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Using SNOMED CT as a Mediation Terminology: Mapping Issues, Lessons Learned, and Next Steps Toward Achieving Semantic Interoperability

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ABSTRACT

The Clinical Data Repository / Health Data Repository (CHDR) project is a combined effort of the Department of Veterans Affairs (VA) and the Department of Defense (DoD) to exchange clinical information between our Electronic Health Records (EHR). CHDR exchanges standardized, computable data, as opposed to textual data that is only human readable. CHDR utilizes mediation terminologies for health data exchange. For allergy reactions data, CHDR uses SNOMED CT in conformance with Health Information Technology Standardization Panel (HITSP) recommendations. This paper reports how we implemented this solution.

Business rules for mapping allergy reactions were established jointly. Each agency independently mapped its legacy data to the same version of SNOMED CT. CHDR has since been implemented in seven locations where VA and DoD have joint patient care environments. Statistics on actual patient data from February-June 2007 showed a 74-99% mediation success rate for allergy reactions data.

Examination of mediation failures exposed issues related to mapping and SNOMED CT concept modeling. In addition, we emphasize the significance of adherence to a detailed terminology mediation strategy, desirability of a standard SNOMED CT-based subset for allergy reactions, and the creation of this subset for publication and distribution.

INTRODUCTION

The President has ordered Federal agencies to promote improved healthcare quality and efficiency through secure and standard-based data exchange[1]. When clinicians exchange data, interoperable meaning is possible because clinicians share structures of clinical practice and familiar clinical language[2]. Similarly, meaningful electronic data exchange requires a shared structure for transmission and a common electronic vocabulary[3], which yields Computable Semantic Interoperability (CSI)[4]. CSI makes order checks and electronic alerts possible across institutions, and is an essential component of a longitudinal EHR that protects patient safety.

The CHDR project is a Congressionally-mandated, combined effort which aims to exchange standardized, computable data, as opposed to textual data that is only human readable. Computable data exchange enables "semantic interoperability" and permits utilization of electronic decision support tools on the sum of local and remote data at either agency[6]. CHDR currently exchanges pharmacy and allergy data elements and the agencies are working to share laboratory data elements by the end of fiscal year 2008.

CHDR has informed the Health IT Standards Panel (HITSP) that designates interoperability standards for EHRs. VA and DoD use different internal data standards for allergies, and under CHDR utilize a common, HITSP-specified mediation terminology. CHDR exchanges pharmacy, drug allergens, and allergy reactions, and will soon exchange laboratory (chemistry/hematology) data. CHDR exchange of comprehensive pharmacy information[7] and drug allergy reactant information[8] have been well described.

The CHDR strategy for exchange of allergy reactions (signs and symptoms) data uses SNOMED CT, in conformance with Consolidated Health Informatics (CHI) and now HITSP recommendations. We now report how VA and DoD have used SNOMED CT successfully as a mediation terminology, and describe the results.

METHODS

Initial work for allergy reactions under the mediation approach included the commitment at each agency to normalize legacy terms, using a list of centrally maintained concept terms[9]. Allergy reactions were comprised primarily of signs and symptoms, but could also include disorders or clinical conditions attributable to exposure to a drug reactant. Each agency mapped its legacy allergy reactions data to SNOMED CT[10]. The four-part terminology mediation strategy was outlined as follows[11]:

1. Select a mediation terminology compliant with CHI/HITSP standards (if possible).
2. Map each agency's terms to concepts within the mediation standard.
3. Exchange the mediation codes.
4. Coordinate content maintenance plans.

Table 1 shows the CHI standard terminologies and releases designated for the four domains at the start of the CHDR project.

Business rules for mapping allergy reaction legacy terms to SNOMED CT concepts were developed jointly[12]. For example, SNOMED CT hierarchies were prioritized in order of preference for mapping as follows: 1) Findings, 2) Disorders, 3) Morphologic abnormality, 4) Observable entity, 5) Context Dependent Category. Mappings from specific to more general terms (and vice versa) were avoided, because of the bidirectional nature of the data exchange. For instance, mapping "nasal burning" to "burning sensation of mucous membrane (finding)" creates either a loss of the clinical detail "nasal" when translated (for an outbound message), or forces the translation of a general term "mucous membrane" to a specific one--"nasal"--(for an inbound message). Local terms not found in SNOMED CT were collected for potential submission to the SNOMED development organization. Other mapping rules governed misspellings, qualifiers, synonyms, ambiguous terms, and outdated terms.

Table 2 shows a sample of VA allergy reaction terms with their VA unique identifiers (VUIDs) and SNOMED CT mappings.

Once mapping rules were established, terminologists at each agency manually mapped allergy reaction terms to SNOMED CT. VA used Apelon's TermWorks tool and SNOMED's CliniClue® browser, and DoD used the Terminology Service Bureau (TSB) and the CliniClue® browser.

Table 1. CHDR Domains and Designated Standards.

