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Representing Clinical Practice Guidelines with Declarative Programming

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ABSTRACT

Clinical practice guidelines (CPG) describe recommended actions for diagnosis and treatment of various patient conditions. These guidelines are most often presented in a narrative form, requiring time from a physician's already busy schedule and careful study, considering the guidelines may contain poor organization and lack clear, descriptive evidence for recommendations. Too often, this means that the information provided by guideline authors is ignored in clinical practice. Over the past few decades, much effort has gone into translating clinical practice guidelines into clinical-decision support systems to make guideline information more accessible and improve physician-patient interactions.

To contribute to physicians' accessibility of guideline information, we attempted to develop a methodology to represent clinical practice guidelines as computer-implementable guidelines (CIG) with declarative programming. There are many obstacles in this implementation, such as underspecified conditions for recommendations, lack of knowledge and consensus in several areas, and heavy use of ambiguous terms. We report the measures we took to counter each of these issues, which allowed us to ultimately produce several models that could serve as computer-implementable guidelines for use in clinical practice. Through close analysis of our guideline implementation process, we hope to recognize patterns of knowledge and issues in the medical domain that will ease future clinical practice guideline implementation.

Figure 1 [1]

> Previous disease or treatments involving the neck (head and neck irradiation during childhood), recent pregnancy, and rapidity of onset and rate of growth of the neck swelling should be documented. Presence of thyroid nodules during childhood and adolescence should induce caution because the malignancy rate is 3- to 4-fold higher than in adult patients (15). The risk of thyroid cancer is also higher in older persons and in men (3,9).

Figure 2 [1]

> Thyroid nodules are a common clinical finding, with an estimated prevalence on the basis of palpation that ranges from 3% to 7% (1,2). The prevalence of clinically inapparent thyroid nodules is estimated with US at 20% to 76% in the general population, with a prevalence similar to that reported from autopsy data (3-5). Moreover, 20% to

KNOWLEDGE SPECIFICATION

The first step in developing the computer-interpretable guideline was obtaining the essential information from the clinical practice guideline. All extracted statements either expressed some recommendation or described a connection between pieces of knowledge (Figure 1). In addition, each statement was accompanied by any associated questions or notes of ambiguity. By doing this, we were able to create a clear set of information that highlighted issues we needed to address while also removing insignificant statements and medical jargon (Figure 2). The subsequent clarification process later helped to define challenges in modeling and representation.

It should be noted that the project members' lack of medical experience hindered comprehensive understanding of the CPG. To combat this, we attempted to structure the extracted knowledge by grouping the indications, contraindications, and results of each procedure described by the clinical practice guidelines. This reorganization and processing of knowledge provided a better understanding of the knowledge itself.

CLASSIFICATION OF ISSUES

To identify patterns in the specification process, we developed several categories to encompass the issues we observed:

Category	Brief Description
Ambiguity / Vagueness / Underspecification	Ambiguous medical terminology, vague adjectives (ex. "young"), underspecified patient conditions
Implications of Facts / Fact Versus Recommendation	Determination of whether facts can be reasoned with to suggest an action when an explicit recommendation is not made
Discordant Emphasis	Variation in individuals' background, goals, and interpretations affects what knowledge is considered, extracted, and questioned
Inexplicit Connections Between Knowledge	Recognition of implied relationships between statements versus using only explicit connections given in the documentation
Incomplete Knowledge Base	Not all information needed for comprehensive understanding is stated explicitly
Contradictions	Independent statements within the guidelines directly conflict with one another

Each category was addressed with a variety of tactics including group meetings, consultation with physicians, flowcharts, extensive analysis of relationships between statements, verified patient scenarios, and more.

Figure 3

> Given a history of observations and actions, how has the state of the patient changed over time and what conclusions can we make?
>
> a. Based on a limited set of knowledge from the current work-up, what final diagnosis of the nodule have been ruled out and which are more likely?
> b. Based on the known characteristics, is the nodule suspect of being more benign or malignant?
> c. Can we exclude malignancy based on the diagnostics so far?
> d. At some point in diagnosis, should we continue testing or move on to treatment?
> e. What diagnosis are suspect at some point?
> f. Which class categorization is most likely based on any amount of evidence?

MODELING

Preparatory Tasks and Scenarios

We developed a list of tasks the computer-implementable guideline should perform, confirming the usefulness of each with a physician. These tasks provided a fixed understanding of our model expectations.

Conceptual Challenges

Despite our groundwork with the clinical practice guidelines, there were still multiple challenges in modeling such as the configuration of procedures, results, and recommendations and the ability to connect related knowledge.

One of the more interesting phenomena we came across was contriving a system to categorize and represent the reasoning behind a recommendation. The most obvious solution would be directly quoting the guidelines as literals, but the result of such organization would be an overwhelming amount of unrelated information as well as an inability to prioritize certain recommendations. We also considered probabilistic reasoning, but the guidelines lacked the necessary knowledge for this method of representation. Our current proposals for representation are given in Figure 4.

Discussion

We've developed working models of the clinical practice guidelines, but have continued exploring patterns in health care to determine better methods of representation. Our goal is to take advantage of declarative programming and its ability to respond to patient and physician questions.

Figure 4

Short Summaries of Concepts for Reasoning
Higher level reasons consist of {for basic testing, to determine initial hypothesis, to eliminate possible conditions, to determine further course of action}. Lower level reasons are quotes from the guidelines.
Specific indications describe the exact conditions that dictate a recommendation be made. Nonspecific indications display general, related facts when relevant.
Reasoning classes are represented as factual, evidence, or opinion based. Goal classes consist of local availability, minimized risk, minimized cost, most critical information.
Reference physician-described recommendation grade (recommendation, provisional, consensus).
Rank recommendations by medical evidence grade (1-4) and use degree of certainty to determine a particular course of action.

CONCLUSIONS

Our research aims to improve clinical practice and patient experience in diagnosis and treatment through the understanding and accessibility of medical knowledge in clinical practice guidelines. We want to understand how a set of knowledge revolving around suggestion may be represented computationally as well as how our methods compare to what is already in use. We do not yet have a finalized methodology for specifying knowledge and modeling clinical practice guidelines, but we've developed a foundation for further study. Additional research is necessary to resolve some of the issues we've encountered and determine what structure of model and interface would be most effective and useful to physicians and patients.

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