

Development of a HL7 CDA R2 Compliant Discharge Summary Teaching Template for the QEII Renal Clinic

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Acknowledgement and Endorsement

This report has been written by me and has not received any previous academic credit at this or any other institution.

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Signature

Date

Executive Summary

Internships give students of Health Informatics opportunities to receive on-the-job training and to connect their academic health informatics knowledge to the real world. This internship is composed of two objectives, encoding lab tests into multiple coding systems and designing a HL7 CDA R2 compliant discharge summary teaching template. Both objectives aim at implementation of standardization and interoperability. The first objective allowed the intern to learn how medical terminologies are organized to represent medical concepts, and how they are related to each other in a common ontology to enable sharing among health care providers. As the main task of this internship, the second objective provided a test bed for the intern to experiment how such a template can serve as a boundary object among physicians, residents, and health informaticians to bridge the knowledge gap, how the concepts of HL7 template and archetypes are applied, and how the CDA document is produced and enables interoperability among health care providers. The success of health informatics depends on the cooperation between health informaticians and healthcare providers. There is a need for widely accepted terminology. Considering the HL7 standard is still under development, this template should be updated and refined accordingly to keep it up-to-date.

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1. Introduction

1.1 Overview

This 13-week internship is shared between Medical Informatics at Dalhousie University and Renal Clinic at Queen Elizabeth II Hospital (QEII), Halifax, Nova Scotia, composed of two objectives:

- I. Coding lab tests into multiple vocabularies which was taken at the Medical Informatics during the first week of the internship;
- II. Designing a Health Level 7 (HL7) Clinical Document Architecture (CDA) compliant XML Discharge Summary (DS) teaching template for QEII Renal Clinic which was taken at the Medical Informatics and QEII Renal Clinic during the remaining 12 weeks of the internship.

This is a work underpinning Ms. Grace Paterson's paper HL7 Template as Boundary Object for Clinical Care and Health Informatics.

1.2 Introduction to the Organizations

Medical Informatics at Faculty of Medicine and the Faculty of Computer Science, Dalhousie University, began the first Master of Health Informatics program in Canada in 2002, aiming at using information technology to improve clinical care, research, teaching and health services administration.

QEII Renal Clinic operates a residency training program in Nephrology and provides consultation and dialysis to the renal disease patients of Nova Scotia and Prince Edward Island.

1.3 Objective I: Encoding Lab Tests

1.3.1 Background

Encoding of medical information is one of the fundamental tasks of Health Informatics. It facilitates sharing and exchanging information between health information systems and health care providers by standardizing and highlighting the key terms in medical records. Meanwhile, multiple coding systems coexist among various vendors and hospitals. Thus, understanding how

terms are coded into different coding systems is important for translation between coding systems.

1.3.2 Objective and Lessons Learned

Dalhousie University COPS case titled "Michael O'Brien" has a HL7 CDA demo at the <http://www.healthinforx.ca/dme> website. The intern encoded its lab tests into the four code systems, UMLS, SNOMED International 1998, SNOMED CT, and MEDCIN and learned basic knowledge about the structures and coding guidelines of these coding systems.

1.4 Objective II: HL7 CDA R2 Complaint DS Teaching Template

1.4.1 Background

Medical discharge summaries carry the relevant facts of a patient's stay in the hospital and act as a key information source sharing by various health care providers during optimal follow-up care and visits. [1] In training programs, medical residents learn to write discharge summaries by dictating following a set of guidelines. However, these guidelines are loosely defined and lead to ambiguity. As a result, discharge summaries are narrative with rather casual structures and terms. Previous work has shown that essential data is either difficult to be located or missing in discharge summaries when being abstracted for registries or research. Data that the physician has not written or dictated remains unknown. [2] This could be a natural consequence of narrative discharge summaries. Study has also shown that physicians prefer standardized discharge summaries to narrative ones because of more relevant data and easier information location the former provides [3].

“Chronic kidney disease develops when the kidneys permanently lose most of their ability to remove waste and maintain fluid and chemical balances in the body. This process can develop rapidly - within 2 to 3 months - or slowly, over 30 to 40 years. The severity of chronic kidney disease depends on how well the kidneys filter wastes from the blood (glomerular filtration rate).” (my.webmd.com)

In the case of QEII Renal Clinic, its patients with Chronic Kidney Disease (CKD) have many medical problems that need to access the health care system frequently and intend to have even more complicated and lengthy discharge summaries which are more difficult for a resident to achieve. On the other side, the QEII regularity which requires the attending physician to validate

and sign a discharge summary may keep residents from reviewing a sophisticated discharge summary completed by an experienced physician.

