Standard for improving emergency information interoperability: the HL7 data elements for emergency department systems

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ABSTRACT

Background Emergency departments in the United States service over 130 million visits per year. The demands for information from these visits require interoperable data exchange standards. While multiple data exchange specifications are in use, none have undergone rigorous standards review. This paper describes the creation and balloting of the Health Level Seven (HL7) Data Elements for Emergency Department Systems (DEEDS).

Methods Existing data exchange specifications were collected and organized into categories reflecting the workflow of emergency care. The concepts were then mapped to existing standards for vocabulary, data types, and the HL7 information model. The HL7 community then processed the specification through the normal balloting process addressing all comments and concerns. The resulting specification was then submitted for publication as an HL7 informational standard.

Results The resulting specification contains 525 concepts related to emergency care required for operations and reporting to external agencies. An additional 200 of the most commonly ordered laboratory tests were included. Each concept was given a unique identifier and mapped to Logical Observation Identifiers, Names, and Codes (LOINC). HL7 standard data types were applied.

Discussion The HL7 DEEDS specification represents the first set of common ED related data elements to undergo rigorous standards development. The availability of this standard will contribute to improved interoperability of emergency care data.

Key words: emergency medicine, military medicine, terminology as topic, public health surveillance

OBJECTIVE

Hospital emergency departments (EDs) in the United States provide a vast array of services to sick and injured people 24 hours a day, 7 days a week. Services range from providing the sole source of care to indigent and migrant populations, acting as the social and clinical safety net, and caring for the acute and severely injured, ill, or poisoned. With over 130 million visits annually and increasing, EDs are under constant pressure to provide care under difficult circumstances1. With this burden the need for accurate, automated, and interoperable information collection and exchange has grown dramatically.

The requirement for agreed upon or standardized data elements to support interoperability has led to the creation of a number of data sets for emergency care.2–4 The US Centers for Disease Control and Prevention (CDC) National Center for Injury Prevention and Control (NCIPC) addressed this need by developing a novel specification called Data Elements for Emergency Department Systems (DEEDS) in 1997.5 However, none of these published data specifications benefited from formal incorporation into an ongoing standards development process. The Health Level Seven (HL7) Emergency Care Workgroup (ECWG) is addressing this need through a set of standard information system artifacts defining the information needs of the ED.

The objective of this work is to extend the concept of the original DEEDS specification based on changes in the practice of clinical informatics, availability of HL7 V3–based standards, the recognized changes in the scope of emergency care in the United States, and the need for specifications with the details needed for Emergency Department Information Systems (EDIS) vendor implementation. This paper describes the development of a HL7-approved standard for an emergency care data set complying with currently accepted information standards.6
BACKGROUND
As the safety net for healthcare in the United States, hospital-based EDs serve multiple roles beyond direct patient care. Secondary use of ED data serves public health surveillance needs, quality improvement, and research.

The ED is a unique care setting in terms of information systems requirements. This uniqueness was recognized by the Certification Commission for Health Information Technology (CCHIT) in 2004 and confirmed by the Department of Health and Human Services (DHHS) in the Federal Register. As a unique care setting, the information system requirements are likewise unique. In recognition of this, the American College of Physicians encourages the development and use of data standards associated with emergency care. Detailed data specifications and information models are required in order to leverage our national investment in health information technology (HIT) to meet the aims of decreased cost, increased quality, and reduced errors in emergency care.

HL7 is a standards-setting organization accredited by the American National Standards Institute (ANSI) and the official US representative to the International Organization for Standardization (ISO). As a vendor- and provider-supported organization, HL7’s mission is to provide standards for the exchange, management, and integration of data supporting clinical patient care and the management, delivery, and evaluation of healthcare services. The work of HL7 encompasses the complete lifecycle of a standards specification—development, adoption, market recognition, utilization, and adherence. A major value of the HL7 specifications is the provision of a unified reference model of healthcare information.

The HL7 ECWG was established in 2005 to address the need for functional and information standards associated with the emergency care enterprise. The ECWG consists of volunteers providing expertise to adapt existing standards or develop new standards for the description of system functions and the management of information associated with emergency care settings including hospital based EDs, free-standing EDs, and combat trauma settings. The ECWG works closely with other HL7 workgroups and external standards development organizations to ensure nascent standards address the needs of all stakeholders in emergency healthcare services and integration with the national health information infrastructure.

