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# INTEGRATING CMAPS INTO THE EMR: USING CMAPS TO IMPROVE QUALITY AND PRODUCTIVITY IN CLINICAL DOCUMENTATION SYSTEMS IMPLEMENTATION AND MAINTENANCE

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**Abstract.** Building the content necessary to create and operate an EMR (electronic medical record) is a complicated and time consuming process. An EMR's usefulness is totally dependent on the content that was initially loaded and then continually updated. This process is usually very involved due to the variety of programs necessary to operate the EMR. Typically, an EMR needs content built for the nursing staff to record the vital signs and the patient's preliminary and presenting problem's history, the physician's history and exam questions, the orders necessary to load the CPOE system, the order steps needed to manage the patient workflow, and the aftercare instructions necessary for the patients to care for themselves when they leave the medical facility. These are not all of the content areas in an EMR, but they are the ones that require the most involvement of content experts such as the physicians and nursing staff. To reduce the amount of time needed to build and maintain the EMR and the amount of staff needed to support the content in the EMR; this paper describes how one company uses Cmaps to load some of the content into its EMR.

## 1 Research Initiative

One of the commonly accepted approaches to conceptualizing the information access and use in a clinical encounter has the acronym SOAP, which describes a process of Subjective evidence collection, Objective evidence collection, evidence Assessment and diagnostic and interventional treatment Plan. For example, an encounter may consider such evidence at a single point in time or over a period of time and may look at trends, clusters and other data relationships. Generally a clinician will use evidence and the assessment process to hypothesize a diagnosis to explain the evidence and to provide an organizing principle on which to base planning. This information use process has been described as medical reasoning (Patel, V. L., Arocha, J. F., & Zhang, J. 2004).

The evidence collection process is iterative and continues as new information is discovered or acquired. The collection continues until sufficient information has been acquired to confirm a diagnosis and/or disconfirm alternative diagnoses and complete the planning process appropriate to the current encounter. Evidence collection may continuously change the prognosis and planning process.

Paper notes have traditionally been idiosyncratic and quite personal because their purpose was to assist in recalling details of a patient encounter or to act as a reminder for a subsequent patient encounter. A substantial portion of the content has been implicit, contextual and many clinicians have developed personal shorthand systems to streamline record keeping. Relevance judgments during encounters have affected the quantity and quality of information recorded.

A paper note can easily be scanned and converted into a digitized medical record, but such scanned documents require a human to read and interpret the clinical notes. Dictation and transcription can similarly be used to create a digitized medical record. In both cases it is common to have professional coders evaluate medical records and mark-up encounters with the diagnosis and procedure codes required by payers. Metadata annotation and some structured information capture can contribute to retrieval and machine billing, but such record systems are not particularly semantically interoperable and they do not enable the computer to be leveraged to improve clinician productivity.

Fundamental to semantic interoperability between and among users is a common language, format and method for documenting encounters so that they can be easily read and used by other clinicians. Using natural language as a model, clinicians must agree upon a vocabulary, a syntax and grammar for constructing well formed clinical statements and defining organizing principles that can be used to structure, sequence and extract relevant portions of

clinical documents. While there are many initiatives actively seeking to develop such standards and many vendors that have developed structured information templates, the match between user needs and available off-the-shelf solutions has not been sufficient to motivate widespread clinician adoption.

In many cases clinicians need to specify their own requirements to meet the unique needs of their clinical practice. This specification process has traditionally required engineers to develop requirements specifications that are used to develop operational software or to modify vendor templates. This approach presents both economic and quality challenges. The intermediation process in which a knowledge engineer works with a clinical content expert to specify requirements is cumbersome and can be error prone. The knowledge requirements of clinical specialties requires clinical specialists to define their terms and to specify how they organize knowledge to document relevant information that can be used to communicate observations, measurements, signs, symptoms, diagnoses, prognoses and plans.