Therefore, due to the importance and complexity of discharge summaries and the lack of an efficient teaching tool, a joint project between the Medical Informatics and QEII Renal Clinic is carried out, aiming at testing the hypothesis if discharge summaries completed using an electronic structured template are more complete and contain more essential data elements than those completed without the use of a template.

Health Level 7 (HL7) is an internationally accepted health informatics standard. Derived from HL7 Reference Information Model (RIM), the HL7 CDA is a document markup standard for exchange through specifying the structure and semantics of "clinical documents". [4] It provides appropriate frame and promises future development for the discharge summaries. Compliance with HL7 CDA is the requirement of developing such a template.

1.4.2 Objective and Lessons Learned

Developing a HL7 CDA compliant template for this project is the main objective of this internship. The intern developed this HL7 CDA compliant discharge summary teaching template using Microsoft InfoPath as authoring tool, learning the strategy of how to bridge knowledge gap and develop a CDA template.

2. Health Informatics Relevance

2.1 Objective I: Encoding Lab Tests

Infrastructure of standards for interoperability between health care providers is information model, clinical templates, and vocabulary. [6]

A large proportion of medical knowledge is disseminated in narrative medical data and in the form of local vocabularies. [5] It is a big challenge for health information systems to extract, translate, and represent local vocabularies in standardized controlled terminologies for the purpose of sharing and computer processing. [6] This is the standardization gap which Knowledge Management must address by introducing coding systems. [7]

Lab tests are important for diagnosis and treatment. They are usually represented in a structured form which does not require a natural language processing program to extract, thus

they are ideal for encoding. Encoding "Michael O'Brien" case's lab tests into four popular coding systems (UMLS, SNOMED International 1998, SNOMED CT, and MEDCIN) is a procedure of mapping between the local terminology and the standardized terminologies while cross-mapping and comparing between different coding systems. The coding tools used are SNOMED CT Clue Browser, SNOMED CT web browser provided by National Cancer Institute, Online UMLS Knowledge Source Server, and Browser for MEDICIN.

An excerpt of the coded XML file is following:

```
<Observation>
  <code code="T-C2000" codesystem="2.16.840.1.113883.6.5" codeSystemName="SNOMED"
displayName="Blood"/>
  <code code="87612001" codesystem="2.16.840.1.113883.6.96"
codeSystemName="SNOMED_CT" displayName="Blood"/>
  <code code="C0005767" codesystem="2.16.840.1.113883.6.86" codeSystemName="UMLS"
displayName="Blood"/>
  <code code="81467" codesystem="2.16.840.1.113883.6.26" codeSystemName="MedCin"
displayName="Urinalysis Results: Occult Blood"/>
  <text>
    <UMLSdefinition>
      The body fluid that circulates in the vascular system (BLOOD VESSELS). Whole blood
includes PLASMA and BLOOD CELLS.
    </UMLSdefinition>
  </text>
  .....
</Observation>
```

For the purpose of facilitating computer systems to understand medical language, National Library of Medicine's Unified Medical Language System (UMLS) is a collection of concepts linked by different source vocabularies/multiple coding systems (for examples, ICD 9, LOINC and SNOMED CT) and available in multiple languages. It includes Metathesaurus, Semantic Network, and SPECIALIST lexicon. (<http://www.nlm.nih.gov>) Concepts are grouped by meaning and lexical characteristics of terms, resulting in a target term/synonym collection for each concept. There is no real class hierarchy among UMLS concepts. [8]

SNOMED (the Systematized Nomenclature of Medicine) is developed by College of American Pathologists (CAP). Each concept includes description and relationships with other

concepts. SNOMED International 1998 is the last free version of SNOMED. The SNOMED Clinical Terms (SNOMED CT) is the latest release and regarded as the most complete clinical coding system. (www.snomed.org) [8]

MEDCIN is developed by MediComp Systems inc.. Aiming at “directly usable by busy clinicians at the point of care”, it is concept-oriented with strict hierarchy and rich synonymies. It is cross mapped with ICD 9/10 and other coding systems. (www.medicomp.com)

An adequate mapping between local terms and the target code system requires: [6]

- 1) selecting the right target coding system which covers the local clinical domain,
- 2) at least a certain level of similarity and coherence between the local ontology and the ontology of the target code system,
- 3) accurate understanding of the meaning of the local term given its context,
- 4) accurate understanding meanings and context of the terms in the target coding system,
- 5) facilities for searching the closest mapping,
- 6) adopt a realist ontology which is the closet reflection of the reality as the reference to implement the mapping between different coding systems and detect errors in the coding system.

