive impact the HL7 V2 data exchange standard has had on healthcare interoperability including the history, key features, benefits, and challenges. An implementation of HL7 V2 in Canada is also reviewed.

Overview

For most patients in Canada, their data is spread across many different systems, created by diverse vendors. Even within healthcare settings, such as hospitals, their data can exist across multiple systems. These could include the electronic record system, the medication administration system, and the digital imaging system. For the data to be accessible in one parent system, it must be possible for the data to be transmitted from the child systems in a way that ensures the meaning of the data is not lost during transmission. Payne (2015) remarks that, before the creation of data exchange standards, the primary method for exchanging data between systems was to manually create unique interfaces between each system pair. Creating unique interfaces between each system was time-consuming and costly (p. 27).

Data exchange standards provide a solution to the interoperability problem. HL7 V2 enables healthcare interoperability by providing a standard format for data to be exchanged between health computer systems. It is a message-oriented data exchange standard, defining messages using an abstract notion (Oemig & Snelick, 2016, pp. 106–109). There are currently fourteen sub-versions of HL7 V2 that have been released (see Table 1) (HL7 Europe. (n.d.-a); Benson & Grieve, 2021, p. 213; Ringholm, n.d., HL7 version 2 section).

Version	Year Released
2.0	September 2008
2.1	June 1990
2.2	February 1996
2.3	May 1997
2.3.1	April 1999
2.4	October 2000
2.5	July 2003
2.5.1	February 2007
2.6	October 2007
2.7	February 2011
2.8	February 2014
2.8.1	April 2014
2.8.2	July 2015
2.9	December 2019

Table 1 - HL7 V2 Subversions by Release Year

The name Health Level 7 was taken from the fact the standard focuses on communication between applications, and the seventh level of the International Organization for Standardization (ISO) 7-layer communication model is the application layer. The domain of HL7 V2 covers a variety of functional areas, such as Patient Administration, Observation Reporting, and Financial Management (Zaleski, 2015, pp. 107–108).

Development and Maintenance

Over three decades, HL7 V2 has evolved through iterative enhancements, each version building on its predecessors to remain a cornerstone of healthcare data exchange. The intellectual property of Health Level Seven International, the first version of HL7, V1, was developed in 1987 with the goal of exchanging admission, discharge, and transfer (ADT) information between systems. The second version, HL7 V2.0, was published a year later. It added new message types for exchanging orders and reports related to tests and treatments (Benson and Grieve, 2021). The format of these early versions of HL7 messages was heavily influenced by the limited storage space of systems being used in the 1980s (Oemig and Snelick, 2016). Many new versions of HL7 V2 have been released since the introduction of HL7 V2.0; the latest version, released in December 2019, is Version 2.9. Each new version has built on the previous version while remaining backward-compatible with every version that has come before it. This backward compatibility ensures seamless integration with older systems, reducing the cost and complexity of upgrades. Key updates to HL7 V2 have added features such as advanced handling of data types, improved message structures, and mechanisms for grouping segments and specifying conditions. Notably, the initial release of HL7 V2.0 included only one generic data type (CM), but this number had grown to over 90 distinct types by version 2.6 (Benson & Grieve, 2021).

As stated on Confluence, HL7 International's community workspace, the development and maintenance of HL7 standards is led by HL7 International. HL7 International has a small staff, however, most of the work performed on HL7 standards is done by volunteers (who may be paid by their employers to participate). Work is performed by various work groups that each focus on a specific healthcare area. The number of participants in each work group varies, however each group is led by at least two co-chairs. HL7 International also has a board of directors that provides strategic oversight for the organization (HL7 International, 2024).

Key Features

Oemig and Snelick (2016) state that HL7 V2 is a message-oriented data exchange standard. Several key elements that make up this standard. Health data is encoded into messages that are sent in response to trigger events. Each message contains one or more segments, and each segment contains one or more fields. Fields can contain components and subcomponents (p. 109). This layered design ensures that data is structured in a consistent, interoperable format, facilitating efficient information exchange. Each element of this framework is discussed in the sections below.

Trigger Events

HL7 V2 messages are generated based on trigger events. There are a variety of events that can trigger the creation of an HL7 message in a system. For example, the act of registering a patient in an Electronic Health Record (EHR) system can trigger that system to generate a patient registration message. If another system in the hospital, such as a radiology system, is configured to receive HL7 messages from the EHR, it would receive the information contained in the message. These trigger events can handle varying levels of complexity, including single object actions (e.g., admissions), multi-object relationships (e.g., merges), and collections of loosely connected objects (e.g., inpatient location queries) (Caristix, n.d., What is a Trigger Event section).

Messages

As mentioned previously, HL7 V2 covers a variety of functional areas. Each functional area has its own defined set of message types (Magnuson et al., 2020, p. 29). For example, the Patient Administration functional area for HL7 V2.4 includes message types for 'Register a patient', 'Transfer a patient', and 'Discharge/end visit' (see Figure 1 for an example of a Register a Patient message). The Order Entry functional area for the same version includes messages for 'Dietary order', 'Order Message', and 'Order Response.' Messages are identified by codes and associated descriptions, which can change across HL7 V2 subversions. For example, in HL7 V2.1 the patient admission message is identified by the code and description 'ADT_A01 – Admit a Patient', while in HL7 V2.3 it is identified by the code and description 'ADT_A01 – Admit/visit notification' (Caristix, n.d., Trigger Events section).

Segments

HL7 V2 messages are composed of one or more segments. A segment consists of delimited fields arranged on a single line, representing a specific part of a message such as a patient, an order, or a test result. Segments are either required or optional, can appear once or repeat within a message, and can be nested. Each segment is identified by a unique three-character Segment ID that appears at the beginning of the segment, such as MSH (message header), EVN (event type), or PID (patient ID). Within the message, the segments must appear in the order dictated in the specification for the subversion being used. Table 2 shows the segments in the correct order for an ADT_A04 – Register a Patient message for HL7 V2.4 (HL7 V2.4 ADT_A04), along with the repeatability and optionality for each segment. It also shows the PR1 and ROL segments nested under PROCEDURE, creating a group that is both optional and repeatable (Caristix, n.d., HL7 v2.4 - ADT_A04 – Register a Patient section; Benson & Grieve, 2021, pp. 217–218).

Segment ID	Segment Name	Optionality	Repeatability
MSH	Message header segment	Required	Not Allowed
EVN	Event type	Required	Not Allowed
PID	Patient Identification	Required	Not Allowed
PD1	Patient Additional Demographic	Optional	Not Allowed
ROL	Role	Optional	Infinite
NK1	Next of kin / associated parties	Optional	Infinite
PV1	Patient visit	Required	Not Allowed
PV2	Patient visit - additional information	Optional	Not Allowed
ROL	Role	Optional	Infinite
DB1	Disability	Optional	Infinite
OBX	Observation/Result	Optional	Infinite
AL1	Patient Allergy Information	Optional	Infinite
DG1	Diagnosis	Optional	Infinite
DRG	Diagnosis Related Group	Optional	Not Allowed
PROCEDURE		Optional	Infinite
PR1	Procedures	Required	Not Allowed
ROL	Role	Optional	Infinite
GT1	Guarantor	Optional	Infinite
INSURANCE		Optional	Infinite
IN1	Insurance	Required	Not Allowed
IN2	Insurance additional info	Optional	Not Allowed
IN3	Insurance additional info certification	Optional	Infinite
ACC	Accident	Optional	Not Allowed
UB1	UB82 data	Optional	Not Allowed
UB2	UB92 data	Optional	Not Allowed
PDA	Patient death and autopsy	Optional	Not Allowed

Table 2 - HL7 V2.4 ADT_A01 - Admit/visit notification message segments

Fields and Components

HL7 V2 segments are composed of one or more fields, separated by pipe "|" characters, ending in a carriage return "<CR>" character. If there is no data to populate a given field, the pipe character for that field will still appear, unless the empty field is at the end of the segment; empty fields at the end of a segment are truncated to reduce message size. Like segments, fields can appear once or repeat within a segment and must appear in the order dictated in the specification for the subversion being used (Benson & Grieve, 2021, pp. 215–218). Fields can be Required, Optional, Conditional (conditional on the trigger event or some other field), or Backwards Compatible (left in for backward compatibility with previous versions of HL7) (HL7 Europe, n.d.-b). Fields are identified by a combination of their segment ID and their location within the segment. For example, in HL7 V2.4 ADT_A04, the Patient Address field has the identifier PID.11, as it is the 11th field in the PID segment. Table 3 shows the PID segment fields in the correct order for an HL7 V2.4 ADT_A04 message, along with the repeatability and optionality for each field (Caristix, n.d., HL7 v2.4 – PID – Patient Identification section; Benson & Grieve, 2021, pp. 215–218).