Accessibility and legibility seem to be the principal values sought from digitized medical records. Accessibility can be achieved with scanned charts even if those charts are not universally legible. Legibility can be achieved in a variety of ways, including dictation and transcription; however, to achieve communication of information between and among users requires that the information have the same meaning to each user. The ability to contribute to user productivity by summarizing or processing information to enable statistical analysis, quality reporting, translational research, etc., requires semantic interoperability and an information organization and representation that facilitate automated computation.

The development of detailed clinical models is in its infancy. The meaningful use requirements of the US Department of Health and Human Services are limited to the complexity typical of recording vital signs and calculating body-mass indices. In some clinical situations an observation that includes a finding and finding site may be sufficient, but if the finding involves contingent components, the rules for formulating a complete and correct clinical statement can become complex. For example, while a simple blood pressure measurement may consist of two pressure observations, one systolic and one diastolic, a more complex situation might be described by the Cmap in Figure 1.

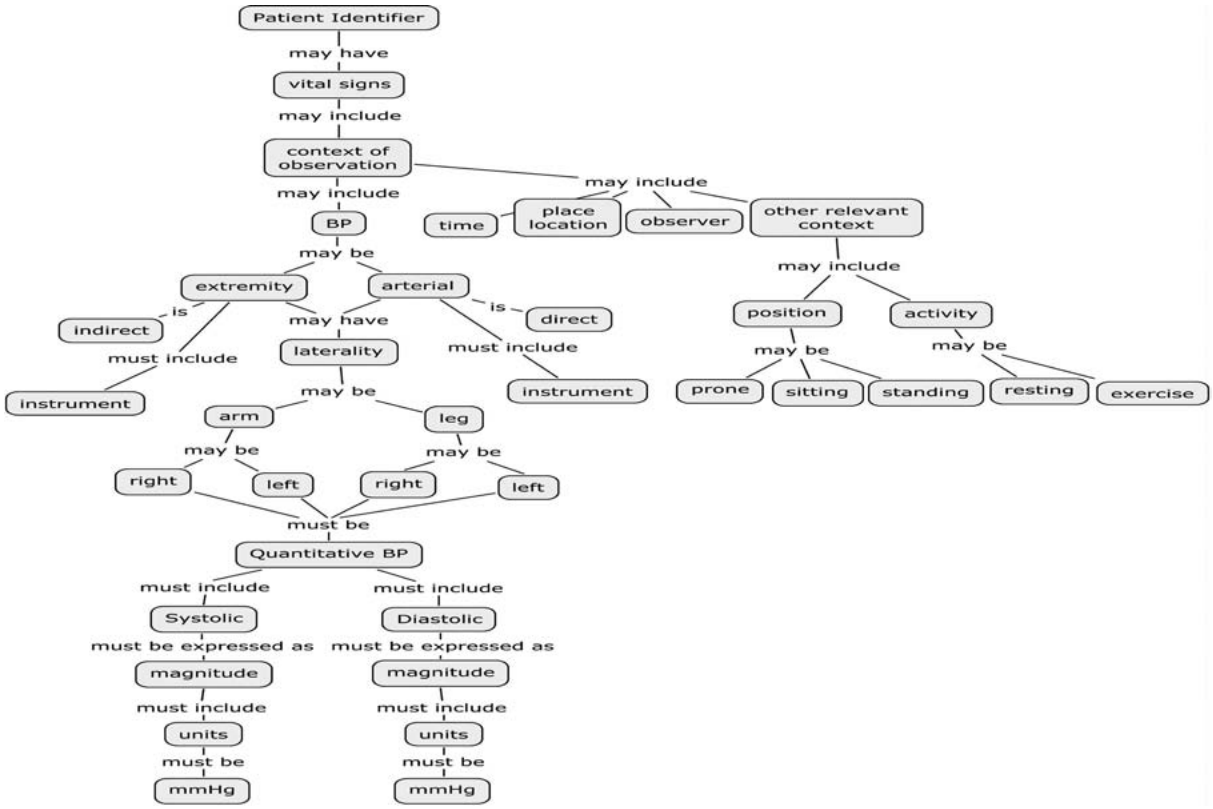


**Figure 1.** Complex Blood Pressure Description Model

To pragmatically involve clinicians in developing useful, detailed clinical models to use in recoding and communicating clinical encounter information requires functionality to convert the models and implement the modeling results directly into an electronic medical record system that can be used for clinical encounter record keeping. The modeling and development of a specialty vocabulary, such as the American Academy of Ophthalmology SNOMED-CT subset, without a mechanism to directly implement and use it in a functional EMR, limits that model's pragmatic usefulness to the annotation of documents, such as the Basic Science course for ophthalmology residents. To overcome this limitation, a predominately automated process is required to translate detailed clinical models into useful EMR templates. We propose the use of Cmaps for the specification of detailed clinical models of specialty and subspecialty medical knowledge and, working with MedTrak Systems, Inc., have developed and demonstrated a conversion process that enables the Cmaps to be predominately automatically used to drive a production EMR system.

## 2 Description of the Approach/Solution

The traditional approach to software development consists of a series of successive hurdles. At the beginning is a requirements specification process. This process typically involves engineers interviewing users to ascertain the user's needs. Inherent in the interview and specification process is the translation of those users' needs. During the software engineering process the users' needs are captured and then expressed in the language of a technical expert. This process can introduce miscommunication and misunderstanding. A software quality process typically includes a verification step that seeks to test or evaluate the coherence between the requirement specifications and the users' needs. Verification may identify errors in capture, translation, specification, etc., but when the process is not under the users' direct control; it is possible that a difference may remain between the semantic intentions and assumptions of a user and the expressions of an engineer.