The mission of HL7 Vocabulary Technical Committee is to identify, organize and maintain coded vocabulary terms used in HL7 messages. [9] The application of coding systems in HL7 RIM can be illustrated in Figure 1.

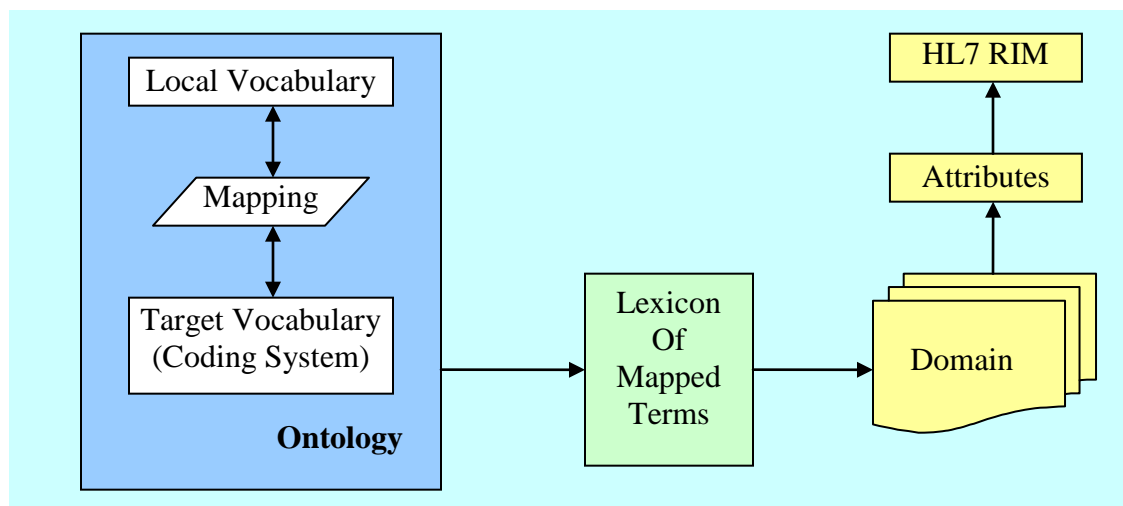


Figure 1: HL7 RIM Vocabulary

2.2 Objective II: HL7 CDA R2 Compliant DS Teaching Template

As previously noticed, discharge summaries are key references at the point of continuity care, shared among health care providers. It gives the referred physicians a quick review of the patient's health history and status. This discharge summary teaching template will enable computerized process to maintain standardized work processes, and to prompt. Its further development can facilitate case-based teaching, clinical research, and decision support.

An abstract of EHR core dataset contained in this template makes it within the EHR context and an instance to test the idea of EHR. [13] HL7 CDA R2 facilitates the implementation of interoperable EHR and represents clinical documents both machine-readable and human-readable.

The declaration of "Discharge Summary" in a CDA document implemented by XML document codes and section codes can specify the template as a discharge summary document. [4] [14] HL7 CDA transforms tacit knowledge down to tagged XML documents for later explicit knowledge extraction.

The constraining of context, structure, vocabulary, data formats/types, and validation of user input against predefined rules in a HL7 CDA template can strengthen medical education and practice through: [11]

- unambiguous information exchange among people,
- decreased input errors,
- guided input resulting in increased essential information,
- definition of rules and trigger events to reveal interdependency among data and to prompt and guide physicians into the correct diagnosis pathology
- post-processing, such as query, clinical research, etc.

Star and Bowker define boundary object as "those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them." [10] As a structured collection information of discharge summary in the interest of physicians, residents and health informaticians, this HL7 DS teaching template works as a boundary object: [11] [12]

- 1) It is a teaching tool for physicians.

- 2) It provides a use-case frame for residents for the purpose of improving their quality of discharge summaries.
- 3) Health informaticians establish and assess archetypes in it by analyzing feedbacks from physicians and residents.

In conclusion, a HL7 CDA R2 template is a desirable health informatics solution for the issues about discharge summary teaching template addressed at the beginning of this report.

