A Step Toward Structured Representation of Clinical Alerts within an Enterprise Knowledge Management System

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Introduction

Modern Clinical Decision Support (CDS) applications are crucial components of enterprise Electronic Medical Record (EMR) systems serving as a platform for managing patient data and improving healthcare delivery, while decreasing clinical errors and adverse events. CDS tools, such as clinical alerts, can intelligently filter information to enable healthcare providers with patient-specific recommendations, including warning on duplicative procedures and medications as well as providing order validation and alternative treatment to help improve the delivery of care. However, best practice clinical alerts, are subject to numerous changes as they are regularly maintained to keep up with new clinical and research findings. Furthermore, manual cataloguing and maintaining those alerts in encoded format impose a major challenge. Therefore, it is highly desirable to create and maintain a structured catalog of best practice clinical alerts bound to standard terminologies to facilitate access, discovery and life-cycle driven maintenance in a dedicated enterprise knowledge management system.1

At Vanderbilt University Medical Center, our legacy clinical best practice alert glossary has been recently migrated to a new EMR system with currently no dedicated catalog for them within the enterprise EMR system. A clinical alert consists of a description for the intended usage as well as optional group (or groups) of related components such as diagnosis, medication, or procedure. For example, the “CAD or MI DX Recommended Antiplatelet Therapy” alert consist of two diagnosis components (“HX Coronary Artery Disease”, “HX Myocardial Infarction”) and one medication component (“General Antiplatelet”). Our vendor-supplied EMR CDS content curation tools lack some sophisticated content management features, which would’ve expedited content delivery. We hypothesized that by analyzing display names and description of clinical alerts through natural language processing methods, we could annotate them with structured and coded concepts relevant to diseases, medications, and procedures semantic concept types and ultimately help optimize classification, retrieval, update, and maintenance of such CDS knowledge assets.

Methods

The display name of all clinical alerts (n=313) together with their textual descriptions (n=234) were analyzed through a Natural Language Processing (NLP) pipeline with pre and post processing components wrapped around MetaMap2.

Figure 1. Classification of clinical alerts by disease and medication in the NCBO OntoPortal environment

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For example, analyzing the display name and description of “CAD and No Antiplatelets” by NLP exposes coded concepts such as “Coronary Artery Disease” [UMLS C1956346], “Antiplatelet Medications” [UMLS C1704311], and “Antiplatelet Therapy” [UMLS C1096021]. Unified Medical Language System (UMLS) Concept Unique Identifiers (CUIs) was used both for classification and adding standards synonyms to the clinical alert catalog. We also leveraged a local instance of the National Center for Biomedical Ontologies OntoPortal environment to visually represent classification of clinical alerts under International Classification of Diseases Clinical Modification (ICD10CM) and Anatomical Therapeutic Chemical (ATC) Classification terminologies (v2018). Based on the identified CUIs from NLP output and equivalent matches in those terminologies, we were able to automatically classify clinical alerts under ICD10CM and ATC hierarchies. A sample clinical alert classification is shown in Figure 1. For standard synonym retrieval from UMLS knowledge base (v2018AB), the query output was limited to preferred names excluding fully specified names, plurals, prefixes and suffixes bound in parenthesis. The NLP pipeline output was also limited to three UMLS semantic groups (Disorders, Medications, Procedures) and MetaMap evaluation score threshold of 580. Results were validated against a manually annotated gold standard and precision, recall, and F-measures were calculated.

Results

Approximately 70% of clinical alerts in our catalog were mapped to at least one disease or medication concept. Six clinical alerts didn’t generate any NLP result. Figure 2 shows the distribution of semantic groups from the NLP output. Using extracted CUIs, 56% of the alerts were classified under ICD10CM and 50% by ATC terminologies. The average number of identified concepts and synonyms by NLP for each alert was 2.8 and 13.4 respectively. NLP performance achieved high precision, recall, and F-measure (94%, 96% and 95% respectively), partly due to the existing fine-tuned pre and post-processing filters for CUIs known to cause false positives from other studies.

Discussion

Creating a structured catalogue for clinical alerts and binding them to standard terminologies is a critical step in enabling efficient development and maintenance of knowledge assets used in clinical applications with EMR systems, as it facilitates execution-time functionality ranging from addressing patient safety concerns, such as medication order deduplication to helping with provider frustration through easier EMR navigation. Such enrichment is best performed in dedicated knowledge management systems (KMS), preferably with extensions to support content and functionality specific to the clinical domain (e.g. clinical terminologies, EMR-specific content loaders). The aforementioned benefits of a structured catalogue of alerts can be obtained by the use of design-time features of typical KMSs, including formal knowledge representation, versioning, life-cycle management, and metadata enrichment. These ultimately increase efficiency of content curation by aiding update, review, and analytic processes.

We are evaluating the initial data from this study to quantify the time saved from preventing duplicative effort by using a structured catalogue in order to enhance the overall discovery and maintenance processes. Semantic enrichment of clinical alert names with standard terms from terminologies will enable our knowledge engineers to quickly search, find, and review relevant content. We are also considering using such codes for classification and validation of alerts by relevant order sets, patient diagnosis, and integration with other structured components captured elsewhere in the EMR system such as patient problem list. Such linkage of alerts would allow them to be viewed in context of other CDS assets, which enables the optimization of CDS coverage, as in different CDS assets and types (e.g. order sets, calculators, patient handouts) working in tandem to achieve the desired holistic care.

References: