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Addressing SNOMED CT Implementation Challenges Through Multi-disciplinary Collaboration

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Abstract

This article describes the challenges of implementing SNOMED CT into electronic clinical documentation systems for discharge summaries, synoptic operative notes and ambulatory documentation. Four significant implementation challenges were identified throughout these projects, which required collaboration between specialists across several disciplines to resolve. The challenges included: designing the graphical user interface for selecting SNOMED CT values, gathering and validating template specifications that use SNOMED CT subsets, handling SNOMED CT subsets and extensions, and, creating algorithms and the technological infrastructure to generate fast, meaningful, non-redundant search results. Our experiences suggest that, while the usage of SNOMED CT in tertiary care settings is promising, collaboration between specialists from multiple disciplines is needed to utilize their unique project management, data modeling, technical, and clinical skills in overcoming implementation challenges.

Keywords:

SNOMED CT, Electronic documentation, Synoptic notes and algorithm.

Introduction and Background

The Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) is an emergent data standard that provides the core clinical terminology for electronic health information systems and is endorsed by the International Health Terminology Standards Development Organization (IHTSDO) [1]. In the January 2009 release, SNOMED CT contained more than 350,000 concepts with unique meanings and formal logic-based definitions organized into hierarchies. [2] SNOMED CT was identified “as the most suitable choice of terminology for 24 priority clinical information groupings (or subdomains) of the core interoperable [Electronic Health Record (EHR)].” [2] With the demands to adopt EHRs across healthcare, it is increasingly important to implement SNOMED CT enabled information systems to facilitate interoperability between systems and allow consistent, reliable and comprehensive methods of capturing clinical information.[1,3]

This paper describes the implementation challenges faced when implementing SNOMED CT and the need for collaboration and expertise across several disciplines.

Methods

The University Health Network (UHN) is a tertiary care academic health centre comprised of three teaching hospitals in Toronto, Ontario. The Health Informatics Research and Medical Informatics departments at UHN have implemented SNOMED CT in several electronic documentation projects. The usage of SNOMED CT allows UHN to capture synoptic clinical data specific and adaptable enough to meet the complex needs of clinical documentation. It also provides the foundation for system interoperability with other SNOMED CT-enabled applications; it avoids the issues associated with retrospective mapping to SNOMED CT from a locally maintained vocabulary list [4]; it allows the capture of synoptic data in line with an international standard; it allows UHN to leverage future institutional benefits of the Cross-mapping mechanism to international classifications.

Electronic Discharge Summary

In 2006, SNOMED CT was used to capture diagnoses in the electronic discharge summary. The project focused on building a tool to address known discharge summary deficiencies and improve the continuity of care, clinician communication and accuracy of patient data.

Synoptic Operative Note for Ovarian Cancer

The ovarian cancer synoptic operative note uses SNOMED CT for modeling diagnosis, finding, tumour, and surgical procedure data, as part of the requirements set out by the Canadian Partnership Against Cancer Synoptic Reporting Tools Project. The goal of the project is to establish a shared national surgical outcomes database for ovarian cancer and other disease sites via pan-Canadian collaboration. [5]

Ambulatory Documentation Application

The ambulatory documentation application uses SNOMED CT to model diagnoses, physical exams, chief complaints, findings, procedures, and diagnostic tests. The application was built to provide four surgical clinics (General Surgery, Orthopedics, Plastics and Urology) with a method to document consultation and follow-up notes, reduce transcription volumes and improve access to usable electronic data for patient care, research and organizational planning.

Challenges

Creating an implementation of SNOMED CT that could leverage the comprehensiveness and hierarchy of the clinical terminology identified four significant challenges that required consultation and collaboration with specialists across a spectrum of disciplines:

1. *Designing the graphical user interface for selecting SNOMED CT values*: The graphical user interface (GUI) had to be simple, usable and intuitive. The complex relationship structures of SNOMED CT are not inherently simple to navigate.
2. *Gathering and validating template specifications that use SNOMED CT subsets*: SNOMED CT uses its subset mechanism to group meaningful concepts together. Collecting, mapping and validating the SNOMED CT terms requires additional work.
3. *Handling SNOMED CT subsets and extensions:* SNOMED CT uses its extension mechanism to allow the creation of terminology and subsets specific to local, national, or organizational needs that are missing in the core SNOMED CT content. [6]
4. *Creating algorithms and technological infrastructure for generating fast, meaningful, non-redundant search results:* GUI's involving search functionality required an effective method of navigating SNOMED CT's hierarchies to create fast and meaningful search results in real-time.

Results

Challenge 1: Designing the graphical user interface for selecting SNOMED CT values

Clinicians worked closely with the project teams to provide the functional and data requirements which directed the GUI design. Concerns were raised regarding delays to clinical workflow and the impact to medical practice. Designing a GUI that is simple, intuitive and fast-performing was difficult given the complexity of SNOMED CT. The intended clinical usage and user base of an implementation influenced the choice of interface; a multi-disciplinary application favoured a search-based interface while an application intended for a specific disease or medical specialty favoured clinically focused sets of checkboxes customized to the most common and clinically relevant options.

Electronic Discharge Summaries

To address the needs of multiple clinical services, a simple keyword-based search was implemented to select diagnoses. All disorder SNOMED CT values were copied to a local relational database for executing the search. The challenges encountered included:

1. The project and technical team initially lacked the expertise required to extract only disorder values from SNOMED CT.
2. Three iterations of the UI were required until users were satisfied with its ease of use; the interface required users to wait while the search was executed.
3. Users were frustrated with scrolling through a repetitive list of synonyms that potentially did not contain the desired search result.

34961 discharge summaries that had a value saved for most-responsible diagnosis have been created between September 2007 and October 14th 2009. In 15431 (44%) of these cases the user was able to find and select the appropriate SNOMED CT code using the basic keyword search. In 19530 (56%) of the cases the user entered free text to describe the diagnosis. Preliminary analysis showed that 50% of free text values actually had matching SNOMED CT terms, which suggested deficiencies with the GUI.

Synoptic Operative Note for Ovarian Cancer

Disease-specific subsets of SNOMED CT concepts were used to populate standard form fields such as radio buttons and checkboxes. Disadvantages of this design include:

1. Several iterations of the design were required to determine the ideal set of SNOMED CT values
2. Any clinical scenario not modeled by subset values is captured as free text.
3. Additional resources were needed to collect and map specifications specific for ovarian cancer to SNOMED CT.

260 operative note reports were created between June 2008 and October 2009. Data was entered using form fields encoded from SNOMED CT subsets a total of 8851 times. In 8572 (97%) of these occurrences, the user was able to select a synoptic SNOMED CT code; in 279 (3%) of these occurrences, the user was forced to enter free text.

Electronic Ambulatory Documentation

For this project, an interface which combines search functionality with SNOMED CT subset values was created. Developers created a web server at UHN that applications could query to search for SNOMED CT terms and subsets. This server implemented a faster, more intelligent search algorithm and real-time calculation of related concepts. For example, if a clinician indicates that bone tenderness was during a head exam, searching for a list of anatomical site options should give precedence to bones in the head. This project is currently in a pilot phase, and data completion rates could not yet be measured.

Challenge 2: Gathering and validating template specifications that use SNOMED CT subsets

The subset mechanism enables concepts to be grouped together for "a particular language, dialect, country, specialty, organization, user or context". [6] Existing, published subsets could not address the specificity requirements of our projects. Project analysts worked with clinicians to determine the desired template specifications and the associated mapped SNOMED CT values. For example, an analyst worked with gynecological oncologists to create lists of the procedures, diagnoses, findings and tumour locations relevant to ovarian cancer. These mappings required validation for semantic correctness by a SNOMED CT specialist.

Process Challenges

Collecting, mapping and validating the SNOMED CT terms was time-consuming and project timelines had to accommodate the additional work required. (Table 1) This process involved continual communication with clinicians to identify, refine and verify mappings.

