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A Comparative Analysis of HL7 and NIEM: Enabling Justice-Health Data Exchange

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Introduction

Jails and prisons are responsible for providing medical and mental health care to individuals in their custody. In many cases, correctional facilities have become the default medical and mental health treatment provider for offenders. Public health and public safety are interrelated issues; for example, drug abusers are 3–4 times more likely to commit crimes, and individuals with mental health illness are 2–3 times more likely to be incarcerated.[1]

The vast majority of incarcerated individuals will eventually return to the community—and in many cases their medical and mental health issues persist, which then require treatment by community care providers. Offender reentry programs seek to facilitate the successful transition of offenders from incarceration into the community. They focus on strategies that improve the likelihood of successful reintegration in society at large and reduce the likelihood of recidivism. One area of focus is to improve continuity of care so offenders re-entering the community do not experience disrupted medical and mental health treatment. Unfortunately, many of these same individuals reoffend and return to the criminal justice system, along with their ongoing medical and mental health treatment needs. Again, maintaining continuity of care is a critical part of ensuring the health and safety of these returning individuals, as well as others in the corrections environment.

Continuity of care: A process that involves the patient and all members of the health care team. The correctional health care team should work to manage all care delivered and should always strive for quality in delivery of that care.
— National Commission on Correctional Health Care

Improving continuity of care to those individuals who enter, leave, or return to the justice system presents business and technical challenges for justice and health practitioners. The focus of this paper is to address a basic technical challenge: *How to communicate or exchange basic information about an individual between the justice and health communities in order to improve timeliness and delivery of needed*

[1] Adam K. Matz, Carl Wicklund, Jim Douglas, and Bob May. "Justice-Health Collaboration: Improving Information Exchange Between Corrections and Health/Human Service Organizations, Making the Case for Improved Reentry and Epidemiological Criminology." September 2012. SEARCH, American Probation and Parole Association, and the Association of State Correctional Administrators. http://www.search.org/files/pdf/Justice-HealthCollabBusinessCase.pdf.

medical, health, and treatment services. Both communities have developed parallel "vocabularies" to communicate between computer systems—each of which describes information in a semantically clear and precise way:

- The health community's vocabulary is called Health Level 7, or HL7.[2]
- The justice community's vocabulary is known as the National Information Exchange Model (NIEM).[3]

This *Technical Brief* examines these two data standards by providing a basic description of each, a simple analysis of their commonalities and differences, how and why to translate from one standard to another, and a look at the future of their alignment.

HL7 and NIEM Standards Overview

HL7 and NIEM are parallel information technology data standards that define a vocabulary to exchange electronic messages between computer systems for specific business purposes by each community of interest. Both standards achieve this objective, but do so through different approaches to structuring data.

HL7 Version 2

Introduced in 1987, Version 2 of the HL7 standard is a formatted Electronic Data Interchange (EDI) text delimited messaging structure that organizes medical information in terms of **message types**, **segments** and **fields** (or composites), and **coded enumerations**. HL7 published these messages with the intent to reduce the cost and level of effort involved in establishing customized interfaces between medical stakeholders. Prior to HL7's development, each implementation, vendor, and product had to invent or reinvent a common message structure.

Each HL7 V2 message type corresponds to a healthcare event and specifies the expected segments. The data fields within each segment provide meaning based on their sequential position within the segment. Each field is defined using an externally referenced data dictionary.

HL7 V2 contains over 80 message types, which includes more than 200 specialized message types referred to as **sub-types**, more than 100 segments, and thousands of corresponding codes or enumerated values for certain fields.[4] HL7's extensive use of code sets reduces the size of messages exchanged with stakeholders and limits bandwidth concerns. While this increases the transaction speed, implementers must translate these coded values into local system values using the data definition tables per release version. Figure 1 is a sample of a commonly used V2 message type for Admissions, Discharge, and Treatment (ADT) that exemplifies the V2 messaging structure.

```
MSH|^~\&|MegaReg|XYZHospC|SuperOE|XYZImgCtr|20060529090131-0500||ADT^A01^ADT_A01|01052901|P|2.5
EVN||200605290901||||200605290900
PID|||56782445^^^UAReg^PI||KLEINSAMPLE^BARRY^Q^JR||19620910|M||2028-9^^HL70005^RA99113^^XYZ|260 GOODWIN
PV1||I|W^389^1^UABH^^^^3||||12345^MORGAN^REX^J^^^MD^0010^UAMC^L||67890^GRAINGER^LUCY^X^^^MD^0010^UAMC^L|
OBX|1|NM|^Body Height||1.80|m^Meter^ISO+|||||F
OBX|2|NM|^Body Weight||79|kg^Kilogram^ISO+|||||F
AL1|1||^ASPIRIN
DG1|1||786.50^CHEST PAIN, UNSPECIFIED^I9|||A
```

