A Web-Based Dynamic Clinical Informatics Page

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Abstract

Health care depends heavily on timely access to information and requires the distribution of information services in support of clinical care. Optimal use of biomedical information, data, and knowledge is the important factor for problem solving and decision-making. This application is to act as an integration point between patient information and health care users within Baylor Family Medicine Clinic. It provides web-based dynamic reports including clinic productivity of primary care, general medical information analysis, and quality improvement.

Keywords: Database access, delivery Electronic patient records, Quality assessment and improvement, Internet applications, Patient record management
Introduction

The computer-based patient record (CPR) system is an essential technology for health care. As trends move toward eliminating paper charts and records to a more streamlined and efficient way of maintaining patient information, CPR is gaining more attention as an efficient way for data acquisition, data storage, data access and data retrieval. \(^1\) Developed by GE Medical system (formerly Medicalogic), Logician is an electronic medical record system that enables health care physicians and clinical staff to document patient encounters, streamline clinic workflows, and securely exchange clinical data with other providers, patients, and information systems. \(^2\) Baylor Family Medicine Clinic (FCM) has started to use Logician for patient visit since April 1999. Currently there are 65342 individual patients records aged between one month and 102-years old with various races, which provides useful data source for patient’s health information and data analysis.

Study shows that the CPR improves the completeness of documentation and data collection. \(^3\) Based on Logician data source, health personnel require sufficient data and information management tools to make appropriate decisions. Logician system allows simple inquiring, such as lab data viewing, medication record listing. For more complicated data analysis, the query function in the system could not satisfy the different users’ requirements. Hence, it is highly desirable to develop an easy query tool for optimal use of biomedical information. This paper describes a Web-based dynamic query tool used by clinical physician, medical director, clinic administrator, and research coordinator. It is implemented in Baylor Family Medicine Department and in use at FCM Clinic.
Background

Medical record has been used for more than a century as a tool to assist clinicians in the care of patients.¹ The increasing amount of data in many environments requires efficient computer-assisted analysis to extract useful or hidden information in large collections of medical data.⁴ In medical practice, information overload is a common problem for clinicians,⁵ a major challenge occurs when decision-makers are bombarded with so much information that they cannot process and synthesize the information intelligently and rapidly.¹ Study has showed that physicians were better able to predict their patients’ future symptoms and laboratory test results when they had access to a computer-based flowsheet of summary data.⁶

Clinical decision-making is driven by information in the form of patient data and clinical knowledge.⁷ Data retrieval and analysis are the tools to extract the useful information from patients’ data. All view of medical data can be categorized into three classes – source-oriented view (which organize data on the basis of where they were collected); time-oriented views (which primarily use time to organize data); and concept-oriented views (which center on clinical concepts, such as diseases or organ systems).⁸ The concept-oriented views directly deal with patients’ medical problems, which will provide clearer view than other view classes for clinical users.

The web technology provides an easy-to-use, inexpensive, cross-platform that allows even a casual user to successfully navigate the complex site, it significantly impacts on biomedicine and medical informatics.⁹,¹⁰ A growing number of health-care organizations are in the process of modifying their clinical information systems (CIS) to support browser-based access.
Consequently, care-providers are expected to modify their workflow to take advantage of the new technology. Based on large data collection of Logician system, a concept-oriented web data retrieval application will not only help physicians or clinic administrator to summarize and calculate their patients’ data, but also provide an efficient way for medical director to observer physicians’ performance in the clinic. In addition, it will support research development in the medical informatics field.

**Design Objectives**

**Data Reporting and Analysis**

The first objective was to build complicated SQL query processes to meet user’s different requirements. Logician system keeps data in a large relational database. There are around 350 tables in the system, and 88 tables are the most common used tables which are related to patient medical records. It has kept patient information over three years. In order to extract useful information efficiently based on users’ purposes, the SQL query processes need to fully complete the complicated query task and finish the task within the user accessible time period.

**Dynamic Data Displaying**

The second objective was to display the results dynamically and access easily. The Internet and the World Wide Web have laid the foundation for ubiquitous access to electronic medical information. By using web-based application, users can input the necessary parameters (date, lab test items, patient age, gender, medical problem, risk factors, …) and run the query easily and conveniently on different locations where user can access to the department’s intranet.
Data Security

The third objective was to show the data reports on a secure site with user’s privilege. Medical director can view all reports; clinical manager can view referral productivity reports; individual physicians can view their patient’s medical information reports. The application also needs a timeout process to lock out the user within a time interval.

System Description

FCM Clinical Informatics site is three-tier Web architecture and developed with Active Server Page, Java Script and dynamic HTML. The Web server runs on a Microsoft Windows NT machine with Internet Information Server and is implemented using Active Server Pages (Figure 1). The clinical information is stored in an Oracle Database (Oracle 8.0), which is a copy database of Logician database, and runs on a separate CPU and located on different office. Users’ account privileges are stored in SQLServer database (SQLServer 7.0) and runs on same server machine with Web server. The user’s interaction is through a Web browser with Microsoft Explorer 5.x or greater. The database connection between application and database is through ODBC. The user interface is divided into two frames. The topmost frame is a query information part, users can select report name through drop down list, and select/input the required parameters, then click the “View” button to view the data, or click “Back Home” button to back to login page. The second frame displays the query results that selected by user.