3. Design a HL7 CDA R2 Complaint DS Teaching Template

3.1 Literature Review

Markle Foundation's report argues that an important trade-off in health information standard adoption is whether requiring completely structured and coded data idea for computer processing or narrative text suitable for human being interpretation. The drawback of the former approach is the rigid formalization might conflict with physicians' habits. The advantage of the latter approach is in the short term it minimizes the burden of physicians. [15] Besides, Canada InfoWay's report points out that "The Rx, DI, and Lab programs will all require the ability to transfer and store narrative text information in their domain repositories." [16] Consequently, the ability of carrying both structured and narrative content makes HL7 CDA an outstanding standard for exchange of clinical document.

Thomas Beal suggests separating the semantics of information and knowledge into two levels: [19]

- HL7 RIM level which is relatively static and small,
- Knowledge level which is derived from HL7 RIM and where constraints happen and templates/archetypes are created in a certain ontology,

This separation facilitates object-oriented design. It allows: [17]

- quick development of "Future-Proof Systems and Data": sub-classes can be changed without affecting the non-volatile HL7 RIM based software model;
- domain empowerment: soft models are developed by software engineers, while knowledge concept definitions are developed directly by domain specialists;
- knowledge-level interoperability: the concepts can be shared;

- intelligent querying.

In the light of object-oriented design, HL7 views template as “A structured aggregation of one or more archetypes, with optional order, used to represent clinical data”, while archetype is “A syntactically and semantically structured aggregation of vocabulary or other data that is the basic unit of clinical information”. Both of them further constrain the content of a HL7 v3 message or document. [11]

The HL7 recommended template life cycle is: [18]

- Analysis
- Design
- Validation
- Registration
- Discovery/Retrieval
- Instance creation
- Instance validation

Some explanations are: [11]

- templates and archetypes cover at least 85% of real-world use cases;
- syntactical and semantic constraints can be applied to templates and archetypes;
- a template/archetype can contain other templates and archetypes;
- a library of R-MIM Fragments will be setup to create constrained instances of templates and archetypes;
- templates and archetypes will be validated against R-MIM fragments and vice versa;
- templates and archetypes will be registered and cataloged by their metadata for retrieval, revise and reuse;
- the main body of the archetype is completely independent of terminologies and particular natural languages.

Archetypes allow domain experts such as clinicians to create the concept definitions which drive their information systems to share and validate data input at runtime. They are the basic query units. (<http://www.openehr.org>)

Steps to create an archetype are: [19]

- separation of Concerns
- separation of Viewpoints
- separation of Knowledge and Information
- abstraction
- re-use of models and software components

Templates are generated by chaining archetypes together, selecting terminology and language among those available in the archetypes, and further constraining archetypes according to the context templates apply to. (<http://www.openehr.org>)

The structure of a clinical document can be divided into three layers. [20]

Layer 1 Documents and Sections		HL7 CDA Documents levels (Template)
	Layer 2 Clinical Statements	HL7 CDA Section levels
	Layer 3 Internal Structures in a statement	HL7 CDA Entry levels (Archetypes)

HL7 CDA has the following features in favour of an interoperable EHR: [4]

- reference to the HL7 RIM,
- the adoption of a XML encoding,
- CDA Schema describing the style of XML markup of CDA instances for the purpose of exchange,
- three constraint level templates (document-level, section-level and entry-level),
- the ability to include both structured and narrative content,
- the extensibility to add local semantics through customer-defined XML tags and attributes,
- the allowance of multiple coded vocabularies.

A HL7 V2.x or V3 message views a CDA document as a multimedia object which can be exchanged as a Multipurpose Internet Mail Extensions (MIME, RFC 2046) package and encoded as an encapsulated data type (ED). [4]

Figure 2 adapted from [11] illustrates the tooling and relationship among template, archetypes, CDA and RIM.