Existing emergency care data exchange specifications, external reporting requirements and recommendations for emergency care are fragmented. They have been developed and issued in an ad hoc fashion with different organizations developing incompatible data standards to address their needs. Development and publication of specifications for ED patient records systems—specifically, DEEDS in 1997—showed relevant data standards can be consolidated and distributed in a single document. The original DEEDS specification has been widely used for a variety of purposes, including healthcare claims attachment specifications mandated by the federal Health Insurance Portability and Accountability Act (HIPAA); emergency care terminology additions to the Logical Observation Identifiers, Names, and Codes (LOINC) clinical vocabulary; as well as data definitions and terminology for public health surveillance initiatives, such as the BioSense program at the Centers for Disease Control and Prevention, the ED component of the North Carolina Disease Event Tracking and Epidemiologic Collection Tool, and the Frontlines in Medicine Project.

Over the intervening years, healthcare data communications has progressed and with the passage of the HITECH act system, implementation has accelerated. Rapid recognition of and response to unusual health events requires close monitoring and communication of emergency care activities. However, the original DEEDS specification has not kept pace with recent changes or remained compatible with federal health information standards as initially defined by the Consolidated Health Information (CHI) program and maintained by the Office of The National Coordinator (ONC). Therefore, the ECWG felt it was an appropriate time to update the DEEDS specification.

MATERIALS AND METHODS
The HL7 ECWG conducted an environmental survey during 2011–2012 to identify users of data generated during the ED encounter (Table 1). Workgroup members contacted identified organizations who were primary and secondary users of ED information to obtain their data requirements as specified in their data dictionaries. The ECWG also engaged with vendors, emergency care leadership such as The American College of Emergency Physicians, and secondary users of ED data to collate data requirements for EDIS.

The original DEEDS specification provided a framework for selecting specific data elements to add to each data segment. Concepts were mapped to HL7 V3 Reference Information Model definitions utilizing appropriate ONC approved value tables. Where possible, the ECWG adopted existing concepts developed for items such as X12 claims attachments administrative reporting or pre-existing detailed clinical models previously developed by HL7 to guide discrete data element selection.

DEEDS is designed at the data element level with the understanding that interoperability may require either transformation or aggregation of data elements. Therefore, when the requested data represented a calculated value, the ECWG identified the core data elements necessary to fulfill the request to harmonize with external data reporting requirements. For example, when age was requested the workgroup recognized age was calculated from visit date minus birth date and did not need to be part of the core data set of data elements. Where there were multiple ways to represent complex medical concepts such as blood pressure or other vital signs, the HL7 membership works with outside organizations to define standard representations. These representations have been balloted as DCMs and widely shared.

The material was assembled by the ECWG membership over 3 years, 2010–2013, through normal HL7 ANSI approved open meetings. The data elements were given a functional description by domain experts from HL7 and the ECWG membership. The EC related data elements were matched to existing
standards such as LOINC and SNOMED-CT concept identifier or used to extend those standards. They were also assigned an HL7 standard data type (e.g., CodedSimpleValue, CharacterString, Quantity). The ECWG then mapped those data elements to DHHS-approved transaction and code sets standards. The resultant enumeration of data elements and their defining characteristics were then subject to HL7 information ballot processes. In general, the HL7 balloting process is open to all members and non-member interested parties. HL7 ballots occur three times annually through an ANSI accredited and audited process. The ballot calendar includes a timeline for submission of materials, registration as an interested party to the ballot, and then an open period for comments. As part of the ballot process HL7 provides notification not less than 30 days prior to ballot opening distributed widely on list serves and in newsletters. Interested parties that sign up to participate in a ballot are provided numerous reminders about deadlines and the processes for completing their ballot. For this ballot cycle the ECWG also posted information about the ballot on emergency-care-related list serves in order to reach a larger audience. Following balloting in May of 2012, the ECWG utilized the feedback to revise the specification. The revised specification was discussed with the reviewers who participated in the May 2012 ballot. Changes to the specification were then approved by the participants. The final specification was published in 2013.

RESULTS
The final specification was divided into eight content areas (Table 2) reflecting the workflow of hospital EDs. The changes in data elements increased the overall size of the original DEEDS specification from 156 items to 525 items. An appendix contained the top 200 medications ordered and prescribed in EDs as reflected by an analysis performed by the US Navy Bureau of Medicine and Surgery. This resulted in a net change

Table 1: Organizations with ED Data Definitions

<table>
<thead>
<tr>
<th>Agency</th>
<th>System</th>
<th>Abbreviation</th>
<th>Description</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center for Disease Control and Prevention (CDC)</td>
<td>National Hospital Ambulatory Medical Care Survey</td>
<td>NHAMCS</td>
<td>National sample of ED visits</td>
<td><a href="http://www.cdc.gov/nchs/ahcd.htm">http://www.cdc.gov/nchs/ahcd.htm</a></td>
</tr>
<tr>
<td>University of Pittsburgh Department of Biomedical Informatics</td>
<td>Real-time Outbreak and Disease Surveillance</td>
<td>RODS</td>
<td>Classification of ED chief complaints</td>
<td><a href="https://www.rods.pitt.edu/site/component?option=com_frontpage/Itemid,76/">https://www.rods.pitt.edu/site/component?option=com_frontpage/Itemid,76/</a></td>
</tr>
<tr>
<td>OASIS Emergency Management Technical Committee</td>
<td>Hospital Availability Exchange</td>
<td>HAVE</td>
<td>Standard message for communicating hospital status including ED status</td>
<td><a href="http://docs.oasis-open.org/emergency/edxl-have/v1.0/errata/edxl-have-v1.0-os-errata-os.pdf">http://docs.oasis-open.org/emergency/edxl-have/v1.0/errata/edxl-have-v1.0-os-errata-os.pdf</a></td>
</tr>
<tr>
<td>ED Benchmarking Alliance</td>
<td>Emergency Department Operational Metrics, Measures and Definitions</td>
<td>EDBA</td>
<td>Database of ED process and performance measures</td>
<td><a href="http://www.edbenchmarking.org">www.edbenchmarking.org</a></td>
</tr>
<tr>
<td>Agency for Healthcare Research and Quality</td>
<td>Healthcare Cost and Utilization Project State ED Databases</td>
<td>HCUP SEDD</td>
<td>SEDD captures emergency visits at hospital-affiliated EDs that do not result in hospitalization.</td>
<td><a href="http://www.hcup-us.ahrq.gov/sedoview.jsp#data">http://www.hcup-us.ahrq.gov/sedoview.jsp#data</a></td>
</tr>
<tr>
<td>Integrating the Healthcare Enterprise</td>
<td>ED Encounter Summary</td>
<td>EDES</td>
<td>four content profiles for exchange of ED encounter information</td>
<td><a href="http://www.ihe.net/uploadedFiles/Documents/PCC/IHE_PCC_Suppl_EDES.pdf">http://www.ihe.net/uploadedFiles/Documents/PCC/IHE_PCC_Suppl_EDES.pdf</a></td>
</tr>
</tbody>
</table>
of 569 items for a total of 725 items included in the final data specification.

Each entry contained a short description of the data element, the recommended data type based on the HL7 Version 3 standard, the associated LOINC code where available, and the SNOMED-CT concept identifier for associated values.

During the ballot period in May 2012 83 votes were cast; 19 affirmative votes, 5 negative votes, and 59 abstentions for an overall response rate of 67% of all who had registered to vote on this document (Table 3). The HL7 Ballot reviewers represented EHR vendors, government agencies, healthcare provider organizations, consulting companies, and HL7 affiliate organizations. The ballot registration process does not require individual reviewers to indicate their professional credentials so it is unknown the exact number of clinicians or clinical disciplines engaged in the review and voting process. It is known however, what type of organizations the reviewers represent. Of the responses to this ballot, 37% were representing provider organizations, 35% were affiliate organization representatives, 8% were government/non-profit representatives, 13% represented vendor organizations, and 7% were independent consulting organizations.

For each ballot comment submitted, the specification was updated to address any substantive issues. These changes were shared with the balloting organization or person. Any disagreement was discussed and agreement reached through the HL7 Ballot Reconciliation process. Following reconciliation of the comments, all negative ballots were withdrawn and the

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**Table 2: Overview of Organization and Data Elements in DEEDS**