Field	Description	Optionality	Repeatability
PID.1	Set ID - PID	Optional	Not Allowed
PID.2	Patient ID	Backwards Compatibility	Not Allowed
PID.3	Patient Identifier List	Required	Infinite
PID.4	Alternate Patient ID - PID	Backwards Compatibility	Infinite
PID.5	Patient Name	Required	Infinite
PID.6	Mother's Maiden Name	Optional	Infinite
PID.7	Date/Time of Birth	Optional	Not Allowed
PID.8	Administrative Sex	Optional	Not Allowed
PID.9	Patient Alias	Backwards Compatibility	Infinite
PID.10	Race	Optional	Infinite
PID.11	Patient Address	Optional	Infinite
PID.12	County Code	Backwards Compatibility	Not Allowed
PID.13	Phone Number - Home	Optional	Infinite
PID.14	Phone Number - Business	Optional	Infinite
PID.15	Primary Language	Optional	Not Allowed
PID.16	Marital Status	Optional	Not Allowed
PID.17	Religion	Optional	Not Allowed
PID.18	Patient Account Number	Optional	Not Allowed
PID.19	SSN Number - Patient	Backwards Compatibility	Not Allowed
PID.20	Driver's License Number - Patient	Optional	Not Allowed
PID.21	Mother's Identifier	Optional	Infinite
PID.22	Ethnic Group	Optional	Infinite
PID.23	Birth Place	Optional	Not Allowed
PID.24	Multiple Birth Indicator	Optional	Not Allowed
PID.25	Birth Order	Optional	Not Allowed
PID.26	Citizenship	Optional	Infinite
PID.27	Veterans Military Status	Optional	Not Allowed
PID.28	Nationality	Backwards Compatibility	Not Allowed
PID.29	Patient Death Date and Time	Optional	Not Allowed
PID.30	Patient Death Indicator	Optional	Not Allowed
PID.31	Identity Unknown Indicator	Optional	Not Allowed
PID.32	Identity Reliability Code	Optional	Infinite
PID.33	Last Update Date/Time	Optional	Not Allowed
PID.34	Last Update Facility	Optional	Not Allowed
PID.35	Species Code	Conditional	Not Allowed
PID.36	Breed Code	Conditional	Not Allowed
PID.37	Strain	Optional	Not Allowed
PID.38	Production Class Code	Optional	Infinite

Table 3 – HL7 V2.4 ADT_A01 - Admit/visit notification message – PID segment fields

