Structured Representation for Core Elements of Common CDS Interventions to Facilitate Knowledge Sharing

L Zhou, T Hongsermeier, A Boxwala, J Lewis, K Kawamoto, S Maviglia, D Gentile, J Teich, R Rocha, D Bell, B Middleton
Introduction

- There are no widely accepted, standard approaches for representing computer-based CDS intervention types and their structural components.
  - Most institutions implement CDS in different ways.
  - It slows the implementation of CDS in institutions because they cannot easily leverage interventions developed elsewhere.

- One fundamental step is to
  - Represent best available clinical knowledge and CDS interventions in standardized formats
  - Provide knowledge sharing services
Introduction

- This work was a subtask of the “Advancing CDS” project supported by the Office of the National Coordinator for Health IT (ONC)
  - Identify key requirements
  - Outline core parameters and elements
  - Propose an approach for the representation of structured and shareable CDS intervention artifacts, which can be
    - subsequently transformed to a machine executable format
    - consumed by EHR systems
    - accessed as web-services

Requirements Identification  Approaches Comparison  Solution Proposal  Validation  Distribution
Requirements Analysis

- Commonly Used CDS Intervention Types
  - Alerts and Reminders
  - Infobuttons
  - Order Sets
  - Documentation Templates and Forms
  - Relevant Data Presentation

- Core Structural Elements Shared across All Five Intervention Types
  - General Metadata
  - Applicable Clinical Scenarios
  - CDS Inputs
  - CDS Outputs
  - CDS Logic
Comparison of Approaches

- Relevant work reviewed included: HL7 Arden Syntax, ASTM GEM model, HL7 Order Set specification, HL7 Infobutton, HL7 Virtual Medical Record, OpenEHR, OpenCDS, GELLO, AHRQ Structured Care Recommendation approach, CDS Consortium approach, etc.

- There are no universally adopted, comprehensive standards for the representation of CDS interventions and their core structural elements.

- However, these existing efforts share many similarities that are amenable to harmonization.
Proposed Approach

- The proposed approach largely leverages and extends the previous work of the CDS Consortium.

- A four-layered knowledge representation framework (Boxwala, 2011)
  - **Unstructured (L1)**: human readable knowledge in any document format.
  - **Semi-structured (L2)**: knowledge is deconstructed as individual recommendations. A schema is developed, but knowledge is not codified.
  - **Structured (L3)**: specifies the structure and semantics of data elements and logic needed to make the knowledge interpretable by computers.
    - The knowledge is independent of implementation in a particular CDS tool or a particular clinical setting, to maximize its ability to be shared.
    - Unified Modeling Language (UML) models and XML schemas are developed for this layer.
    - Data elements are codified as necessary.
  - **Executable (L4)**: dependent on the specific CDS tool employed and clinical setting; implemented into specific rule engines or clinical systems.

*Boxwala AA, Rocha BH, et al. A multi-layered framework for disseminating knowledge for computer-based decision support. JAMIA. 2011 Dec;18*
Overview of the Approach / L3 XML Schema

1. General Definitions and Metadata
   (unique identifier, contributor, coverage, evidence basis, type, and versioning and life cycle management information)

2. Applicable Clinical Scenario

3. A collection of unsequenced recommendations are organized into modules

4. Each recommendation consists of metadata, applicable scenarios and clinical advices (actions)
An Example of L3 Stylesheet

Reference eMeasure and CDC Value Sets for Smoking

Anti-Smoking Medications
- Substance Administration Request: Nicoderm-CQ 14mg 1 patch/day - Nicoderm-CQ (RxNorm: 351427)
- Substance Administration Request: Varenicline po 1mg 1tab / day - Varenicline (Chantix) (RxNorm: 637190)
- Substance Administration Request: Zyban ER po 150mg 1tab / day - Bupropion (RxNorm: 993955)

Referrals
- Encounter Request: Smoking cessation education (SNOMED Clinical Terms: 225323000)
- Encounter Request: Referral to smoking cessation advisor (SNOMED Clinical Terms: 395700008)
- Encounter Request: Referral to stop-smoking clinic (SNOMED Clinical Terms: 315232003)

Patient Education
- Knowledge Asset Request: Smoking Cessation Education Leaflet - Smoking cessation education (SNOMED Clinical Terms: 225323000) Target: Patient (SNOMED Clinical Terms: 116154003) [http://www.ahrq.gov/consumer/tobacco/helpsmokers.htm]

Figure 6 - Screenshot of ACDS Order Set for Smoking Cessation
“Definition” can be used to specify the meaning of a term that exists across recommendations or guidelines.