Figure 1 – Sample Admission Message Type[5]

[2] www.hl7.org
[3] www.niem.gov
[4] Complete table for all V2.6 data definitions: www.hl7.org/special/committees/vocab/V26_Appendix_A.pdf.
[5] http://en.wikipedia.org/wiki/Health_Level_7

All HL7 messages contain numerous segments. In Figure 1, the **MSH** segment is the message header, the **PID** segment is the Patient Identification segment, and the **PV1** segment is the Patient Visit segment. Within each segment, each field is separated by the pipe symbol (|) and each field position is predefined. For example, in the sample message in Figure 1, the PV1 segment contains the message segment type followed by the Patient Class of |I|, which translates to "Inpatient." The third field is the assigned patient location, which defines a distinct location: Point of Care=W (wing), Room=389, bed=1, facility=UABH, location status, person location type, building elements are not used, followed by floor=3. The next three elements are not used (Admission Type, Preadmit Number, and Prior Patient Location), and the remainder of the segment identifies the medical service provider(s).

This simple example is one of many hundreds of distinct elements within segments within messages and message sub-types. *This translation involves a familiarization process with clinical semantics and can be challenging and time-consuming for an inexperienced development team.*

HL7 recognizes that information sharing partners will have unique requirements and provides the flexibility to accommodate these needs through what is called the **Z segment**. The Z segment extends any message type to capture patient or clinical data required by stakeholders that are unaccounted for elsewhere in HL7. To do this, information sharing partners must establish an agreed-upon structure and characteristics of Z segment content and implement this customized version of the given message type. Consequently, like NIEM, any given HL7 message can be unique to fit the requirements of the exchange.

Later releases of HL7 V2 use Extensible Markup Language (XML) encoding and organize message types in XML schema. These schemas reflect distinct segments and include the available elements and expected code values in that segment. The V2 schemas restructure the same content in XML schema as an option for exchange partners with XML capabilities to leverage newer tool functionality.[6] However, they do not address the inconsistent and customized nature of HL7 implementations.

HL7 Version 3

In an effort to establish a more formal and consistent means to implement the data model, HL7 published Version 3 (V3) in 2005. The V3 information model employs an object-oriented modeling approach that can be represented in Unified Modeling Language (UML). This approach organizes physical or conceptual "things" into classes with characteristics (**attributes**) and defines the relationships (**associations**) among those classes.

The foundation of HL7 V3 is the Reference Information Model (RIM), which is a static conceptual model that provides the structure for the supporting healthcare domains. The RIM includes concepts for defining **entities**, **roles**, **participation**, **acts** (actions), and **relationships** between those basic components.[7] RIM classes and associations are generalized and intended to be refined according to the needs of a healthcare

[6] HL7 XML Special Interest Group Informative Document, Robert H. Dolin, MD, and Paul V. Biron, MLIS, editors, "HL7 Recommendation: Using XML as a Supplementary Messaging Syntax for HL7 Version 2.3.1." http://www.hl7.org/documentcenter/public_temp_E815D2B0-1C23-BA17-0C7C9AFB56A16A18/wg/xml/drafts/hl7v231xml.pdf.

[7] HL7 V3 Guide. ftp://ftp.ihe.net/International/Europe/HL7%20V2.5/Version%203%20Ballot%20Cycle%204%20-%20DRAFT/v3ballot4/html/foundationdocuments/helpfiles/v3guide.htm

domain (e.g., Medical Records or Patient Administration). These specialized RIM derivations are referred to as **Domain Message Information Models** (DMIMs) and provide the framework for creating messages. DMIMs are further refined in order to express the specific message content and supporting annotations. These DMIM derivatives—known as **Refined Message Information Models** (RMIM)—provide the message content in XML instance documents.