The traditional approaches to system development have been both costly and cumbersome and frequently result in continual incremental improvements that may or may not ever resolve into a "finished" solution particularly in the presence of a continuously evolving situation like medical science. In most clinical situations finding a meeting time that is convenient to a clinician with daily patient loads and the right software engineer adds to the cost, effort and difficulty. There are clearly situations where specific skill sets help bridge the discipline gaps between medicine and computer science, but more typically clinicians have limited intimate experience with computer systems and computer experts have no formal training in medicine. Anything implicit or ambiguous can be "the enemy of the good".

Cmaps present a tool that can enable a clinician to describe a clinical situation, information requirement, process, workflow, EMR template, etc., by defining concepts and connecting them with relationships under their own control with the guidance or aid of an information scientist or computer scientist facilitator. In an EMR, the goal is to capture the clinical evidence, diagnostic inferences, diagnostic and interventional treatment plans in a way that places each element in an appropriate context for understanding and use. In conjunction with a facilitator, to probe and assist in eliciting concepts and relationships, we have found that clinicians are quite capable of explicitly expressing their information requirements directly in Cmaps.

The result of the requirements elicitation process is a clean specification expressed in a computable form. The four critical elements to understanding the information requirements and their interrelationships in an EMR template are: (1) concepts, (2) relationships, (3) logical propositions and (4) template outline. These can be used directly to write rules that drive the information capture and display processes in a production EMR.

## 3 Results

The Washington National Eye Center has developed and refined a number of Cmaps focused specifically on the field of ophthalmology. This work has demonstrated the advantage of enabling an expert to directly manipulate a tool to express their expertise in the form of logical propositions. Working with a number of ophthalmologists, a collection of Cmaps was developed to describe the evidence collected during an ophthalmic examination. For example, a tear film Cmap required 75 propositions. The decision to begin by mapping measurements and observations was selected to enable later development of clinical decision support Cmaps using the described clinical observations, measurements and findings.