Domain	**Mediation Terminology (CHI Standard)**
Pharmacy	RxNorm Jun 2005
Drug Allergens	UMLS Jan 2005AA
Allergy Reactions	SNOMED CT Jan 2005
Lab (Chemistry & Hematology)	LOINC 2.14 Jan 2005

Table 2. VA Unique Identifiers, Allergy Reaction Text, and Corresponding SNOMED CT Mappings.

VUID	**VUIDText**	**SNOMED CT ID**	**SNOMED CT Text**
4637123	BLISTER	339008	Blister of skin AND/OR mucosa (finding)
4543527	ORTHOSTASIS	271648003	Postural drop in blood pressure (finding)
4696326	ASEPTIC NECROSIS OF BONE	398199007	Aseptic necrosis of bone (disorder)
4538635	RASH	271807003	Eruption of skin (disorder)
4538640	SEIZURES	91175000	Seizure (finding)
4539274	NOSEBLEED	249366005	Bleeding from nose (finding)

For mapping validation of allergies terms (both reactions and reactants), two reviewers conducted three separate reviews (10 hours each for a total of 60 experts' hours) and identified various discrepancies in about 5% of the total number of terms. All discrepancies were corrected[13]. An independent review of concepts common to both agencies was performed to ensure accurate translation and calculate expected mediation success rates[14]. See Table 3.

Terminology "translation" and "mediation" are described as follows by Bouhaddou et al.:

"The mediation success rate defines the percentage of data in one system that is understood and computable by the other system. For each direction of the data exchange, inbound or outbound, there is a different mediation success rate. For mediation to succeed, two translations have to be successful. First, the source agency has to translate from its vocabulary to the mediation terminology. Then, the target agency has to translate from the mediation terminology to its native vocabulary without loss of meaning[15]."

Mediation success rates are calculated by multiplying the translation success rates of each agency. When coded mediation fails, the CHDR project exchanges allergy reaction data as text without a mediation code.

RESULTS

Terminology translation and mediation statistics were compiled for allergy reactions data during a 5-month period in 2007. The numbers of translation and mediation attempts fluctuated from month to month, but generally showed an increasing trend as the project was implemented at additional sites over the 5-month timeframe. Table 4 shows translation and mediation success rates for allergy reactions sent from VA to DoD. Table 5 shows statistics for allergy reactions sent from DoD to VA. Overall, mediation success rates varied from 74% to 99%.

Table 3. Common and Unique Allergy Reaction Concepts Determined by Each Agency Mapping to SNOMED CT.

Agency	Total	Common Terms	Mapped Terms Unique to Each Agency	Unmapped Terms
VA	346	299	25 (7%)	22 (6%)
DoD	456	299	47 (13%)	110 (24%)

Table 4. VA-to-DoD Mediation Statistics for Allergy Reactions, Feb-June 2007.*

VA-to-DoD	February	March	April	May	June
Total VA-to-SNOMED CT translation attempts	168	193	338	959	502
Translation failures (VA-to-SNOMED CT)	4	0	1	13	1
Total VA allergy reactions sent to DoD	164	193	337	946	501
Translation Success Rate: VA-to-SNOMED CT	**98%**	**100%**	**100%**	**99%**	**100%**
Total allergy reactions received by DoD	164	193	337	946	501
Translation failures (SNOMED CT-to-DoD)	17	17	34	121	5
Total VA allergy reactions sent to DoD CDR†	147	176	303	825	496
Translation Success Rate: SNOMED CT-to-DoD	**90%**	**91%**	**90%**	**87%**	**99%**
MEDIATION SUCCESS RATE: VA-to-DoD	***88%***	***91%***	***90%***	***86%***	***99%***

*Yellow areas designate translation services performed by VA. White areas designate translation services performed by DoD. †CDR=Clinical Data Repository.

Table 5. DoD-to-VA Mediation Statistics for Allergy Reactions, Feb-June 2007.*

DoD-to-VA	February	March	April	May	June
Total DoD-to-SNOMED CT translation attempts	1,509	1,788	2,025	3,521	4,030
Translation failures (DoD-to-SNOMED CT)	306	467	432	432	107
Total allergy reactions sent to VA	1,203	1,321	1,593	3,089	3,923
Translation Success Rate: DoD-to-SNOMED CT	**80%**	**74%**	**79%**	**88%**	**97%**
Total allergy reactions received by VA	1,203	1,321	1,593	3,089	3,923
Translation failures (SNOMED CT-to-VA)	1	0	8	11	69
Total DoD allergy reactions sent to VA HDR†	1,202	1,321	1,585	3,078	3,854
Translation success rate: SNOMED CT-to-VA	**100%**	**100%**	**99%**	**100%**	**98%**
MEDIATION SUCCESS RATE: DoD-to-VA	***80%***	***74%***	***78%***	***87%***	***96%***

*Yellow areas designate translation services performed by VA. White areas designate translation services performed by DoD. †HDR=Health Data Repository.