The V3 approach is quite different from V2. It presents an opportunity for a more consistent approach to increase semantic clarity, enable object reuse in different contexts, and specify cardinality,[8] among other benefits. Yet the reception of V3 among healthcare practitioners and the vendor community is mixed. The scope of this brief does not include a full assessment or comparative analysis of V2 and V3, but will summarize their respective strengths and criticisms based upon review of industry literature with an eye toward their relevance to NIEM.

Comparing HL7 Versions

By many accounts, V3 is the "latest and greatest" technical approach to managing complex information in a widely distributed healthcare environment. It reflects a strategic and enterprise perspective intended to align and support newer technologies and development practices. V3 leverages industry standard modeling practices (i.e., UML) and flexible implementation techniques referred to as the **HL7 Development Framework** (HDF). HDF defines the structural requirements of a message independent of the model, which provides more consistency to the message development process and clarity of the content without belaboring event-specific message content. Ultimately this provides an explicit data model, clear data and message definitions, and the ability to dynamically incorporate new material into the standard.[9]

Understanding and implementing these new advancements and features comes with a degree of difficulty. The steep learning curve of the V3 approach is daunting and complicated by its drastic difference from V2 and the highly specialized and complex supporting documentation. The V3 scope is vast and some stakeholders may be quickly overwhelmed and lost in the documentation that easily blends tangentially related topics. The refactoring and continual evolution of HL7 and its use in initiatives—such as the Clinical Document Architecture (CDA), Continuity of Care Document (CCD), Clinical Context Management Specification (CCOW), and the Fast Healthcare Interoperability Resources (FHIR) specification—presents significant challenges for novices to determine what resources they should use or even where to begin.[10]

When compared to V2 message structure, V3 is completely different. This presents technical challenges for implementers, which translate into financial concerns for adopting V3. In 2010, Corepoint Healthcare Solutions conducted a survey of HL7 version implementation across the country with the results shown in Figure 2.[11]

[8] That is, is an element required or optional?
[9] http://msdn.microsoft.com/en-us/library/bb967001%28v=bts.10%29.aspx
[10] http://hl7-watch.blogspot.com/2012/08/refurbish-verb-to-bish-again-with-fur.html
[11] http://www.corepointhealth.com/sites/default/files/whitepapers/hl7-v2-v3-evolution.pdf

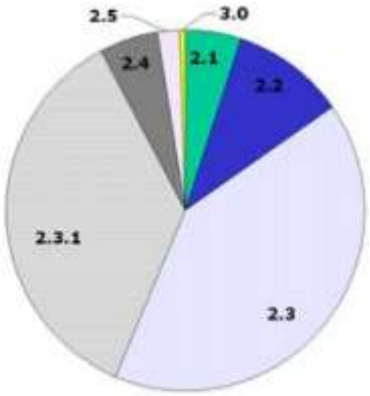

Figure 2 – Approximate real-world usage of different versions of HL7 messaging standards.
(The vast majority of HL7 messaging is done using messages that approximate HL7 2.3 or HL7 2.3.1. Newer releases of HL7 (2.5, 3.0, and soon 2.6) represent a very small portion of real-world interfaces.)

In practical terms, the likelihood of encountering a V3 implementation is quite small, as the overwhelming use of HL7 is V2.x. The predominant use of V2.x will play a significant role in decision-making when the justice and public safety agencies that use NIEM engage in integration efforts with healthcare stakeholders. It is most likely that justice professionals working on data exchanges with the health community will use one of the older versions of HL7.

NIEM

The National Information Exchange Model has grown from a domain-specific data model beginning with the justice and public safety communities of interest into a more generic data model being adopted by government agencies at all levels (federal, state, local, and tribal) for a variety of government administration purposes.

The more recent versions of the NIEM data model employ a flexible approach to define and establish relationships between data objects: people, activities, locations, and "things" to create XML documents—similar to HL7 V3. NIEM organizes commonly used objects in the NIEM **Core**, and tailored or specific objects into one of numerous **domains** established for specific government disciplines (e.g., emergency management, justice, maritime, screening, etc.). The NIEM content is defined by XML schema with the NIEM Core and each domain defined in unique namespaces. NIEM is on its third major release since 2004, and while all previous releases are defined by XML schema, they are not backwards-compatible.