The complexity of clinical description is substantial. In the case of a Lens Cmap, approximately 180 propositions were required to describe the observations, measurements and findings related to an ocular lens. While that number of propositions cannot be easily viewed on a single page Cmap, the network of concepts and relationships can be navigated using Cmap Tools and the complexity of that system of propositions can be converted into a structured checklist that can capture the elements of evidence necessary to describe a patient's lens.

One specific complex lens statement that can be extracted by selecting a leaf node and its suptree consists of 36 propositions that describe both the characteristics of the observation and the organizing principles associated with contextualizing an observation. That specific statement may be used to describe either an OD (Right) or OS (Left) lens specification in which a patient might have an intraocular lens with fixation in the posterior chamber which is described as a capsular haptic fixation involving a single haptic (lens fixation element) suspended in a meridional orientation that is temporally oblique. This example includes both evidentiary elements and organizing principles. It requires 13 conceptual levels connected by relationships to diagram. In this particular example, the relationships are used to convey whether the next lower tier of concepts must or may include specific alternatives. For example, a haptic fixation may include capsular, sulcus or suture fixation types of "haptic fixations." In our experience in clinical modeling, a conceptual level may require the inclusion of multiple elements or types at each level of specificity. This can result in a clinical statement composed of many interacting descriptive propositions.

MedTrak Systems, Inc. has developed an automatic conversion of Cmaps into EMR templates for building physician checklists for problem focused history and exam questions, nursing assessments and flowsheets, orders workflow steps, patient aftercare instructions, and care pathways for inter-disciplinary care. Figure 2 is a partial screen example of an information structure that MedTrak converted to address the capture of a blood pressure as described by the Cmap in Figure 1.

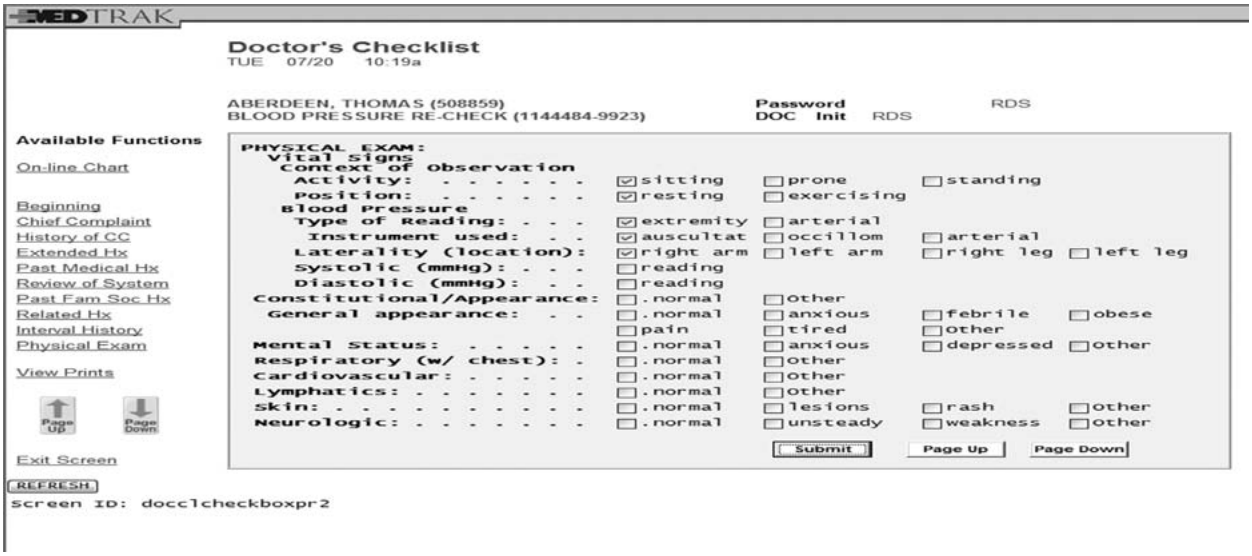


**Figure 2.** MedTrak Systems, Inc. point-of-care EMR Blood Pressure Template

## References


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