Implementing a Hypertension Guideline in a Health Care Information System: Insights, Challenges and Implications

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We studied the implementation of a hypertension guideline in a computer-based health care information system (HCIS) of an ambulatory care practice, using a form-based approach. The study focused on the transformations made to the guideline in order to implement it and the reasons for the transformations. We also examined how the decision criteria and recommendations needed to be encoded in the HCIS. The narrative guideline, the practice setting, and the decision support functionality of the HCIS, all have implications for how guidelines are implemented. Such an analysis can help in developing more robust guideline representation models, to facilitate authoring of guidelines that can be readily implemented, in building more usable and effective software tools for implementing guidelines, and in creating more sensitive instruments for measuring compliance to guidelines. Experience with more guidelines in different settings is needed for a comprehensive understanding of the issues in guideline implementation.

INTRODUCTION

Clinical guidelines have the potential to standardize care, improve quality of care, and increase the cost-effectiveness of services that are provided [1]. However, the current model of dissemination and implementation of guidelines has certain shortcomings that limit compliance with guidelines [2, 3]. Guidelines are developed and published as narrative text documents. Guidelines in this form are non-interactive and cannot be accessed during the patient encounter. Nationally developed guidelines may often not be applicable to a patient or in a local care setting [4].

Implementation of guidelines as part of an HCIS has been found to improve compliance [5, 6]. These systems bring the guideline knowledge into the clinical workflow by providing the practitioner with patient-specific recommendations at the point-of-care.

Several factors may affect implementation of guideline-based decision support in the HCIS of a practice. For example, narrative guidelines often contain vaguely stated decision criteria and recommendations, which must be translated to precise computable expressions and actions. In other cases, nationally developed guidelines may contain recommendations that cannot be implemented in a practice because a resource (such as imaging equipment) may not be available locally. The recommendations need to be customized to local resources and practices.

In most of the HCISs in which guidelines have been implemented, this has been done in a proprietary, system-dependent and application-specific manner. This limits sharing and customization of guidelines.

Representation models and formats are been developed for computer-interpretable guidelines that are not HCIS-dependent and allow sharing of encoded guidelines [7, 8]. Yet guideline modeling environments tend to be developed in a top-down approach, based on (1) representation of knowledge in the narrative text guidelines; and (2) assumptions of the importance of features that are needed for the kinds of applications to be supported.

The development of a representation for shareable, computer-interpretable guidelines is hampered by lack of real world experience that identifies successful approaches and barriers to implementation of more globally developed guidelines within a local system environment. The bottom-up experience of attempting to implement guidelines in real-world systems can provide valuable feedback to developers of guideline formats and software tools for authoring and implementing guidelines.

Many issues encountered in implementing guidelines have been identified in the literature. One such issue is the availability of patient data in an encoded form and its impact on specificity of messages [9]. The functional capabilities of the HCIS such as providing event-driven decision support is another important factor [10]. Features of the narrative guidelines, such as the impreciseness in definitions of decision criteria and recommendations, makes translation into a computer environment difficult [11].

The study we undertook was aimed at furthering the understanding of modeling requirements by better understanding guideline implementation issues within an HCIS. We studied the implementation of a nationally developed hypertension guideline in an

HCIS using a form-based approach. The study focused on the transformations made to the guideline in order to implement it. Such an analysis should guide us in developing a more robust guideline representation format and needed software tools.

METHODS AND MATERIALS

Hypertension guideline

We were particularly interested in gaining understanding of the issues involved in integration in primary care of guidelines for chronic disease management. The implementation of chronic disease management guidelines has the potential to streamline relatively common activities where there is evidence of non-optimal use, considerable complexity, and a user community that is interested in approaches that simplify and improve quality, as well as facilitate practice workflow.