NIEM's approach to message development is a **constraint** or refinement process of the model. Through sub-setting the larger model, reusing components, and doing so in an ad hoc manner, NIEM does not attempt to define a standard type of message. *This is a key distinction between NIEM and HL7*. NIEM supports the creation of unique messages that meet specific needs, while HL7 has a multitude of pre-defined message types.[12]

Creating a NIEM-conformant document (message) specification involves selecting any required data elements for a specific business purpose or activity. The result of this process produces a subset of NIEM content that preserves the NIEM structure. A key requirement of this process is to include NIEM elements *only if the definitions precisely match the business semantics understood by information sharing partners*.

[12] Some domains have developed messaging structures that are analogous to HL7 message types, such as the Logical Entity Exchange (LEX); however, this is not a requirement to use NIEM.

Should the NIEM definition not match, or if NIEM does not define a business concept, information sharing partners can extend NIEM to capture unique data requirements following some simple rules defined by the NIEM **Naming and Design Rules** (NDR). Again, this is similar to the V3 capability to support new data requirements. Ultimately, the NIEM message specification includes only the required elements from the entire NIEM data model and extensions, if necessary. Below is an example of a NIEM instance document that contains some basic information about a person under supervision.

```
<nc:SupervisionRelease>
    <nc:ActivityDate>
        <nc:DateTime>2001-12-31T12:00:00</nc:DateTime>
    </nc:ActivityDate>
</nc:SupervisionRelease>
<nc:SupervisionPerson structures:id="Person_01">
    <nc:PersonBirthDate>
        <nc:DateTime>2001-12-31T12:00:00</nc:DateTime>
    </nc:PersonBirthDate>
    <nc:PersonDigitalImage>
        <nc:BinaryURI>http://tempuri.org</nc:BinaryURI>
    </nc:PersonDigitalImage>
    <nc:PersonName>
        <nc:PersonGivenName>nc:PersonGivenName</nc:PersonGivenName>
        <nc:PersonMiddleName>nc:PersonMiddleName</nc:PersonMiddleName>
        <nc:PersonSurName>nc:PersonSurName</nc:PersonSurName>
        <nc:PersonNameSuffixText>nc:PersonNameSuffixText</nc:PersonNameSuffixText>
    </nc:PersonName>
    <nc:PersonRaceText>nc:PersonRaceText</nc:PersonRaceText>
    <nc:PersonSexText>nc:PersonSexText</nc:PersonSexText>
    <nc:PersonSSNIdentification>
        <nc:IdentificationID>nc:IdentificationID</nc:IdentificationID>
    </nc:PersonSSNIdentification>
```

Figure 3 – NIEM Instance Document: Person Under Supervision

The designers of NIEM recognized that simply pulling together XML elements into a set of schemas would not be sufficient to fully describe the expected use and context of the message—*when*, *why*, and *with whom* the information would be exchanged. To address this, NIEM stakeholders established a set of documentation and artifacts to accompany the XML called the **Information Exchange Package Documentation** (IEPD). This collection of artifacts provides additional detail that enables implementers to map line of business systems and terminology to the NIEM definitions. It also helps stakeholders identify the cardinality—or required use—of a given element, and the "path" to follow in the NIEM XML structure to locate a specific element. This additional information provides a helpful transition from business to technical stakeholders to more completely understand the intent and content of the exchange information and streamline implementation efforts.

NIEM is considered a self-describing data model—meaning that the name of an element provides some indication of its meaning. For example, the element used to describe a person's first name is nc:PersonGivenName. NIEM goes to great lengths to limit the use of codes in its naming convention, which improves readability to one unfamiliar with the standard. That said, NIEM is large and contains more than 10,000 simple and complex elements in version 3.0. One consequence to the rapid growth of the NIEM model is that some elements have very similar names or definitions and can be confusing when attempting to capture just the right semantics for an exchange. Adding to the potential confusion is the apparent circular language used to define some of the elements. One example is the definition for the emergency management element, AlarmEventCategory: "A data concept for a kind of alarm event." To a

certain extent, some of this circular language is unavoidable but can present some difficulty when attempting to ensure semantic precision.

The scope of NIEM is limited to describing the **payload**—or message content—of a given information exchange and does not include transmission protocols, security, or interaction requirements. Those components are critically important for implementation, but fall within a parallel effort[13] and not in scope of this analysis.