Fields are composed of one or more components, separated by a carat “^” character. Components can be composed of one or more subcomponents, separated by an ampersand “&” character. In the fictional message example shown in Figure 1 below, the PID segment contains the components of the patient’s name separated by carat characters. The tilde “~” character indicates the repetition of a field, such as the repetition of the allergic reaction symptoms ‘PRODUCES HIVES’ and ‘RASH’ shown in the first AL1 segment below.

```
MSH|^~\&|ADT1|MCM|LABADT|MCM|198808181126|SECURITY|ADT^A04|MSG00001|P|2.4
EVN|A01|198808181123
PID|||PATID1234^5^M11||JONES^WILLIAM^A^III||19610615|M||2106NOT ALLOWED3|1200 N ELM STREET^^
GREENSBORO^NC^27401NOT ALLOWED1020|GL|(919)379NOT ALLOWED1212|(919)271NOT ALLOWED3434~(919)277NOT
ALLOWED3114||S||PATID12345001^2^M10|123456789|9NOT ALLOWED87654^NC
NK1|1|JONES^BARBARA^K|SPO|||||20011105
NK1|1|JONES^MICHAEL^A|FTH
PV1|1|I|2000^2012^01||||004777^LEBAUER^SIDNEY^J.|||SUR||NOT ALLOWED||1|A0
AL1|1||^PENICILLIN||PRODUCES HIVES~RASH
AL1|2||^CAT DANDER
DG1|001|I9|1550|MAL NEO LIVER, PRIMARY|19880501103005|F||
PR1|2234|M11|111^CODE151|COMMON PROCEDURES|198809081123
ROL|45^RECORDER^ROLE MASTER LIST|AD|CP|KATE^SMITH^ELLEN|199505011201
GT1|1122|1519|BILL^GATES^A
IN1|001|A357|1234|BCMD|||||132987
IN2|ID1551001|SSN12345678
ROL|45^RECORDER^ROLE MASTER LIST|AD|CP|KATE^ELLEN|199505011201
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Figure 1 - HL7 V2.4 ADT_04 Register a Patient Message

Challenges

A closer look at HL7 V2 reveals several challenges that highlight the trade-offs and complexities inherent in managing a widely adopted data exchange standard. Braunstein (2018) states that HL7 V2 was not intended to be human-readable, as it was designed for computer processing and optimized for the limited storage capacities of that time. Building on this, Benson and Grieve (2021) add that HL7 V2's reliance on extensive standards documentation and implementation guides poses yet another challenge. The persistence of older versions, driven by low upgrade incentives, forces engineers to address version disparities and manage the associated risks (pp. 213–214). Additionally, HL7 International (2022) acknowledges that the HL7 standards process faces a trade-off between speed and effectiveness, taking 1-2 years for a trial standard and another 3+ years to finalize a stable version. If the process is too slow, the community may move on, while rushing the process risks creating a standard that is unfit for purpose. Finally, Magnuson et al. (2020) note that HL7 V2's adaptability, while beneficial, introduces complexities. The wide range of variations that can be created by users can lead to confusion and increased effort (pp. 134–135). Therefore, these challenges collectively underscore the complexities of maintaining and implementing the HL7 V2 standard, with far-reaching implications for achieving seamless data exchange in healthcare.

Benefits

Despite its challenges, HL7 V2 has had a very positive, widespread impact on the healthcare landscape. Benson and Grieve (2021) emphasize its global adoption, noting that HL7 V2 "is the most widely used healthcare interoperability standard in the world. It is used in over 90% of all hospitals in the USA and is widely supported by healthcare IT suppliers worldwide" (p. 213). Gupta and Biswas (2019) highlight that a key benefit of HL7 is that it provides a standardized language for exchanging and sharing health information, eliminating the need for developers to create custom formats for each interface—a process that was both costly and time-consuming. Magnuson et al. (2020) further commend HL7 V2's flexibility and complexity, as it accommodates a vast array of data requirements across diverse healthcare systems (p. 134). These benefits demonstrate why HL7 V2 remains an integral tool in advancing healthcare interoperability, despite the challenges it presents.

Implementation Example

A case study from British Columbia, Canada, illustrates how HL7 V2 was used to support a hospital-based human donor milk bank program. In their 2017 paper, Kuo and Kuo explain that the milk bank program was expanded in 2012, requiring the manual paper-based process to be replaced with an electronic version. The electronic system chosen, called the Milk Bank Management System (MBMS), would be used to manage and distribute the milk. To ensure the efficiency and accuracy of data collection during the donor screening process, it was determined that an interface would be required between the MDMS and the provincial patient index repository: Enterprise Master Patient Index (EMPI). Since MBMS and EMPI were designed for different versions of HL7 (versions 2 and 3 respectively), they were not able to communicate directly and therefore required middleware to be implemented. Kuo and Kuo further explain:

> To leverage the existing data collection in the EMPI database and enable the database to communicate with the Milk Bank Management System, we applied the Common-Gateway Model using Microsoft BizTalk Broker and Heath Level-7 (HL7) standards to design and develop interfaces for querying and exchanging data (p. 189).

Another solution was considered: modifying the MBMS system to construct HL7 v3 messages to remove the necessity of middleware. This option was declined for several reasons, including the fact that HL7 V2 is a more commonly used standard and that the Biztalk broker provides interface management and monitoring. Kao and Kao concluded that the integration of the two systems was an improvement over the previous paper-based system. They also observed that the Fast Healthcare Interoperability Resources (FHIR) standard, introduced by HL7 in 2014, might offer a more effective solution for future implementations like the MBMS.

Conclusion

Throughout their lives, patients receive care from numerous clinicians in various healthcare settings, yet fragmented data systems often hinder a complete view of their health history. HL7 V2 addresses this challenge by providing a standardized format for healthcare data exchange, facilitating interoperability. By bridging the gap between disparate systems, HL7 V2 enables clinicians to access a more complete view of each patient's health data, facilitating data-driven decisions that improve patient care. However, achieving true interoperability requires continued investment in and adoption of standards like HL7 V2. By building on its foundation, the healthcare system can move closer to realizing a fully connected, patient-centric future.

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