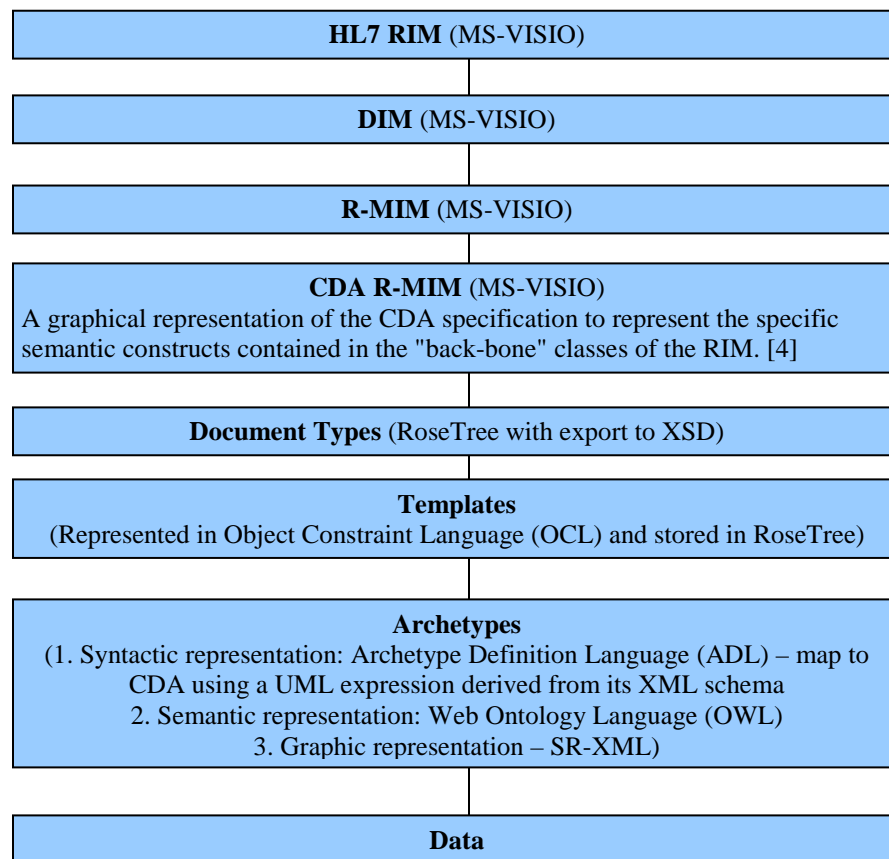


Figure 2: Relationship among CDA, Template, and Archetype

There are two ways to produce a CDA document: [4]

- I. add constraints to the CDA schema so that the resulting specification defines a particular document type;
- II. create a local schema and then transform the local XML instance to CDA.

3.2 Knowledge Gap

Medical education is a cycled procedure of explicit and tacit knowledge transformation. The lack of standardization and knowledge representation media is responsible for the knowledge gap between physicians and residents.

- There is not a wide-accepted discharge summary standard and work flow.

- Though resulting in the same medical conclusion, every expert has his/her own problem identifying/solving methodology and terminology which might be inconsistent with each other.
- Awkwardness of share and reuse knowledge among different health care providers is due to the lack of universal unique terminology. The Renal Clinic adopts localized Canadian Organ Replacement Registry (CORR) codes for diagnosis while the hospital uses ICD 10 codes to report to CIHI.

The HL7 CDA R2 Discharge Summary template can serve as a media or boundary object to bridge the gap (Figure 3).

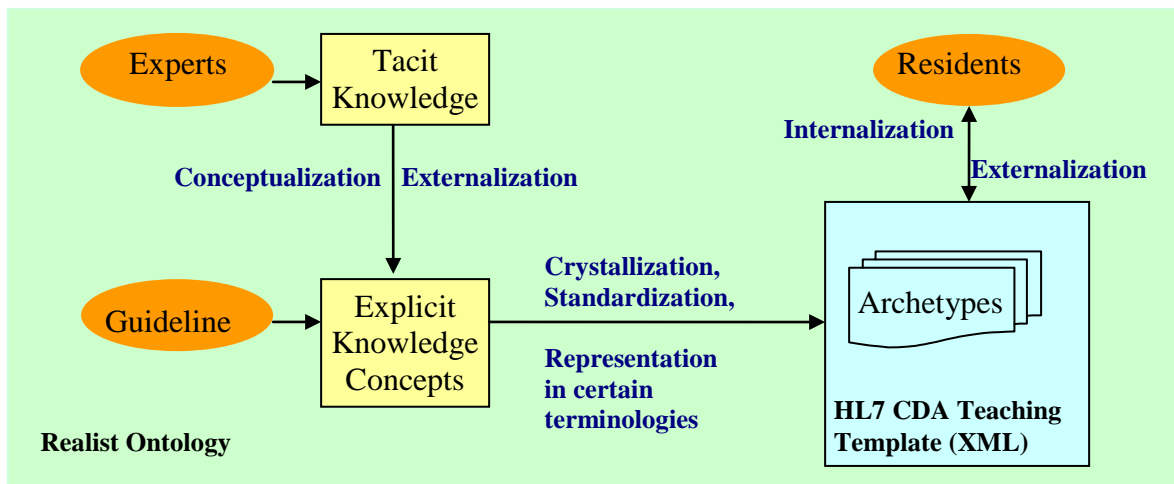


Figure 3: Bridge the Knowledge Gap

3.5 Methodology

3.5.1 Scope

A HL7 CDA (ballot 2 December 2003) compliant Discharge Summary teaching template for CKD patients is developed using controlled terminology and a common ontology, with the integration of “how-to” teaching instructions. Also, a protocol for this study design is proposed.