We implemented a hypertension guideline in Logician 5.4 (Medscape Corp., Hillsboro, OR), a commercially available EMR system. Hypertension is not adequately controlled in a large proportion of patients [12]. The sixth report of the Joint National Committee (JNC VI) on prevention, detection, evaluation, and treatment of high blood pressure (BP) provides a national standard for hypertension management [13]. We implemented the Institute for Clinical Systems Improvement (ICSI)'s guideline for hypertension [14] that is based on JNC VI recommendations.

Health Care Information System

Logician is a multi-user HCIS for an ambulatory practice. While this system does not include explicit support for implementing guidelines, it does provide tools that can be used for encoding guidelines. Of particular interest to this study, the system provides the capabilities to build custom encounter forms for data display and entry, to add user-defined fields and field values, and to program rules for clinical decision support. The encounter form components are modular and sharable with other Logician users. The decision support rules are encoded in a proprietary expression language.

Guideline implementation strategy

In implementing the guideline, the following three issues were considered:

1. Method for decision support to be triggered based on the recommendations of the guideline
2. Identification of documentation that needs to be performed in order to assess compliance to the guideline
3. How the above two should be incorporated into the normal workflow of the clinic

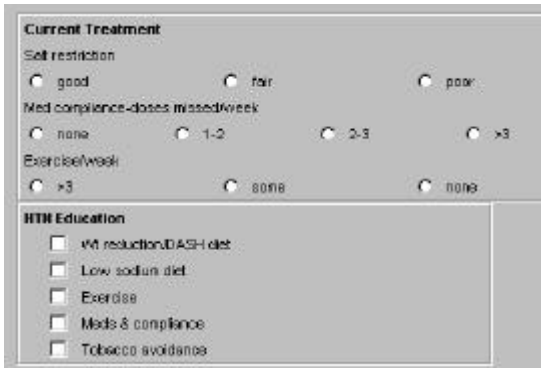

Figure 1. Screenshot of patient education and compliance assessment form for input by the nurse.

The hypertension guideline was implemented by two of the authors (SC and WS) building a set of five encounter forms and embedding within these forms recommendations that are dynamically generated by decision support rules. The providers can override any of the management recommendations provided by the decision support rules. The forms included those for education and evaluation by the nurse, evaluation by the physician, risk factor assessment, goal setting, and treatment.

The workflow was divided so that the nurse carried out the recommendations for education, compliance with lifestyle modification and their documentation (Figure 1). The nurse also entered the chief complaint and vital signs as needed by the guideline. The physicians used the other forms listed above.

Analysis of guideline implementation

The analysis of the guideline implementation centered on how the recommendations and the decision criteria in the ICSI guideline were implemented in the HCIS. This analysis was conducted by AB. We looked at whether decision criteria and recommendations in the narrative guideline were maintained or modified in the implementation in the HCIS. We also reviewed the reasons for the modification.

RESULTS

We classify the results of the analysis into two categories:

1. Adaptation or modification of guideline knowledge content
2. Integration of the guideline knowledge into the HCIS

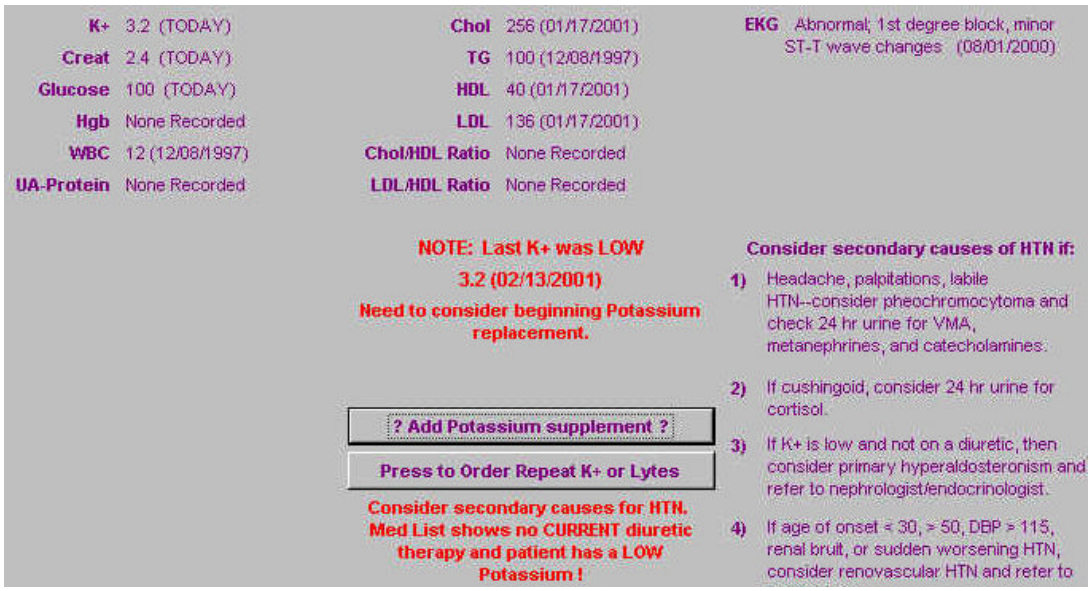

Figure 2. Form for evaluation of hypertensive patients. The top section of the form reviews the latest laboratory results. The lower section of the screen provides decision support. The recommendations on the right for secondary causes of hypertension are static and not specific to the patient. The other recommendations are patient-specific and dynamically generated from the guideline. Overdue or repeat tests can be ordered by clicking on the buttons.

Guideline knowledge modification

Refinement

Refinement is the specification of finer details that are not included in the guideline's recommendations. For example, the guideline recommends classes of drugs such as beta-blockers and diuretics. However, the HCIS provides decision support to the physician regarding the drug from that class that is available on the formulary of the patient's insurance. In another example, one of the ill-defined factors for cardiovascular risk stratification in this guideline is the presence of nephropathy. This decision criterion was defined to be true in this implementation if the patient's serum creatinine was elevated to 2.0 mg/dl or greater.

Deletion of a recommendation

The guideline recommends evaluation of a patient for aortic coarctation as a secondary cause of hypertension. This recommendation was removed since this is a rare diagnosis and not easy to determine from the observations usually encoded. The implementers preferred succinctness to comprehensiveness for the decision support. A recommendation for tapering of pharmaceutical treatment was also removed since the decision criterion required analyzing the trend of BP values, a functionality not supported in this system.

Modification of recommendations

The guideline distinguishes between BP measurements made in the office and outside the office. The implementation in the HCIS did not distinguish between these measurements because most physicians using the HCIS do not make this distinction.

According to the guideline, the diagnosis of hypertension should be made by averaging two or more BP readings made in the same visit. In the implementation, we let the physician pick the most *correct* BP reading. This was done because only the most recent value of BP is available to the decision support system from the EMR.

Integration of guideline knowledge into HCIS

In this section, we describe how the knowledge of the guideline had an impact on how it was implemented in the HCIS.

Generation of recommendations

The computability of the decision criterion had an impact on how a recommendation was implemented. If the criterion for making a recommendation was computable, then the recommendation was dynamically generated so it would only be provided when applicable to a patient. If a criterion could not be computed, then the associated recommendation was designed to be provided for all patients. For example, in Figure 2, the recommendation for referral to a nephrologist was specific to that patient and dynamically generated because the criterion of low serum potassium could be evaluated to true. In the same figure, the other recommendations for secondary causes of hypertension are always displayed for all

patients because the associated decision criteria could not be evaluated. These criteria may not be computable because the required data may not be encoded (Cushingoid features), or because the criterion may be vague (sudden worsening of hypertension).

Implementation of workflow

As described earlier, the guideline was implemented so that many of the recommendations for patient compliance, evaluation and education are performed by a nurse. Other recommendations for evaluation, assessment, and management were carried out by the physician. This distinction for workflow was not made in the narrative guideline. The tasks were assigned based on the usual workflow in the clinic.