- e.g., “poorly controlled diabetes” is defined in terms of serum hemoglobin A1c test results.

“Expression” is used to define a precise meaning of the term. It can be written in GELLO or other rule expression languages.

“DataMapping” provides a link to a patient information model which specifies the data items that are referenced in the logical expressions.
At the core of CDS inputs is patient data.

The model is based upon the Clinical Statement model from the Health Information Technology Standard Panel (HITSP)’s Summary Documents Using HL7 Continuity of Care Document (CCD) Component, i.e., the C32 specification.

We further recommend that this model be harmonized with the emerging HL7 vMR standard.

It also draws from the CCD clinical statements model with the overlaid HITSP constraints.

Concrete actions can be organized by the action organizer using logic operators.

For each action:
- Override or exception reasons
- Priority of the request (high, medium, low)
- Request type (e.g., instruction)
- SelectionCriteria (i.e., action preference)
- Severity of the clinical condition request
Representation of CDS logic

- CDS logic is represented as a pairing of applicable scenarios based on the CDS input model to recommended actions encapsulated in the CDS output model.

- Each recommendation consists of a specification of metadata, applicable scenarios, and one or more CDS advices.
  - Within an applicable scenario, logical expressions may be constructed using various expression formalisms, such as GELLO, Arden Syntax, and pseudocode.
  - Within a given advice, there are concrete actions that represent the CDS outputs.
Representation of Value Sets

- Used standard terminologies and value sets to encode the various data elements
- Maintained separately as independent resources that can be re-used across CDS interventions.
  - E.g., we identified 29 different SNOMED concepts to identify patients who have diabetes mellitus.
- The codes in the value set have a set of attributes (e.g., code and coding system)
- Zero or more qualifiers that increase the specificity of the primary code.
- The codes can be translated to other coding systems or tied to other related work (e.g., National Quality Forum (NQF) eMeasures Value Sets).
Validation and Distribution

- XML schema was validated using a set of CDS interventions
  - Targeted toward guidelines and clinical conditions called for in the 2011 Meaningful Use criteria
  - Implemented at Partners Healthcare
  - Informed by related CDS projects, especially the NQF eMeasures.

- Three custom stylesheets were developed appropriate for clinical Subject Matter Experts, Knowledge Engineers and Developers, to render the logic in human-readable form.

- Clinical elements (e.g., labs) in these artifacts were defined by linking to the NQF eMeasures using the OIDs (HL7 object identifiers).

- 22 CDS artifacts (e.g., order set or smoking cession) and 16 value sets were developed that cover the 5 CDS intervention types.

- Allscripts conducted a demonstration of transformation by importing CDS artifacts and firing the rule logic in their local test environment.
Discussion

- **CDS Data Model**
  - Lacks a standard model for representing data items, including patient information, provider information, clinical actions and workflow information.

- **Rule Languages and Formalisms for Logic Expression**
  - Needs a well-defined and easily adaptable rule expression language to create queries to retrieve and manipulate EHR data and to construct logical expressions to reason about particular data features and values.

- **Quality Measures**
  - Needs to make these measures interoperable with CDS logic in a more automated fashion

- **Terminologies and Value Sets**
  - Maps standard terminologies to local codes
  - Classifies specific problems or medications into generic categories
  - Identifies a clinical state for CDS
Conclusion

- We proposed a structured representation for core elements of common CDS interventions to facilitate knowledge sharing and improve the standard of care.
- We leveraged previous efforts and validated the model to some extent within our own system and with commercial EHR systems.
- Next steps will include further extension and validation of the proposed approach, and make reference to the Health eDecisions work.