

# Challenges in Exchanging Medication Information: Identifying Gaps in Clinical Document Exchange and Terminology Standards

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## ABSTRACT

*The availability of accurate medication history information is invaluable for making sound therapeutic decisions. The Continuity of Care Document (CCD) could serve as a mechanism for exchanging interoperable medication information between EHRs. We evaluate the feasibility of representing a medication and its underlying components in a Healthcare Information Technology Standards Panel (HITSP) compliant CCD. Our evaluation resulted in successfully mapping 94% of medication entries and greater than 92% of medication component mappings to CCD constraints. We identify gaps and provide recommendations for improving the representational adequacy of the Federal Medication Terminology (FMT) to fully represent orderable medication concepts.*

## Introduction

Incomplete medication histories contribute to over a quarter of all hospital prescribing errors.<sup>1, 2</sup> Accurate and complete medication histories can prevent possible adverse drug events (ADEs) and improve patient safety.<sup>1</sup>

Medication history information is often distributed across disparate sources. The fragmented nature of the healthcare system necessitates distribution of medication history information among providers, retail pharmacies, pharmacy benefit managers (PBMs), and patients. Automated extraction of information, across entities could allow a

more complete and accurate estimation of the patient's medication history.

The federal government has endorsed standards to allow interoperable exchange of medication history information. As part of the Medicare Modernization Act (MMA) of 2003, the Centers for Medicare and Medicaid Services (CMS) have mandated the use of the National Council for Prescription Drug Programs (NCPDP) SCRIPT Version 8.1 standard for Medicare Part D beneficiaries. This standard allows connectivity between providers, retail pharmacies and pharmacy benefit managers (PBMs). However, interoperability among EHRs remains a challenge and limits the ability to share information between healthcare settings.<sup>3</sup>

The CCD offers a possible solution for interoperable medication history exchange between EHRs as well as PHRs. The Certification Commission for Health Information Technology (CCHIT) has endorsed the use of the Continuity of Care Document (CCD) as its standard for clinical document exchange. The 2008 CCHIT certification criteria require EHRs to demonstrate the ability to file and display, as well as generate Continuity of Care Documents (CCDs) formatted to the Healthcare Information Technology Standards (HITSP) C32 specifications.<sup>4, 5</sup> Prior to the introduction of the CCD as certification criteria, very few EHRs in the United States have used the CCD in a

HITSP compliant manner. While the CCHIT mandate will expedite adoption, the relative newness of the standard calls for actual field testing to examine utilization for specific use cases for health information exchange.

In this pilot study, we evaluate the ability of the CCD, for the specific purpose of exchanging medication history information. Additionally, we examine the comprehensiveness and representational adequacy of the underlying terminologies in the CCD for expressing a medication order, which includes both the medication concepts and the *signatura* or 'sig' components (route, frequency, dose, dose units). We provide recommendations for strengthening this emerging standard and possibly narrowing the gap towards seamless interoperability.

## **Background**

This study was conducted as part of a larger effort at Partners Healthcare to bring together disparate sources of medication history for a patient, for the purpose of medication reconciliation. In 2006, Partners implemented an in-house medication reconciliation application called Pre-Admission Medical List (PAML), at two Academic Medical Centers, Brigham and Women's Hospital (BWH) and Massachusetts General Hospital (MGH).<sup>6, 7</sup> The PAML application allowed reconciliation of medications upon admission, by allowing the provider to extract medication history from our outpatient EHRs and discharge medications from our inpatient CPOE systems. To extend our medication reconciliation capabilities, across disparate EHRs and in the future to our PHR we needed an interoperable mechanism for, as a first step, exchanging medication information and in the future, problems, allergies, etc. to facilitate decision support.

The CCD was developed through the joint effort of two existing information exchange standards the Health Level 7's (HL-7) Clinical Document Architecture. (CDA) and the ASTM's Continuity of Care Record (CCR). The goal of the CCD was to employ the flexible CDA structure to express the CCR data for interoperable information exchange. In order to achieve this interoperability, HITSP constrains the expression of clinical data using the standard vocabularies in the FMT. The FMT represents a collection of terminologies including the National Library of Medicine's (NLM) RxNorm for clinical drugs, the Food and Drug Administration's (FDA) Unique Ingredient Identifiers (UNII)s for ingredient name, the FDA's Dosage Form, FDA Route of Administration, Unified Code for Units of Measure (UCUM) for dose units of measure, and the Department of Veterans Affairs' National Drug File – Reference Terminology (NDF-RT) for drug classes.

The goal of this study is to evaluate the utility of the CCD as a mechanism for exchanging medication history information. Further, within the CCD, the study evaluates the use of the FMT for representing clinical drug concepts and common discrete medication order components of route, dosage form, frequency, interval and dose units of measure. This examination will improve our understanding of the FMT and enable us to provide recommendations for further improving its representational adequacy.

## **Materials and Methods**

We extracted 530,086 PAML records for 17,075 patients admitted at BWH or MGH, from October 2007 to February 2008. This resulted in 3610 unique medication concepts (including investigational and compounded drugs) from our medication dictionary, expressed in the medication records.

In order to codify medication concepts, according to the HITSP C32 constraints, we created prototype cross-references between medication concepts expressed in PAML records and the terminology constraints prescribed by HITSP. We leveraged a previously built cross-walk from our internal medication dictionary to a vendor terminology (First Data Bank's (FDB) NDDF Plus). Since FDB provides clinical medication concepts to the NLM for publication within RxNorm, we were able to navigate to corresponding RxNorm clinical drug concepts. For example for a medication order of:

METFORMIN 500 MG PO TABLET =  
FDB GCNSEQNO ID 13318=  
RxNorm ID 311570 "Metformin 500 MG Oral Tablet"

In this example, if the medication order was represented as our internal medication dictionary concept then the algorithm would look for additional concepts of 'dosage form' (tablet) and 'strength' (500mg) to arrive at a specific SCD to which the order could be mapped.

Thus, we attempted to increase the proportion of matches between medication entries and RxNorm by looking for the best match between an orderable medication concept and a single "representative" RxNorm terminology type that spanned the collection of associated clinical drugs. Key RxNorm terminology types included a Semantic Clinical Drug (SCD), Semantic Clinical Drug Dose Form (SCDF) or an Ingredient (IN). Below we note two examples that illustrate this methodology and map to two different representative RxNorm terminology types to provide the closest possible match for the orderable medication concept.

INSULIN NPH HUMAN SC=  
Partners ID 384 =

RxNorm SCD 311028 "NPH Insulin, Human 100 UNT/ML Injectable Suspension"

DOCUSATE SODIUM 100 MG =  
Partners ID 248 =  
RxNorm IN 82003 "Docusate"

In order to measure the representational adequacy of the FMT we excluded orders that did not contain a codified medication concept, such as, non-medication orders and free text entries. Instead of mapping every unique instance of a medication component we adopted a pragmatic approach of mapping medication components covering more than 90% of medication entries, to the FMT. Development of this cross-reference allowed us to identify gaps in the adequate expression of the medication components. We present these as recommendations to improve the comprehensiveness of the underlying terminologies in the CCD and provide specific examples to illustrate these issues.

## Results

We successfully mapped 94% of medication entries and greater than 92% of medication component mappings to CCD constraints. Of 95,944 patient records 41.65% (n=39961) contained a FDB Clinical Formulation Identifier which allowed us to map to the generically named orderable medication to an RxNorm clinical drug concept. Use of representative mappings resulted in an additional 44% (n=42,220) linkage to RxNorm concepts. Another 3% (n=3,131) of medication concepts could be mapped to a SCDF by improving specificity using the sig components of dosage form and route. The remaining 6% of medication entries could not be assigned to a meaningful RxNorm concept.