<table>
<thead>
<tr>
<th>Section</th>
<th>Elements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Demographics</td>
<td>27</td>
<td>Elements to manage patient identify</td>
</tr>
<tr>
<td>Facility and Practitioner Data</td>
<td>30</td>
<td>Identity of practitioners and facility involved in care</td>
</tr>
<tr>
<td>ED Payment Data</td>
<td>15</td>
<td>Information concerning payor and authorization</td>
</tr>
<tr>
<td>ED Arrival and First Assessment Data</td>
<td>51</td>
<td>Prehospital transport, triage assessment, and initial nursing assessment</td>
</tr>
<tr>
<td>History and Physical Examination Data</td>
<td>272</td>
<td>HPI, injury, pain, medications, ROS, PMH, allergies, PE, screening assessments derived from most common elements found in selection of ED documents</td>
</tr>
<tr>
<td>ED Procedure and Results Data</td>
<td>80</td>
<td>Details on procedures performed in the ED and the results</td>
</tr>
<tr>
<td>ED Medication Data</td>
<td>12</td>
<td>Standard medication data elements for both administered and prescribed medications</td>
</tr>
<tr>
<td>ED Disposition and Diagnostic Data</td>
<td>38</td>
<td>Includes discharge diagnosis, follow-up information and location</td>
</tr>
<tr>
<td>Laboratory Test Data</td>
<td>200</td>
<td>Department of Navy, top 200 ordered lab tests with associated LOINC codes</td>
</tr>
</tbody>
</table>

**Table 3: Breakdown of Votes by Organizational Type. Percent Response Indicates How Many Voters that Registered Cast a Vote**

<table>
<thead>
<tr>
<th>Member type</th>
<th>Registered</th>
<th>Affirmative</th>
<th>Negative</th>
<th>Abstain</th>
<th>% Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Affiliate</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>29</td>
<td>54</td>
</tr>
<tr>
<td>Consultant</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>75</td>
</tr>
<tr>
<td>Government</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>75</td>
</tr>
<tr>
<td>Provider</td>
<td>41</td>
<td>13</td>
<td>1</td>
<td>17</td>
<td>76</td>
</tr>
<tr>
<td>Vendor</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>85</td>
</tr>
<tr>
<td>Total</td>
<td>124</td>
<td>19</td>
<td>5</td>
<td>59</td>
<td>67</td>
</tr>
</tbody>
</table>
resulting standards was registered and published on the HL7 website. The final specification was then registered with ANSI as an informative standard in May of 2013.

DISCUSSION

Consensus agreement upon healthcare information representation and manipulation is fundamental to realizing the promise of HIT to improve care, reduce costs, and advance healthcare sciences. Adoption of the HL7 approach of using a shared information model to guide the development of domain specific systems specifications allows an incremental approach to convergence on a single reference standard. Shared standards guide system developers, integrators, and users to create and adopt more robust solutions by allowing incremental improvement while avoiding the high cost of system change.

In 1996 the CDC began this process by assembling stakeholders interested in the data captured in EDs. The resulting CDC DEEDS represented the then current data requirements. At the time many of the current standards associated with the CHI and meaningful use requirements were not yet available. This new HL7 DEEDS specification replaces the HL7 v2.3-based data types and modeling approach with a more modern treatment, suggests data elements for deprecation, and identifies new data elements required for further development.

During the environmental survey (Table 1) many candidate data specifications were identified that did not have sufficient overlap with ED data or did not have a fully specified data dictionary. One purpose of creating the DEEDS specification was to define data standards relevant to hospital based emergency care. This data standardization provides the crucial foundation for interoperability and reuse of healthcare data. Provision of the HL7 DEEDS specification will enable innovative use of ED data including (1) integration of prehospital data with the ED record, (2) benchmarking of ED services, and (3) the secondary use of ED data for reporting and research. Conformance with established HL7 standard development methodologies ensures regular updates and interoperability with inpatient and outpatient EHR data as well as supporting research and other secondary uses of ED data.

Intended to represent the information requirements of hospital based emergency care, the HL7 DEEDS specification coordinates with prehospital information requirements and ongoing care processes in the hospital or outpatient setting. First responders travel to the field to assess, stabilize and, if necessary, transport patients for definitive care. This emergency medical system (EMS) generates a great deal of data as defined by the OASIS National EMS Information System (NEMSIS) data standard. The NEMSIS standards group is working with HL7 to coordinate with the DEEDS working group to ensure that data elements definitions are aligned where they overlap with hospital based emergency care. The trauma system operates out of hospital-based EDs but provides ongoing care after the patient leaves the ED including operative and critical care. The American College of Surgeons Trauma Registry is currently undergoing standards ballot at HL7. By utilizing HL7 information standards, the OASIS NEMSIS data set and the ACS Trauma registry contain overlapping defined data elements coordinated with DEEDS.