Mapping of patient data

The decision criteria in the guideline require interpretation of patient data values. Thus references to patient data in the guideline must be mapped to entries in the EMR. This was straightforward for most data items including observations, laboratory results, diagnoses, and current medications. In some cases, one diagnosis in the guideline had to be mapped to more than one ICD-9 code (hypertension, diabetes). Some expressions required knowing the class to which the medication belonged, such as beta-blocker or diuretic. This functionality is available in Logician. In a few cases, the data required in an expression was not available in the EMR. Observation terms were added to the EMR to allow entry of these data.

Several of the metrics for assessing compliance to the guideline require documentation of the interventions, such as the education of patients on lifestyle adjustments. The documentation of these tasks was implemented by adding new fields to the EMR.

Linking recommendations to order entry

The usability of the decision support system and, perhaps, compliance with the guideline can be improved by providing links from recommendations to appropriate order entry screens. In the current version of the system, the ability to link to forms specific to the medication or laboratory test recommended was not available. Instead links were provided to the main order entry screens. A future version of the HCIS is expected to have the functionality to link to custom orders.

DISCUSSION

An analysis of how guidelines are implemented in an HCIS environment is useful for several purposes:

1. For the development of guideline representations
2. For development of new guidelines
3. For development of software tools to aid in implementing guidelines in HCISs
4. For evaluation of compliance with guidelines

Development of guideline representation formats

Our interest in this analysis was to enable us to enhance the GuideLine Interchange Format (GLIF), a language for the representation of sharable, computer-interpretable guidelines [8]. The development of GLIF has been primarily driven by the knowledge representation requirements of guidelines. An understanding of the issues involved in implementing guidelines in an HCIS will allow us to improve the GLIF representation for easier sharing of guidelines.

From this analysis, we could identify several different ways in which the guideline was adapted for implementation in this practice. We can design GLIF and the guideline authoring tools to allow easier adaptation of guidelines.

Development of software tools for implementing guidelines in HCISs

Software tools are being developed to assist in the implementation of guidelines in HCISs. One such tool, known as the guideline execution engine, interprets guidelines against patient data to provide recommendations specific to the patient. However, before that occurs, the guideline may be adapted locally and the patient data references in decision criteria must be mapped to entries in the EMR. The execution engine may need to support a workflow process with multiple users performing different tasks at different times. The execution model must also be robust to provide recommendations when the decision criteria are not clearly specified.

Development of new guidelines

For developers of guidelines, an analysis such as this can provide insights on how to write guidelines such that they can be implemented in the HCISs of their target users. The guideline documents can be written to be flexible to allow implementers room for local adaptation and can be specific in areas where precise interpretation of the recommendations and decision criteria are required.

Evaluation of compliance with guidelines

When measuring compliance with guidelines, it would be essential to recognize that the guideline may be adapted locally. The evaluation instruments must be adapted accordingly. Local adaptation of guidelines, while important for implementation, can raise questions about adherence to nationally developed standards of care. These issues can also be evaluated when measuring compliance with guidelines.

In interpreting results from compliance measurement studies, an understanding of the issues in guideline implementation can provide useful insights. For example, a vaguely worded decision criterion may lead to lower compliance if providers or the decision support tool cannot determine clearly to which patients the recommendation applies.

CONCLUSIONS

We studied the implementation of a hypertension guideline in an HCIS in order to improve the guideline representation format and the software tools for guideline authoring and execution that we have been developing. This analysis has provided us with useful insights in that direction. However, for a more comprehensive analysis, we need to study the implementation of many more guidelines in other EMR systems. We have studied the issues of adapting the guideline to one proprietary environment initially (Logician), because it is installed in our institutions (SC and WS), and because of its wide penetration in the ambulatory practice environment. For this study, we analyzed the implementation before the guidelines were used clinically. Getting feedback from the users and measures of compliance may tell us which implementation techniques worked well and which ones need more refinement.

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