Test is not within the internship scope.

3.5.2 Literature Review

Literature review surveyed previous related work:

- current available techniques can be used in medical education

- computerized discharge summary and EHR
- HL7 template and CDA

3.5.3 System Requirement Analysis and Specification

Based on literature review, the functions, structure, components, and development tool of the template is specified and approved by the supervisors.

- 1) Reviewed the following documents to gain domain information and knowledge about the template.

Documents	Comments
Patient chart (1)	To gain knowledge of the scenario, use cases, and pertinent data related to the template.
Dalhousie Medical Education teaching case (1)	
Canadian Organ Replacement Registry (CORR) – Kidney forms (1)	To learn how the CORR categorizes epidemiological data.
QEII Renal Clinic structured out-patient Dialysis form	To know the structure and pertinent data related to discharge summaries for CKD patients.
QEII Renal Clinic localized CORR diagnosis code list	To know the diagnosis codes and their categories used at the Clinic.
The tentative Discharge Summary Guideline Manual compiled by Department of Medicine at Dalhousie (permission granted)	To know components of a standardized discharge summary and guidelines for writing discharge summaries. This is the starting point of the template.
Acute Renal Failure Guide by Dr. C. Clase (permission granted)	To learn knowledge of kidney diseases.
Scoring scheme for Discharge Summary by Department of Medicine at Dalhousie (permission granted)	To score quality of discharge summaries.

- 2) Used UMLS MMTx and SNOCODE software to process natural language to capture the medical concepts and their semantic categories.

Software	Comments
Unified Medical Language System MetaMap Transfer (UMLS MMTx), UMLS	To abstract concepts and map them to UMLS codes.
SNOCODE software, MEDSIGHT Informatique Inc.	To abstract concepts and map them to SNOMED CT and ICD 10 codes.

- 3) Talked with physicians and residents at QEII Renal Clinic to learn their requirements to the template.

Roles	Comments
Physicians	<p>The goal of discharge summary is to facilitate the following-up care.</p> <p>This template should be mixed with structured and narrative content.</p> <p>Proposed overall structure and detailed essential data/concepts description contained in each component.</p> <p>Nice to have some automatic computerization, e.g. the calculation of CKD stage.</p> <p>Residents are easily lost in the huge information of patient charts and ignore the essential information when dictating a discharge summary.</p>
Residents	<p>Requested prompts when filling out discharge summaries:</p> <p>“What is the essential data for this component?”</p> <p>“What are the composites of the essential data?”</p> <p>“What is the scope for this component?”</p>

- 4) Produced CDA document through constraining the HL7 CDA schema.

The path is to constrain the HL7 CDA schema to discharge-summary-specified HL7 CDA schema, because there is no existing local discharge summary schema available at this time and it is easier to create such a schema from the HL7 CDA schema than to generate one from scratch and then transform to HL7 CDA schema.

- 5) Chose Microsoft InfoPath as the authoring tool.

Tools	Pros	Cons
MS InfoPath (www.microsoft.com)	<p>Learn by examples. MS InfoPath HL7 CDA demos are available for study and reference.</p> <p>Easy access. It is part of the Professional edition of Microsoft Office.</p> <p>Graphic XML authoring tool. Its documents can conform to a designated XML schema while offering a clear, straightforward interface to the end user.</p>	<p>Not flexible at dealing with CDA schema. To reduce programming workload, CDA schema has to be transformed.</p> <p>Some limitations on the graphic controls, e.g. population limitation on dropdown menus.</p> <p>It is not web-based. Users have to install InfoPath to use.</p>
Java/XSLT	<p>Flexible.</p> <p>Easy access. It is web-based and does not need to install any particular application on users' computers.</p>	<p>Difficult to start with.</p> <p>Heavy programming workload.</p>

3.5.4 Study Protocol

The study protocol based on the system specification and literature review is proposed.

3.5.5 Design

1) Structure of the template

This template is structured into three parts to imitate the real health care procedure of an in-patient. Due to the constraint of time, availability of technique tools, and practical requirements from physicians, only medications, lab tests and diagnosis sections are fully structured. The other sections are either narrative or partly structured.

Table 1 lists the template's structure.