Comparative Summary

HL7 and NIEM were created to perform the *same* function but for *different* communities, much like languages in different countries. The similarities among these standards are limited—they convey meaning for similar concepts but through distinct methods:

- HL7 V3's use of XML and object-oriented modeling approach vaguely resembles the NIEM structure in the same way that English is heavily influenced by Latin, but the rarity of V3 (and Latin, aside from prescription writing) in current healthcare integration limits its immediate value to the NIEM community.
- V2's structural resemblance to NIEM is comparable to the resemblance between Chinese and Swahili.

One important similar characteristic of these standards is that they accommodate the "80/20" solution to defining data among independent stakeholders. Both standards include thousands of elements that should reflect most of the business semantic concepts used by their respective communities—but neither claims to have identified all concepts.

HL7 V3 and NIEM provide a framework to leverage a set (or subset, to be more precise) of commonly used semantics—without dictating strict adherence to an established message type or exchange schema—and extend the data model to include any unique elements or concepts required by the specific scenario or stakeholders. Namely:

- NIEM does not publish or mandate the use of a standard data exchange. For example, NIEM does not predefine a traffic citation and require its use by all law enforcement and courts across the country. Rather, NIEM promotes the use of reference exchanges and allows for each implementation to determine unique requirements and extend the model where necessary.
- HL7 V3 takes a similar tack of restricting the RIM to create Refined Message Information Models for subsequent augmentation by information sharing partners.
- Conversely, the HL7 V2 message structure is very rigid. Each message type (or sub-message type) has a very specific composition and each character placement is intentional and carries a specific meaning. That said, V2's use of the Z segment provides the flexibility to include any additional detail in a given message type.

What this means in practical terms is that each implementation—whether NIEM- or HL7-based—is customized according to stakeholder requirements. Two integration scenarios with the exact same

[13] For more information, refer to the Global Reference Architecture initiative: https://it.ojp.gov/default.aspx?area=nationalInitiatives&page=1015

content requirements rarely occur across jurisdictions or healthcare providers; HL7 and NIEM accommodate and recognize that their respective stakeholders all do the same thing a little differently.

Translating NIEM and HL7

What does this mean for justice and healthcare information sharing efforts? How will integration partners from both communities share important information while leveraging their respective technology capabilities and/or preference and experience with one of these data standards?

The simple answer is that translation from one standard to the other will need to occur. As stated above, each standard serves an important function for its respective community and includes content specialized to that community. HL7 does not contain content about arrest charges and NIEM does not have physician clinical observations—nor should they. It would not make sense to try to force this specialized content into a standard that neither community wants, needs, or uses. Rather, each data exchange initiative should focus on the areas where content overlaps—such as person information. This can be difficult to do in the abstract, and a group of justice and healthcare stakeholders identified over 30 data exchange scenarios[14] and subsequently prioritized many of these,[15] which can provide some context for demonstration purposes.

One of these priority scenarios involves correctional offender case management systems that provide basic personal demographic information to inmate healthcare providers. Following this scenario, assume that the corrections facility captures this information during intake or a booking event using a NIEM-based intake message, and that the healthcare provider uses HL7 and would receive the information at admission using the ADT message.

To transform these data between NIEM and HL7, stakeholders must address two key issues: establish semantic equivalence and data parsing/conversion rules.

Semantic equivalence. Ensuring semantic equivalence is essential to ensure translation accuracy and fidelity. The potential of misunderstanding the intended meaning of words—getting "lost in translation"—is a critical mistake that is avoided by involving subject matter experts from either line of business. In the inmate demographic information exchange, stakeholders must establish a common understanding of the information to be exchanged and document or map these semantic equivalents. For example, stakeholders could agree that the NIEM construct of nc:SupervisionPerson, a person who is being supervised, is the equivalent of a patient in HL7 V2 ADT event message. Table 1 provides a simple example of potential semantic equivalents among HL7 and NIEM structures.