Table 1-Summary of work to gather SNOMED CT Specifications

Project	Ovarian Cancer Operative Note	Ambulatory Documentation
# of analysts	1	5
# of subsets	38	138
# of mapped concepts	276	1254
# of work hours	50	480
# of incorrect mappings	34	65
% of incorrect mappings	12%	5%

Short forms used by clinicians were a frequent cause of incorrect ontological mapping. These short forms are meaningful to clinicians, but are ambiguous or lack specificity for others without medical experience. For example:

1. In orthopedics, the term "SLAP tear" is a short form for describing a tear to the labrum.
2. In ovarian cancer, the term "lesser sac" is a short form for describing the omental bursa. The term "left adnexa" is used to describe the left uterine adnexa, but it could also refer to the left ocular adnexa.

Challenge 3: Handling SNOMED CT subsets and extensions

Out of the 1530 concepts mapped, 211 terms were not found in the January 2009 release of SNOMED CT (Table 2). These were split primarily into two categories:

1. Terms that lacked a higher degree of detail. Example: "left femur" as opposed to solely "femur".
2. Terms that were extremely specific to a specialty or service such as "Surgical repair of facial fracture" or "Debulking of tumour for symptom relief".

SNOMED CT lacked the synonym preferred by UHN clinicians for 101 concepts. (Table 2) Examples include "ovarian cancer" instead of "cancer of the ovary", and "Abdominal ultrasound" instead of "Ultrasonography of abdomen".

Table 2-Summary of SNOMED CT mapping problems

Project	Ovarian Cancer Operative Note	Ambulatory Documentation
# of mapped concepts	276	1254
# of missing synonyms	43	58
% of missing synonyms	16%	5%
# of missing concepts	43	168
% of missing concepts	16%	13%

Supplemental codes beyond SNOMED CT can be created to capture these outliers by using the mechanisms of extension and post-coordination. Canada Health Infoway (CHI) is responsible for managing a pan-Canadian extension and submitting new concepts to be evaluated and incorporated into the SNOMED CT core content. This process results in a delay for new SNOMED CT concepts to be approved and included in future releases. For project timelines it was essential to implement a form of local extension mechanism and to not be dependent on the approval process. Designing a local mechanism required the following considerations:

1. The vocabulary specialist was required to validate against adding semantically incorrect, ambiguous or poorly defined synonyms and concepts to the extension.
2. Local extension data had to be represented in a format that could be searched using the same mechanism for core content, and later mapped back to assigned ID's in the pan-Canadian extension and core dataset.
3. A liaison must be appointed to work with standards bodies and working groups, to manage submissions for new content and extension requests.

Challenge 4: Creating algorithms and technological infrastructure for generating fast, meaningful, non-redundant search results

SNOMED CT provides sets of pre-generated indexes to improve the speed of searches. Much like the index in the back of a book, indexes provide shortcuts to the desired SNOMED CT concept. The indexing mechanisms provided with SNOMED CT were implemented, but still yielded unwieldy search results. A keyword-based search for "Pain" returns 3790 results in the January 2009 release. Of the 1280 terms that are current and in a clinician-readable format, 465 are situations, procedures or therapies and are not semantically compatible to be selected as a "symptom". The remaining 815 terms require additional refinement to present an appropriate list of search results. Development of search algorithms with the following capabilities was required:

- Terms relevant to a specialty and more frequently used would appear higher in the search results.
- Unnecessary synonyms would be hidden.
- A search could be limited to terms that fall under a certain classification.
- The above search capabilities would also apply to concepts and relationships from the local extension
- Search capabilities had to be fast and efficient.

Search Algorithms

A technical specialist with experience in numerical methods and algorithm analysis was required to design a search algorithm that could perform well in a multi-user environment.

To search a specific classification the algorithms must traverse SNOMED CT's structures to locate concepts that are linked by 1 or more "is a" relationships. The "is a" relationship defines a concept's ontology relative to its parent concepts. For example, liposuction is a "cosmetic surgery (procedure)", and cosmetic surgery is a "surgical procedure". Therefore, a searching algorithm can start at the concept for "surgical procedure" recursively query all its child concepts and its child concepts' children. Benchmarks showed that this approach was too slow.

To address searching performance all possible inferred relationships were pre-generated. The collection of these relationships is called the *transitive closure*. Figure 1b illustrates the additional relationships that would be stored in addition to the relationships in Figure 1a.

