Providing Multiple Views to Meet Physician Information Needs

Qing Zeng, James J. Cimino
Department of Medical Informatics
Columbia University, New York, New York
qzeng@dsg.harvard.edu
ciminoj@flux.cpmc.columbia.edu

Abstract
Browsing the entire electronic medical record of a patient can often be time consuming and inefficient. There is a great need for ways to organize and present views of clinical data that could satisfy physicians' information needs without overwhelming them with extraneous information. We carried out a study on the information needs of physicians during patient care to determine the types of views may best meet their needs. In the study, physician information needs in inpatient and outpatient settings were observed and classified. Our study showed that each type of view (time-, concept-, and source-oriented) is appropriate for certain situations, although there may not always be an advantage of one view over another in some situations. The findings confirmed our supposition that physicians need different types of views.

1. Introduction

Modern medical records are comprehensive documents that contain information such as patient medical history, hospital discharge summary, electrocardiogram (ECG), lab test, and X-ray report. The information is collected for clinical, legal, financial, and administrative purposes from many sources such as primary care doctors, pathologists and social workers.\(^1\)

While it is necessary to keep an extensive record of patient information, it is not always easy for physicians to retrieve information from the records.\(^2\)\(^3\) The amount of available data can overwhelm clinicians, making it hard for them to identify the desired information. In a survey conducted by Tange, retrieval of specific tests was considered by physicians to be a weak aspect of paper-based medical records, as significant as poor legibility.\(^4\) As electronic medical records (EMR) gradually replace paper charts, many problems of paper-based medical records were solved. However, the information overload problem still remains.

Although clinicians need access to the entire patient record, they often seek answers to specific questions and wish to browse certain subsets of data. We refer to these subsets as views. The problem of information overload can be eased by providing views that are specific to the tasks that motivated the clinicians to obtain patient information. For example, specially designed summary views of patient data were shown to be able to reduce the time consumed by medical decision making and improved the quality of the decisions.\(^5\)\(^6\)

Given a set of patient data, there exist many possible views. We classified the views into three major types based on how data are organized: time-oriented views (e.g. longitudinal history views), concept-oriented views (e.g. problem-oriented or organ system-oriented views) and source-oriented views (e.g. ancillary department views). [Figure 1] This classification is an extension of Dore's work, published in 1995.\(^7\)

We have designed and implemented a view generation system for use with the New York Presbyterian (NYPH) EMR system that is capable of generating all three major types of views. One of the under-lying hypotheses for developing such a system is that different types of views are needed to satisfy the diverse information needs of physicians in clinical practice. In order to validate this hypothesis, a study was undertaken regarding the information needs of physicians and which views would be appropriate for which type of needs.
2. **Background**

2.1. The NYPH multiple view generation system

The view generation system was created to generate patient-specific concept-oriented views as well as source-oriented and time-oriented views for clinical data. [Figure 2, 3, 4] The source of clinical data is the central clinical data repository at NYPH.8 9 The views generated by the system have been tested on clinical users and users reported feeling comfortable and confident using them.

Figure 1. This chart demonstrates that the source-oriented, time-oriented, and concept-oriented views are organized respectively by the source, time, and meaning and potential use of clinical data.

![Diagram showing source-oriented, time-oriented, and concept-oriented views]

Figure 2. Three types of views were available for users. (a) When View by Department (source-oriented view) was chosen, a list of clinical departments was shown. (b) After the lab department was selected, an index of lab reports was displayed. (c) The details of a lab report were displayed after a click on the name of the report. (d)
In the design and implementation of the system, a knowledge-based approach was employed. The system needs a large amount of knowledge, particularly for concept-oriented view generation purposes. For example, in order to generate a view for angina, the computer needs to know that angina is a heart disease, ECGs monitor the heart and thus an ECG report should be included in the angina view. Such knowledge was obtained from domain experts, publications and computer-based sources, and then represented as a semantic network and a set of rules.