[14] Scott Parker, Kamala Mallik-Kane, and Aaron Horvath, IJIS Institute and The Urban Institute, April 2013. *Opportunities for Information Sharing to Enhance Health and Public Safety Outcomes*, a report by the Criminal Justice and Health Collaboration Project. http://www.urban.org/UploadedPDF/412788-Opportunities-for-Information-Sharing-to-Enhance-Health-and-Public-Safety-Outcomes.pdf

[15] Global Standards Council's Justice-to-Health Services Task Team, August 2014. *Aligning Justice to Health Priority Exchanges Task Team Final Report.* https://it.ojp.gov/gist/171/Aligning-Justice-to-Health-Priority-Exchanges-Task-Team-Final-Report

HL7 Segment	HL7 element	NIEM element name
Patient Identification	Patient ID	J:SubjectIdentificationID
	Family Name	nc:PersonSurName
	Given Name	nc:PersonGivenName
Patient Visit	Patient Bed	j:SupervisionBedID
	Patient Room	j:SupervisionCellID
	Point of Care	j:SupervisionAreaID
	Facility	nc:FacilityName

Table 1 – Potential Semantic Equivalents Among HL7 and NIEM Structures

This process is a key first step to ensure that the supporting technical solutions meet the business needs of each stakeholder group. It can be tempting to pass this off as a technical development task, but it must truly be a collective effort among business representatives to eliminate any potential mistakes in the end result.

Data parsing/conversion. The next step in the translation process is to perform the technical transformation of one standard structure to the other. Using the mapping documentation created by the business subject matter experts, developers will be required to perform a series of tasks to generate, convert, parse, and consume these messages within their respective systems.

Following the previous example of a corrections facility sending an intake message to a healthcare provider system for a patient admission using HL7 V2.x, the stakeholders would need to perform a software transformation to a specified NIEM XML message format (and visa-versa). This process varies depending upon several factors including the technology platforms, programming language, tool preferences, etc. In the rare scenario that the HL7 interface supports XML message structure (either HL7 V3 or V2 XML), the process is relatively straightforward for an experienced developer by using XSLT. This process also requires the corresponding mapping documentation in order to accurately map concepts from one standard to the other.

A cursory review of tools to support this process identified several open source options for developers and may be further assessed in future SEARCH publications. One tool in particular, Hapi,[16] is an open source HL7 V2.x parser that would assist in creating Java objects from HL7. The processor would likely require manual development. Conceptually, the complete translation and transformation process is straightforward, but the tedious nature of the processor writing can be time-consuming.

Future of NIEM and HL7 Alignment

HL7 and NIEM are both mature and widely implemented data standards within their respective communities of interest, yet each has gradually become more aware of the increased need to share information and accommodate or integrate their standards. To date, the public sector healthcare stakeholders have expressed an interest in NIEM and have gone so far as to establish a health domain under the stewardship of the Office of the National Coordinator for Health Information Technology in the

[16] Hapi: Open Source HL7 Parser, http://hl7api.sourceforge.net/index.html. Other related tool options include XStream: XML serializer, http://xstream.codehaus.org/index.html; and Apache Camel: Open source integration framework, http://camel.apache.org/index.html.

U.S. Department of Health and Human Services. Further strengthening the federal support, NIEM.gov is actually hosted by the National Institutes of Health. Beyond these activities, healthcare stakeholders requested a number of data structures in the latest NIEM release, but certainly more content is expected in the future. A focus group of justice and healthcare practitioners published a set of recommendations that include content from the HL7 specification Continuity of Care Document (CCD) as justice extensions to the NIEM model.[17]

Alternatively, the NIEM community may pursue incorporating the CCD content directly into a health domain, which would accomplish the same result and align with the current governance approach. NIEM anticipates that the "health information exchanges expected to use NIEM initially are exchanges between government agencies, at the federal, state, local and even international levels. NIEM-based health information exchanges are expected to gradually grow into wider use in the private sector."[18]

Incorporating NIEM information into HL7 may not be necessary should the NIEM community continue to accommodate health content. Regardless, the increased awareness of the dependencies and overlap of justice and health information exchanges will likely be the first of many other potential scenarios where NIEM and HL7 stakeholders recognize the need for increased collaboration and information sharing opportunities. It is reasonable to expect a significant increase of healthcare content in NIEM as these opportunities are realized.

As correctional and community healthcare and treatment providers continue to explore alternatives to incarceration while safely managing offenders in the community, improving the continuity of care among these entities will remain a high priority. As this brief outlines, each of these stakeholder groups can leverage standards-based integration solutions to achieve their collective business and policy objectives.

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[17] Refer to footnote 15.
[18] https://www.niem.gov/communities/emc/health/Pages/about-health.aspx.