Analysis of the causes of the mediation failures revealed the following issues, listed in order of frequency of occurrence:

1. SNOMED CT concept modeling issues were exposed. For example, a search for "nosebleed" in SNOMED CT's CliniClue® browser returns more than one option within the "finding" hierarchy: "bleeding from nose" vs. "nosebleed/epistaxis symptom." Another example of a modeling issue: the "Situation with Explicit Context" hierarchy was not addressed in the original VA/DoD mapping rules, as this hierarchy evolved within SNOMED CT after the initiation of the mapping.
2. New legitimate allergy reaction terms were added independently within each agency, which led to mediation failures in the time interval between synchronization and updating of each agency's files.
3. Maintenance and versioning issues emerged when SNOMED CT released new versions with new concept statuses (e.g., "erroneous", "limited", "duplicate", "ambiguous") during the project. If agency updates were not synchronized, mediation failures would result.
4. Allergy reaction concepts and terms were sometimes deemed appropriate by one agency but not the other. For example, the concept "systemic disease" was used at one agency, but the other agency felt this term added no valuable information about an allergic reaction and did not include it in its list of selectable reactions for use by providers.
5. Divergent approaches to SNOMED mapping existed between VA and DoD, despite shared business rules. For instance, "hypertension" was mapped to "finding of increased blood pressure (finding)" at one agency, and to "Hypertensive disorder, systemic arterial (disorder)" at the other.

DISCUSSION

We begin with a list of lessons learned.

1. Mapping rules must always be tailored to the specific purpose of the mapping. These rules may be influenced by non-terminological issues, such as the potential for the entire message to fail if one component fails. We must recognize that mappings are often purpose- or use case-driven, as well as built by semantic nuances of context.

2. Even with established rules in place, there is a clear need for continued communication between agencies. We were unable to discern any major consistent reason for the mapping rule violations. One possibility is that VA and DoD initially used

different mapping tools. Another is that the process of finding the correct map for a term is variable and influenced by syntax and linguistic features of the search engine. In several cases, the Clue browser yields an apparently correct result (for example, a search for "orthostatic hypotension" returns "orthostatic hypotension (disorder)") but the term is located in the disorder hierarchy, rather than the findings hierarchy (to be used in preference if possible). It may not be immediately apparent that an alternative mapping exists ("postural drop in blood pressure (finding)") in another hierarchy. The clinical knowledge, background, and familiarity with SNOMED hierarchies and features of CliniClue® also are likely to influence search results. Ideally, a common team, process, and toolset would be used to produce the mapping. Perhaps the mapping could become a service of the Standards Development Organization, as is the case with RxNorm.

3. SNOMED CT modeling issues were probably the most difficult to address, as these require a sophisticated knowledge of concept modeling and of the evolution of SNOMED hierarchies over time.

4. Maintenance plans for using mediation terminologies need to include specific plans for synchronizing updates to the standard reference terminology, in this case SNOMED CT, and also for synchronizing updates to each agency's mapping file.

A significant outcome of this project is the generation of a new, unique SNOMED CT subset specific for Allergy Reactions (signs and symptoms) which could potentially be submitted for inclusion in SNOMED CT as an official subset. It could also be published and shared among federal agencies and non-federal partners.

In December 2007, HITSP designated the VA/Kaiser Permanente (KP) Problem List subset (16,430 entries) as the recommended standard for allergy reactions, a departure from previous CHI recommendations to use the VA/DoD Allergy Reactions subset (864 entries)[16]. While many of the VA/DoD Allergy Reactions terms are contained within the Problem List subset, use of the Problem List subset to record allergy reactions (signs and symptoms) may prove problematic, as is the case whenever data is used for a purpose other than that originally intended. Consider the terms "circumoral paresthesia (finding)" and "edema of pharynx (disorder)." These terms are appropriately found within the VA/DoD Allergy Reactions subset, but not within the VA/KP Problem List subset. The sheer size and complexity of the Problem List subset, compared to that of the Allergy Reactions subset, may unnecessarily complicate data entry for providers and result in unwanted entry of inappropriate terms as Allergy Reactions. The smaller subset could enable more precise data constraints and greater computing speed, without sacrificing data integrity. Communication with HITSP is ongoing regarding this issue. We propose that a new study be undertaken to evaluate the VA/KP Problem List and compare it to the VA/DoD Allergy Reaction subset, documenting content gaps, areas of overlap, and suitability for use as a mediation terminology.

In conclusion, we point out that the expense of mapping VA's and DoD's legacy terms (and maintenance of same) was relatively substantial—even for the limited list of Allergy Reactions. As CHDR expands to include more VA and DoD sites, the terminology maintenance requirements will continue.

Adopting the HITSP standard internally as a representation for allergies and reactions would be a more efficient method of working toward true semantic interoperability. Using a phased approach, legacy terms can be mapped to the standard, presented for adoption by the Standards Development Organization (SDO), and eventually migrated to the standard representation itself with deprecation of invalid legacy terms.

The use of mediation terminologies for computable data exchange is a dynamic and evolving process. It is prone to pitfalls, but is an effective, practical method for advancing the goal of semantic interoperability.

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