Part	Section	Entry	Narrative	Structured
Part I On Admission				
	Patient Information			X
		name, sex, birthday, health care card number, hospital unit number, admission date, discharge date, etc.		
	Hospital Information			X
		site		
	Referral Information			X
		physician's name, specialty, address		
	Admission Diagnosis			X
		CKD stage, primary diagnosis and category, co-morbidities and secondary diagnosis, diagnosis date		
	History of Present Disease		X	
	Family History		X	
	Social History		X	
	Past Medical History		X	
	Surgeries Performed		X	
	Allergies and Adverse Reactions		X	
	Immunization		X	
	Medications on Admission			X
		drug name, reason for prescription, route, precondition, dose rate, etc.		
	Relevant Lab Tests on Admission			X
		test name, SNOMED CT code, reference range, unit, value, date		

	Resident Information		X
	Name, title, date		
Part II Course in Hospital			
	Physical Examination	X	
	race, vital signs		
	Relevant Lab Tests in Hospital		X
	test name, SNOMED CT code, reference range, unit, value, date		
	Surgeries Performed in This Encounter	X	
	Course in Hospital	X	
Part III On Discharge			
	Relevant Lab Tests on Discharge		X
	test name, SNOMED CT code, reference range, unit, value, date		
	Medications on Admission		X
	drug name, reason for prescription, route, precondition, dose rate, etc.		
	Dialysis Order	X	
	Follow-up and Recommendations	X	
	Resident Information		X
	name, title, date		
	Physician Information		X
	name, title, department, date		

Table 1: Template Structure

2) Render of the CDA schema

The CDA context is set in the CDA header and applies to the entire document enabling document level constraining and clinical document exchanging across and within institutions. [4] It includes document type (Discharge Summary Report), health care provider, physician and patient information.

The CDA body contains the content of a health care encounter, comprised of document sections. In this case, the structured body is used and the XPath is *ClinicalDocument\component\bodyChoice\StructuredBody\component*. Archetypes are created at the entries level.

However, designed for general purpose by defining <section> instead of a specific element, for example, <HistoryofPresentDisease>, the CDA schema asserts the type of section as History of Present Disease through coded vocabulary in the <section></section> pairs. [4] Consequently, the CDA schema is not suitable for GUI authoring tools such as MS InfoPath. The CDA schema needs to be transformed to facilitate the use of the authoring tool and to be transformed back to CDA validated schema through XSLT. In this case, the repeatable <component> element is replaced by customized elements like <HistoryofPresentDisease>, <AdmissionDiagnosis>, <FamilyHistory>. These customized elements have the same types as the <component> has and have their occurrence constrained to one.

Other constraints applied to the CDA schema include:

- Removed unrelated optional elements and attributes.
- Constrained types of some data to more restrict ones. For example, the *any* type is replaced with *string* type.
- Constrained values of some data type by enumerating allowed values. For example, the patient's race.

3) Terminology

According to the requirements of physicians, the following coding systems are used:

- Localized CORR codes: mapped to the diagnosis;
- ICD 10 codes: mapped to the categories of diagnosis;
- SNOMED CT codes: mapped to laboratory test names.

The medications are not coded due to the huge amount of available medications.

4) Archetypes

Archetypes are normative definitions providing reusable definitional artifacts which are aggregations of clinical concepts. While HL7 template is in flux at this time and the utilization of OCL, ADL, and OWL is complicate, in this template, the definition of archetypes is through the entry level constraints.

An example is the lab test order archetype described in metadata.

```
<ns1:labOnDischarge>
  <ns1:section>
    <code code="11502-2" codeSystem="2.16.840.1.113883.6.1"
codeSystemName="LOINC" />
    <ns1:title>Relevant Lab Data on Discharge</ns1:title>
    <ns1:entry>
      <ns1:entryChoice>
        <ns1:Observation>
          <code code="" codeSystem="2.16.840.1.113883.6.96"
codeSystemName="SNOMED CT" displayName="" />
          <ns1:effectiveTime value=""></ns1:effectiveTime>
          <ns1:value value="" unit="">
            <ns1:low value=""></ns1:low>
            <ns1:high value=""></ns1:high>
          </ns1:value>
        </ns1:Observation>
      </ns1:entryChoice>
    </ns1:entry>
  </ns1:section>
</ns1:labOnDischarge>
```

5) Teaching functions

- Template Help including Discharge Summary guidelines and how-to examples are available in each section.
- Archetypes can guide users to enter complete and pertinent data.
- For narrative sections, essential data are prompted. For instance, in the Family History section, the template prompts the input should be composed of subject, relationship with the patient, disease name, the date on site, severity, treatment, etc.
- The input can be validated against the data type to assure the correct data format and to improve the validity of input.
- A brief MS InfoPath Help is available at the work panel.