Working within the HL7 standards processes provides the opportunity to take advantage of a well-developed process for incorporating standards into practice. The Office of the National Coordinator sponsored Standards and Interoperability (S&I) Framework works with HL7 to adopt, extend or develop information models to support a number of initiatives. Recently, the S&I Framework sponsored Health eDecisions workgroup incorporated HL7 balloted information models in support of shared decision support tools. Another example of the applicability of data standards such as DEEDS is the skin and wound assessment models supporting the documentation of pressure ulcers. These models balloted at HL7 prior to the DEEDS model are published as part of the Federal Health Information Model and were required by all applicants to the 2012 and 2013 ONC Challenge Grant “Mobilizing Data for Pressure Ulcer Prevention Challenge.” In the same vein, the HL7 DEEDS specification provides a foundation and guidance for the adoption of standards in emergency care.

Limitations

The resultant HL7 DEEDS specification is United States-centric. As a result, HL7 affiliate members who are in foreign countries, chose not to participate in the ballot process (Table 3). Future work with international affiliates may expand the specification to support cross border data sharing.

The creation of consensus standards is time consuming. While the HL7 process relies on a volunteer workforce, many of the HL7 consensus standards derive from funded work by other organizations such as the federal government. In our case, much support came as a byproduct of the Department of Defense’s (DOD’s) interest in ED standards. A more formal process of funding development of these standards to ensure a uniform voice of all constituents should be developed.

While no formal accounting took place, this project engaged the ECWG membership and various stakeholders from 2010 through 2013. Thousands of man hours were spent on various aspects of the project from ferreting out the data requirements to reviewing requirements documents. The workgroup held 1–2 h weekly conference calls where work was reviewed and assigned. Three times a year HL7 holds face-to-face workgroup meetings in various parts of the country lasting 5 days. During these meetings approximately 50% of the ECWG agenda was dedicated to moving this project forward.

As a consensus standard, the HL7 V3 DEEDS specification does not represent a binding specification. Although it is a document registered with ANSI, there is no requirement for uptake unless it is adopted by HHS regulations. Thus, at this time the HL7 DEEDS specification serves to inform primary EDIS users as to the necessary data to record in order to enable interoperability and seamless reporting to federal registries, related EHR systems, and other consumers of ED data.

Future plans

This release of DEEDS attempts to bring the specification into alignment with current data standards as supported by the
Office of the National Coordinator. Bringing DEEDS into alignment with other research, reporting, and data modeling initiatives requires ongoing work. The number of data elements defined in this specification (Table 3) does not represent the entire universe of potential detailed data elements. We believe ongoing refinement and alignment with other efforts will continue to blur the boundary between EC standards and general healthcare interoperability standards. Further work will also be required to align DEEDS with international standards development interests as similar efforts have been identified in other countries. While emergency care systems vary in other realms, the authors believe the clinical practice of emergency care should be comparable and the potential for international collaborations can be facilitated by these efforts.

The HL7 DEEDS specification provides the foundation upon which the ECWG is currently building a more extensive description of the ED information environment. Using DEEDS as a foundational data model, the ECWG recently created a domain analysis model containing standard business processes, information system functions, and use cases. A previous specification of the EDIS functions was utilized by CCHIT for the first set of EDIS certification criteria. The combination of a standard data model, process model, and EDIS functional model provides a standard platform for defining ongoing innovative extensions to these foundational models. With the advent of Patient Centered Outcomes Research Institute’s interest in Patient Reported Outcomes (PRO), the ECWG can oversee the specification of standard data and functional models for incorporating PRO into emergency care.

CONCLUSION

The HL7 Version 3 Data Standards for Emergency Department Systems (DEEDS) represents the collaborative work of many stakeholders from industry, government, academics, and standards developers. The creation of a harmonized set of data standards for EDs promises to improve quality, research, and clinical care in the future as part of the learning healthcare system.

The first release of the ANSI registered HL7 V3 DEEDS specification represents over 3 years of effort to harmonize multiple data specifications related to emergency care in the United States. The provision of a common, standardized specification of data related to emergency care will improve interoperability between ED information systems and related systems relying on data collected during the emergency care process. By engaging the HL7 resources for standards development and registering the specification with ANSI, the DEEDS specification benefits from a pathway for continued maintenance and harmonization with ever evolving informatics standards. The intent is to engage the broader community in this evolving work to foster interoperability and information exchange in the emergency care enterprise. It is also a request for other groups working with the same clinical and administrative content to collaborate with the HL7 ECWG to create more universal data element specifications for uniform use across the national healthcare information infrastructure promoting interoperability, improving patient care and enhancing public health surveillance.

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COMPETING INTERESTS

None.

CONTRIBUTORS

JCM and LHL wrote the manuscript and are responsible for the integrity of this work as a whole, from inception to published article. PJP and MGJ provided substantial support to the project and contributions to the manuscript.

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