2.2. Previous studies of physician information needs

Besides theoretical discussions, multiple studies have been undertaken to identify the information needs of physicians. Some studies focused on the needs for patient-specific information, especially information existing in patient medical records. Some studies focused on the needs for non-patient-specific information, such as the possible side effects of a medication. There were also studies that examined both types of information needs. Surveys, interviews, chart reviews and observations are the commonly used methods in information needs studies. Participants in the studies ranged from physicians with a particular specialty to any kind of clinicians. The number of participants varied from less than 10 to several hundred people. Analysis of information needs yielded quite different results partially because there has been no consensus on how to categorize and measure information needs. However, some common information needs such as the need for test results were identified by a number of studies.
Figure 4. After View by Topic (concept-oriented view) was selected, a medical term (congestive heart failure) was supplied to the system as the concept of interest. When Congestive Heart Failure was chosen as the concept of interest, a list of departments was shown. After selecting Radiology Reports, the system returned a list of radiology reports related to congestive heart failure, and the content of a report was displayed by clicking the report name.

3. Methods

This study focused on information needs that could be met with information in the EMR. It was conducted in three steps: observation, data analysis, and evaluation.

3.1. Observation

A literature review of studies on clinician information needs was conducted before the observational study.12-21 Because of our focus on patient-specific information, we found Tang's observational study of the use of medical records as an information source for physicians particularly relevant.17 Tang's study was conducted at a university hospital clinic. It generated a set of 15 prototypical questions which helped us set up a general
framework of information needs to guide our local study. Our observation was carried out in both the in- and outpatient settings of internal medicine. In the outpatient setting, the observation took place in the PIC (physicians in charge) rooms at Presbyterian Hospital, where residents, interns and medical students report patient cases to attending physicians. In the inpatient setting, the observer followed attending physicians on teaching rounds. To make the observation less intrusive, the observer did not interact with the physicians and instead, took notes and taped the conversations. The observational study consisted of 4 half-day sessions in the inpatient settings and 4 half-day sessions in the outpatient settings. An initial half-day of observation was spent to familiarize the observer with the environment and format of information exchange.

3.2. Data analysis

Based on the observation data, information needs were first categorized into major and minor categories. The amount of information needs demonstrated in each minor category was then measured. The distribution of the needs was calculated and implications were drawn from the statistics.

How to measure information needs is an important issue, and measuring by the number of verbalized questions (also called information deficit units) is a natural choice. This measurement had been used by several studies. However, as discussed in Forsythe's paper, information needs may not always be phrased as questions, and sentences that look like questions may not convey an information need. For example, "You should check the patient’s weight" looked like a comment. But given the context of case discussion, it was also a request for information from an attending physician to a trainee. Also, the definition of a question is not always clear. For instance, should “Has he had a CT or an ultrasound?” be counted as one question or two? So for the analysis of this study, a coarser measurement – information need unit – was used instead of the number of questions (or information deficit unit). A unit of information need was defined as information needs of a minor category expressed for a patient case. For example, all demographic questions regarding a patient were counted as one information need unit.

3.3. Evaluation

A comprehensive evaluation was done for the view generation system at NYPH and the details of the evaluation have been reported elsewhere. We also used the data collected from the evaluation to verify that different information needs require different views of the information. In the evaluation, questions were designed for three patient cases based on the identified physician information needs. Although the questions did not reflect all major and minor categories of the identified information needs, they covered three of the four major categories. Participating physicians answered the questions by retrieving patient information from the EMR using different views. Given the limited number and availability of the participants, only concept-oriented views and source-oriented views were tested. The answers physicians gave were graded (The correct answers were scored as '1' and wrong answers as '0') to calculate accuracy. Information retrieval efficiency was also measured by the amount of time (number of seconds) physicians took to answer each question based on video taped user-computer interaction.