6) Other functions

- Look-up tables: for codes and names of diagnosis and lab tests, users can either double click to choose from the look-up tables or type in.
- CKD stage calculation: when users input sex and creatinine of the patient, Glomerular Filtration Rate (GFR) is calculated. Based on the score of GFR, the CKD stage is put into the discharge summary automatically.
- Copying Medications on Admission to Medications on Discharge: user input time is reduced by clicking a button.

3.5.6 Test

Test is not within the internship scope, but it is described in the study protocol.

The template will be tested to verify if it helps to produce a better discharge summary than one generated by the traditional telephone dictation. The scoring scheme developed by the Medical Education at Dalhousie University is used to score discharge summary.

- 1) A standard clinical case will be used as the testing case.
- 2) Residents at the Nephrology Ward will dictate a summary using the clinical case.
- 3) Then, residents will complete a discharge summary on the same clinical case using this teaching template.
- 4) A third party individual will score each of the summaries against the scoring scheme. Each resident involved in testing the template will receive written feedback on his/her performance.
- 5) Refine the template according to feedback from physicians and students.
- 6) Ongoing evaluation.

This would be a with-in subject design which could introduce the carry-off effect that may harm internal validate. When students fill in a discharge summary with the aid of the template, they might benefit from rethinking, since it is the second time for them to work on the same case. It is possible to setup a control group and ask them to work on the same case twice, both without the aid of the template. If the difference between the difference of the first and second results of the control group and difference of the first and second results of the treatment group which uses the template is significant, we could have more confidence that this template does have significant effect on the quality of discharge summary.

Also, the narrative content implies subjective material. Different physicians may give the same content different comments. This could be a potential problem of reliability for this test.

4. Conclusion

Standardization is crucial in today's health care system for the purpose of interoperability. Health Informatics can facilitate the procedure of standardization. Both the two internship objectives involved some extent of standardization implementation.

Encoding lab tests into multiple code systems make medical terms standardized and exchangeable. It reveals how the most basic datum of medical concepts is organized and related to each other in a common ontology. SNOMED CT is the most complete terminology while UMLS is attempting to aggregate several major terminologies in one frame. The so-called realist ontology is important for mapping among different coding systems and detecting errors of a coding system.

The HL7 CDA R2 compatible Discharge Summary teaching template works as a boundary object between physicians, residents, and health informaticians. It bridges the knowledge gap and transforms medical concepts into standardized forms.

Object-oriented archetypes-template design allows domain empowerment. Medical experts can contribute their knowledge to health informatics directly through archetype and templates. IT professionals can focus on the IT implementation that is independent of the declaration of archetypes and templates. Then, reuse of archetypes and templates will occur spontaneously.

Given that both the HL7 CDA and template/archetype are still in the research stage, their implementation specifications are volatile. The idea of the design methodology presented in this paper is to persist to the development track of HL7 CDA and template/archetype while improvizing some practical methods to accelerate the design. For example, the specification of archetypes is compatible with the principles of HL7 archetypes, but is implemented in a simplified way.

5. Recommendations

A powerful Discharge Summary teaching template relies on and nests in a sophisticated health informatics architecture, for example, HER. Close cooperation among health care professionals and health informatics providers are critical for the success of a template.

It is important for health care professionals and health informatics providers to agree on terminologies to use for the purpose of standardizing representations of medical concepts and facilitating interoperability. This process would better give consideration to the terminologies accepted by HL7 standard, such as UMLS and SNOMED CT.

Terminology services, such as the Apelon Terminology Service and UMLS Knowledge Server, could be linked to this template, so users could quickly select the canonical terms and codes and refer to the UMLS Semantic Network for references of the relationships among concepts.

The template and archetypes can be refined by defining if-then patterns to help users with pathology. Here is an example from [11]:

```
If ((fieldOne is "X" or "Y") OR (fieldTwo is "ABC"))
then ((a nested act relationship under Observation is required) AND (fieldThree in the nested act has a
value of "A" or "B" or "C") AND (fieldThree in the nested act cannot be NULL))
```

Switching from MS InfoPath to web-based template would free future template development from the restrictions of MS InfoPath and facilitate user access.

To summarize, tracing and involving the development of HL7 standards can make this template benefit from the latest technologies. The object-oriented design method can facilitate reuse and accelerate the development.

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