## Discussion

Representation of drug concepts is complex and heterogeneous depending on the source of information<sup>8</sup>. Medication reconciliation from disparate sources requires use of a common vocabulary or the ability to cross-walk multiple vocabularies.<sup>9</sup> A previous study by Parrish, et al. evaluated the ability to map pharmacy data to the RxNorm SCD<sup>10</sup> however no study thus far has focused on mapping to each of the terminology constraints identified in a HITSP compliant CCD. Use of the FMT in the CCD facilitates standardized representation of a drug concept. While the FMT is adequate for the representation of over 94% of drug concepts there remain gaps in its representational adequacy.

Below we identify gaps in the FMT's representational adequacy to allow codification of medication entries:

*1. Absence of an Ingredient Set concept:* Multiple-ingredient drug names that span more than one dosage form could not be mapped to a single RxNorm concept. This results from the lack of a concept representative of an ingredient set in RxNorm. For example, a combination drug name such as 'Sulfamethoxazole /Trimethoprim' cannot be resolved to a single RxNorm concept as it spans liquid, tablet and injectable formulations. Therefore, the ingredient set must be represented as multiple RxNorm concepts, which does not reflect that provider's intention to order it as a single product.

*2. Absence of discrete strength and strength unit of measure data elements:* The RxNorm Semantic Clinical Drug Component (SCDC) represents the composite of a single ingredient and its strength and strength unit of measure. Post co-ordination of the data elements of strength and strength unit of measure would enhance the flexibility to match ingredient strength or calculate dosage form quantities required to satisfy

the ordered dose. For example, a medication order of 'Amoxicillin 250 mg' could be calculated to be satisfied with either the SCD corresponding to 'Amoxicillin 250 MG Oral Capsule' or 5 ml of the SCD 'Amoxicillin 50 MG/ML Oral Suspension'. This flexibility would be facilitated by discrete representation of the strength and strength unit of measure data elements within RxNorm.

*3. Lack of a common therapeutic grouping:* Most orderable terminologies allow a physician to order a therapeutically meaningful medication class name, without assigning a specific drug product. For example, 'Multivitamins, PO' or 'Artificial Tears' span a broad range of pharmaceutical formulations and without more specificity these concepts cannot be represented by a semantically equivalent concept in RxNorm.

*4. Lack of granularity in FDA Dosage Forms:* This limitation relates to the loss of specificity that results from expressing the time release characteristics, of controlled release formulations e.g. extended release (ER or XR) or sustained release (SR), etc. The dosage form of these formulations specifies the period of time for which steady levels of the drug would be maintained in the bloodstream, such as 'CR 12 hour' or 'XR 24 hour'. When mapping the dosage form of a time release formulation to the coded FDA dosage form concept, this granularity is lost since all time release formulations are mapped to a single concept represented by 'extended release'.

*5. Lack of guidance on normalization of Periodic Interval of Time Entries (PIVL\_TS):* The frequency mnemonics in the CCD are represented using a combination of the concepts of frequency and time period, expressed as periodic interval of time entries (PIVL\_TS). There is ambiguity around how to express a given frequency mnemonic using a PIVL code. For example, the frequency mnemonic of

QD or 'once daily' could be represented with the frequency as '1' and the interval as 1 day or the same concept could be represented as a pairing of period value '24' and interval represented in hours as 'h'.

The unavailability of any documented conventions for the normalization of period value and interval can pose problems for decision support systems that are expecting a specific representation. Our recommendation would be to use the combination of period values and time units of measure in which the period could be expressed as the smallest whole number.

### Conclusions

The CCD offers a large step towards the goal of interoperability among EHRs. This study demonstrated how a large percentage of codified medication entries were successfully represented in the CCD. Further, codification of sig components along with a medication concept allowed more accurate mapping of clinical drug concepts within a CCD. Future work should focus on validating the CCD for specific clinical use cases to support its value as an interoperable document exchange standard.

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