4. Results

The observed patient-specific information needs were first classified into four major categories: demographics (name, age, gender, race, and etc.); diagnostic procedures; treatment (medications and other treatment procedures); and patient problems. Then the information needs were further categorized into 19 minor categories as shown in Table 1. Another major category of information needs involved non-patient specific information such as the prevalence of a disease or sensitivity of a diagnostic test. But that category is beyond the focus of our work and as such, will not be discussed further.

A total of 37 patient cases were observed over a 30-hour period and 296 information need units were observed. Table 1 shows the number of information need units in each minor category (i.e. the number of cases where information needs of a minor category were observed). The prevalence of each minor category (i.e. how often information needs of the minor category were present for a case) varied significantly, however, even the lowest prevalence was still over 15%. (Figure 5)

The information need for each case was very different because the cases and contexts were different. For example, more information exchange took place when physicians were discussing a new case than when following up an old case. There was wide variation in the number of information need units per case (maximum=19, minimum=1, upper quartile=11, lower quartile=4, median=7). For some cases, all minor categories of information needs were expressed while for others, only a few categories of information needs were mentioned.

We found that the natures of some categories of information needs suggest the use of certain types of views. For instance, questions regarding medical care provided by other health care providers, emphasize the source of care, suggesting that source-oriented views
would come in handy. Time is a focusing factor in questions regarding trend, suggesting that time-oriented views would be very effective for such questions. When retrieving evidence to rule out a diagnosis or searching for past signs of a specific problem, concept-oriented views (in this case, problem-oriented views) can be very convenient to use. It is also worth noting that there may not always be an overwhelming advantage of using one view over another. For example, there are advantages of organizing health maintenance related patient information by source, time or concept. Organizing by source makes it convenient for browsing all checkups done for a patient in a particular department. Organizing by time may allow a physician quickly find out if a patient had a mammography in the past few years. Organizing by concept can help to find a piece of specific finding among all the health maintenance related information in a patient’s record.

Table 1. This table shows the major and minor categories of information needs, the number of information need units in each category, and its percentage of the total number of information need units.

<table>
<thead>
<tr>
<th>Major Category</th>
<th>Minor Category</th>
<th>Number of Information Need Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Name, MRN, Gender …</td>
<td>26 (8.78%)</td>
</tr>
<tr>
<td>Diagnostic Procedures</td>
<td>Results of specific tests</td>
<td>28 (9.46%)</td>
</tr>
<tr>
<td></td>
<td>Past results of specific tests</td>
<td>13 (4.39%)</td>
</tr>
<tr>
<td></td>
<td>Trend of tests</td>
<td>11 (3.72%)</td>
</tr>
<tr>
<td></td>
<td>Any past hospitalizations/tests (why)</td>
<td>25 (8.45%)</td>
</tr>
<tr>
<td></td>
<td>Health maintenance</td>
<td>12 (4.05%)</td>
</tr>
<tr>
<td></td>
<td>Test plan</td>
<td>11 (3.72%)</td>
</tr>
<tr>
<td>Medications and Treatments</td>
<td>Past treatments</td>
<td>20 (6.76%)</td>
</tr>
<tr>
<td></td>
<td>Responses/complaints</td>
<td>7 (2.36%)</td>
</tr>
<tr>
<td></td>
<td>Current treatments</td>
<td>19 (6.43%)</td>
</tr>
<tr>
<td></td>
<td>Treatment plans</td>
<td>18 (6.08%)</td>
</tr>
<tr>
<td>Problems</td>
<td>Care from other providers</td>
<td>16 (5.41%)</td>
</tr>
<tr>
<td></td>
<td>Past diagnoses</td>
<td>24 (8.11%)</td>
</tr>
<tr>
<td></td>
<td>Current diagnoses</td>
<td>22 (7.43%)</td>
</tr>
<tr>
<td></td>
<td>Evidence to rule in/out diagnoses</td>
<td>11 (3.72%)</td>
</tr>
<tr>
<td></td>
<td>Past signs/symptoms of a specific diagnosis</td>
<td>9 (3.04%)</td>
</tr>
<tr>
<td></td>
<td>Allergy</td>
<td>7 (2.36%)</td>
</tr>
<tr>
<td></td>
<td>Family history</td>
<td>6 (0.20%)</td>
</tr>
<tr>
<td></td>
<td>Differential diagnosis for findings</td>
<td>11 (3.72%)</td>
</tr>
</tbody>
</table>