Concerning of data privacy, confidentiality and security, the web site runs on the department intranet. Each user account has been assigned with specific privilege, so different users view different levels of reports. Medical director can view all reports in this site (Figure 2); clinical
manager can view referral productivity reports; individual physicians can view their patients’ medical information reports. The web pages are set to “expire” after a period of idle interval (e.g., 20 min), so that the browser removes these pages from its cache and return to the login page.

There are serial reports in each report category, the query parameter fields are different between those reports. The “Style” object and “Display” element, which are available for Internet Explorer 4.x or greater, with JavaScript have been implemented to generate standard event handling code for the corresponding form fields. The element values in the document were set to “none” initially so that all the elements are hidden; then some element values were set to an empty string after user selected a particular report and triggered “OnChange” event so that some elements were displayed.

1. Referral Productivity Management

Health care management requires monthly referral reports to analyze and manage referral status, calculate the numbers of referrals in Baylor Clinic and the numbers of referrals out of Baylor Clinic. This application displays the summary of referral productivity (Figure 3); number of referrals ordered by specialty; referrals ordered by specialty and by specialist physician; referrals ordered by responsible provider; and referral staff productivity for selected time period.

2. Quality Improvement (QI)

QI application tries to improve performance and documentation of routine health maintenance activities and disease management of specific conditions through data reporting in the FCM Clinic. It is expected that providers will use the data to work within their teams to improve these
outcome measures by modification of the workflow to increase data capture, specifying expectations of clinical support staff for capture data, and change in individual screen activities.

1) Physician Reports

This is for individual physician to observe his/her patient performance of the treatment. After inputting the time frame, patient’s problem, patient’s age, test item, … the application displays logged physician’s patient achieving lab goals for selected diseases; lab monitoring of results for selected diseases; selected referral for patients with selected diseases; percentage of patients with selected diseases who have had a test; percentages of female patients who have had well women exams (Figure 4); percentages of patients whose smoking status has been reported; percentages of patients who smoke; percentages of patients who have had annual hemoccult; and percentages of monitoring test ordered/tested/not tested for patients with selected disease. The application also shows all clinic summary report for above information so that the individual physician can compare his/her patient performance with all clinic average patient performance.

2) Director Reports

This is for medical director to observe all clinical patient performance grouped by individual physician. The application displays summary of patient’s treatments which including clinical QI reports (Figure 5), such as average LDL, average HgbA1C, average HDL, HgbA1C test numbers per year, percentage of micro album tested per year, percentage of eye exam per year for diabetes patients with selected age range; women’s health QI reports, such as percentage of pap smear, percentage of mammogram with patient age range; clinical general health maintenance QI reports, such as percentage of smoking status, percentage of drinking status with age range.
3. General Medical Information

Primary care serves as the patient's first point of entry into the health care system and as the continuing focal point for all needed health care services. The patients who come to this clinic may have different problems, and the medical data will be the good source for analyzing general medical information. This application displays patient distribution by age, gender, race, marital status, season (Figure 6), disease, and medication treatment; the most common patient’s health problems in this clinic; and the relationship between patient’s age or gender or race or marital status or season and health problems for all clinic (Medical Director account) and individual physicians (individual physician’s account).

4. Practical Research Report

Patients with certain medical problems need to have certain tests routinely. For example, diabetes patients need to have lab test for LDL, HDL, and HGBA1C routinely. In order to follow up patients’ medical records, physicians lab test ordering records, FCM clinic residents require an easy tool to search patient lab test records during certain time period. This application displays patient’s medical problem, name, age, gender, test ordered date, tested date and value with order, tested date and value without order, no order and no test patient grouped by physicians (Figure 7). The application also shows all clinic summary report for above information.

Status Report

FCM Clinical Informatics application has been installed to FCM web server and run on the FCM intranet since end of Feb. 2002. Currently, there are about 270 hits. The FCM clinic
physicians, administrators, research coordinators, residents are using the FCM Clinical Informatics site for reviewing the clinical data based on their requirements. There are about 30 users at FCM clinic. Mostly, users view their interesting information monthly. The forms for the queries are designed very simple so that users can easily to query the information without any extra instruction.

The Web and database servers are physically separated and located on different location (one on campus and one on off campus); the speed of the University network is an important limiting factor. Meanwhile, the length of query time period also influences the speed of the query, the longer time period, the more data will be searched, the longer execution time required. Execution time for queries currently runs from 5 sec to 2 min for most reports, individual physician’s reports run fast, and medical director queries take longer time (about 3 to 4 min). Query execution is serialized: Once a query begins to execute, it locks the Web server’s resources for this computer until it is finished, so that another query must wait for the previous query to finish.