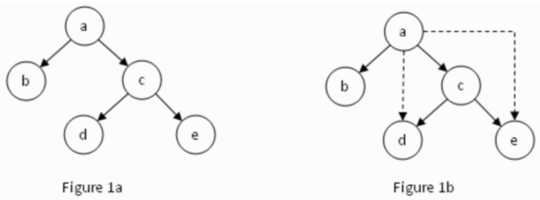

Figure 1 – Transitive Closure Illustration

Several attempts were required to successfully generate the transitive closure. The number of "is a" relationships ballooned to over 5,000,000. Further benchmarking demonstrated that the search response time using transitive closure remained constant no matter the number of child concepts.

IT Infrastructure

Search performance on the terminology server depends on factors such as network traffic and server load. IT specialists were consulted to optimize the performance of the terminology server using load balancing and database optimization.

Considerations

Further analysis and evaluation of the evolution of an ideal process for implementing SNOMED CT is necessary. Additional usability testing and analysis of data completion would assist in identifying the ideal GUI for SNOMED CT integration. Search algorithms can be improved with the help of computer experts. Institutional hardware and budgetary constraints must always be considered. The Electronic Ambulatory Documentation project requires further analysis to determine the effectiveness of the intelligent search algorithms.

Few studies have analyzed the impact that SNOMED CT changes have on clinical applications already in use or those undergoing implementation. [7] Challenges remain when integrating SNOMED CT standards into existing clinical information systems and the continued use of these standards in future EHR systems.[8]

Conclusion

SNOMED CT's comprehensiveness and tree-based data structures created a variety of implementation and resource challenges. Specialists from multiple disciplines had to be consulted for their specific project management, data modeling, technical, or clinical skills. The implementation process evolved and identified the need for several roles and skills. Table 3 identifies the roles and skill sets that were used for SNOMED CT integration across the three projects.

Table 3-Roles and skills required for SNOMED CT Integration

Role	Skills
Clinicians	• Clinical Knowledge for application design • Evaluate effectiveness and clinical value of application
Project Management	• Manage collaboration between disciplines • Facilitate communication between standards organizations • Evaluate clinical requirements, gather specifications and map terms to SNOMED CT codes
SNOMED CT data vocabulary	• Validate SNOMED CT code mapping • SNOMED CT data modeling experience for validating extension data • Train project team in SNOMED CT
Usability	• Usability testing • GUI design
Computer Science	• Improve and evaluate performance of search algorithms and data structures
Information technology	• Load balancing of servers • Database optimization

Figure 2 demonstrates the knowledge transfer required between the various roles involved.

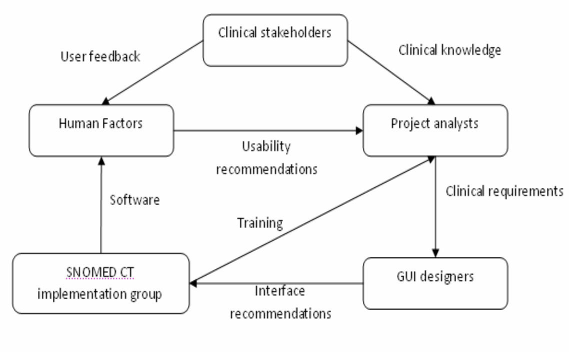

Figure 2 - Knowledge transfer between roles

Through the challenges presented in these various projects, an implementation process was established that helped our teams create working implementations of clinical documentation software that used SNOMED CT to encode data:

1. Project analysts worked with clinicians to obtain requirements for content, synoptic terms, and application workflow.
2. Project analysts and GUI designers collaborated to evaluate clinical requirements and design the appropriate interface.
3. The SNOMED CT implementation group developed the technical implementation and worked with project analysts to map values to SNOMED CT concepts.
4. When available, human factors engineers evaluated application usability at the Centre for Global eHealth Innovation in Toronto. Feedback was evaluated, and incorporated into the application design.

With additional future collaboration, experiences from other SNOMED CT implementations will only improve this process further.

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