In the evaluation of the NYPH view generation system, using concept-oriented views led to better accuracy and worse efficiency than using source-oriented views overall. However, as shown in Table 2, for each category of information needs, the accuracy and efficiency (time) varied. For example, accuracy between using the two types of views differed most for questions regarding patient problems. For questions regarding diagnostic procedures, there was very little difference in information retrieval time between using the two views. This showed that different views are suitable for different information needs.
5. Discussion

This study was motivated by the development of a multiple view generation system. The observation and evaluation verified that different views are needed to meet physician information needs.

The observation showed that physician information needs were quite diverse. We identified 4 major and 19 minor categories of information needs. The prevalence of each minor category ranged from 16% to 76%. The number of minor categories of information needs per case varied from 1 to 19.

These results partially corroborated with previous studies on physician information study.\textsuperscript{14-21} It particularly confirmed the results of Tang’s study,\textsuperscript{17} which largely influenced the design of this study. However, the classification and prevalence of information needs identified in our study differed from previous studies. For example, Tang’s study identified 15 prototype questions and we identified 19 minor
categories of information needs. This is not surprising because there is no standard and well-defined classification scheme for physician information needs. Also, the setting and focus of every study was different. For instance, Tang’s research was conducted in an outpatient setting, while ours was conducted in both inpatient and outpatient settings. Information needs in these two different settings do have some differences. For example, we observed more questions about health maintenance issues in the outpatient setting than in the inpatient setting.

The difference between each category of needs calls for different types of views because each type has a different focus of organization. Source-oriented views are organized by where data are collected; Time-oriented views are organized by when data are collected; Concept-oriented views are organized by the content of data. So when physicians want information by location (e.g. outpatient clinic), source-oriented views can be helpful. When physicians want information by time (e.g. today), time-oriented views can be有益. When physicians want information by content (e.g. symptoms of diabetes), concept-oriented views can be handy.

The varied amount of information needs for a case is another reason for having multiple views. If a physician just wants to search for one specific finding in all past radiology reports, searching by concept would make sense. If a physician looks for a variety of findings that can not even be summarized in a few concepts, browsing by department may be the best way.

Our evaluation verified that different views might satisfy different types of information needs. It also suggested that no on type of views could meet all the information needs. The study showed that there were advantages in using either concept-oriented or source-oriented views depending on which category of information needs and which aspect of information retrieval were concerned. For two categories of information needs (diagnostic procedures and problems), information retrieval accuracy was better when using concept-oriented views than when using source-oriented views. For all three categories of information needs (medications & treatments, diagnostic procedures and problems), information retrieval took more time when using concept-oriented views than when using source-oriented views. However, for one category (diagnostic procedures), the difference in time was quite trivial.

The evaluation did not cover all categories (major and minor) of information needs and all three major types of views. One reason was that we were not able to recruit enough physicians. Another reason was that physicians tend to have a busy schedule and could not spend much more than half an hour for the study. Even though the crossover design was employed, there were not enough subjects to evaluate all categories of information needs and all types of views.

Although the study provided contributive information, further research is needed to determine which views are most appropriate for what information needs. The classification of information needs should be standardized. More extensive evaluations on how well each type of views meet the various information needs are also necessary.

6. Conclusion

Our observation and evaluation study validated our theory that physicians have diverse information needs and that different types of views (source-oriented, time-oriented and concept-oriented views) are needed to meet such needs. Although each type of views may be most appropriate for certain needs, views complement each other and no one type of views is more superior to others.

7. Acknowledgments

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8. References