Discussion

Logician system has good functions on Record Keeping and Access, Communication and Integration of Information, but has limited functions on Data Presentation, Information Retrieval, and Data Analysis. As an integration point between patient information and health care users within the FCM department, FCM Clinical Informatics site has benefited data retrieval and analysis. It also played a useful role for health management. Meanwhile, it identified some Logician forms and documentation problems, and enhanced to modify and resolve data acquisition problems through data retrieval.
As a good patient data collection system, Logician database has stored a large amount of patient medical records, especially the patients’ medical history. The application summarizes and analyzes the information with statistical calculation. By using quality improvement reports, physicians can easily find out summary lab reports for their patients with selected diseases for select time period. Meanwhile, they also can compare their patients’ performance with all clinic summary data which is including in the last part of each report. By using medical director QI reports, medical director can easily observe individual physician’s performance and all clinic’s performance, it helps director on health management and saves director’s time to search individual physician’s performance one by one. The medical director has shared the copies of such summaries to the weekly/monthly supervision meetings with the clinical physicians and discussed the improvement strategies for performance and documentation.

By using referral productivity reports, clinical staffs now are easy to find out the number of referrals sent to Baylor clinics, and number of referrals sent to Non-Baylor clinics at the end of each month (this work was counted by person before). The application also enhanced database updating. During the query processing, there were some referrals sent to “No Preference” which neither can count for Baylor clinic, nor Non-Baylor clinic because those physicians’ name were not in the database. After identified the problem, the message was sent to Logician database team, so that database management staff could update the database tables.

General medical information reports summarized and analyzed patient’s information in FCM clinic. Through the application, medical director can find out the patients distributions based on
age, race, gender, marital status with the medical problems; patient seasoning visit frequencies with medical problems in this clinic. The individual physicians can view their patients’ distributions and seasoning visit frequencies with the medical problems. It also displays patients’ other common medical diseases with particular disease. The application pull out all separated information into a view shot, which simplified user analysis task significantly. It also provides health management personnel a viewpoint for organizing clinical performance (eg. which season is a high season for patients with which medical problems; the most incoming patients are at which age range.).

During the data retrieval processing, some Logician data collecting and documentation problems have been identified. Logician uses various forms as user interface to acquire patients’ information. Some forms did not design well so the clinical users could not find a particular item to input the information, then the information was input with free text; some terms were declare for database which linked with some particular field in the database tables, but the items in the interface forms did not linked with the pre-declared term. Such problems lead data retrieval more complicated and influenced some statistical calculation. Currently, those form are redesigning and the particular items will be input into database with predefined standard terms.

Medical director report view a serial different items together in one output, it involves complicated queries and calculations, which costs longer execution time for running the program. There are some trade-offs between complicated SQL queries with simple program codes, and simple SQL queries with complicated program codes. Depending on the execution time, some complicated SQL queries need to separate into simple queries with more program codes to
implement the same features. The time required for the application queries is currently considered acceptable; there is still the space for performance improvement through the database tuning. One of the quickest fixes to a sluggish application is to identify any ‘hot’ tablespaces, or those applications with their tables and indexes in too few tablespaces.\textsuperscript{15} The index checking and SQL statement modification also are the importance factors for performance improvement.

There are continuous requirements for the various query reports from different users in FCM Clinic, this application is perpetual work-in-progress and will be turned continually to be responsive to its users’ needs. As web technology itself evolves, the application will change to take advantage of new features. Currently, the application requires Internet Explorer as the web browser because the “Style” object and “Display” element are not available for Netscape browser. The application needs to use other function to implement the above features so that the user with Netscape browser also can view the same features. Meanwhile, some decision-support features are concerning to develop in the near future by using some algorithms, such as Bayesian algorithm. Clinical information is expanding at a rapid rate, if the web application can link to some knowledge sources, it will be very helpful for clinicians to analyze the patients’ information.
Figure Legends

Figure 1

The overall architecture of the FCM Clinic Informatics Page. In this three tiers architecture, the application resides on a Web server, which mediates between the Web browser and the database.

Figure 2

The User Interface for Medical Director. The user can click the report link to view the specific topic site.

Figure 3

The results returned by the query for summary of referral productivity. This is the report for clinic administrator to view the referral ordered by month between Baylor clinic and non-Baylor clinic.

Figure 4

The results returned by the query for female patients who had pap smear test. This is the report for individual physician to view his/her patients’ medical records and all clinic summary records. Concerning the privacy, the physician name and patient names have been changed to not be identifiable for this paper.
Figure 5

The results returned by the query for patient distributions grouped by age, race, gender, visit season, and marital status in FCM clinic. This is the report for general medical information.

Figure 6

The results returned by the query for diabetes patient lab test summary group by providers in FCM clinic during the time period. This is the report for medical director. Concerning the privacy, the provider’s names have been changed to not be identifiable for this paper.

Figure 7

The results returned by the query for clinic HGBA1C test ordered, tested with ordering, and tested without ordering. This is the report for clinic resident to follow up the diabetes patient’s routine lab test. Concerning the privacy, the physician names and patient names have been changed to not be identifiable for this paper.
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