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HELP: A Medical Information System With Decision Making Capability

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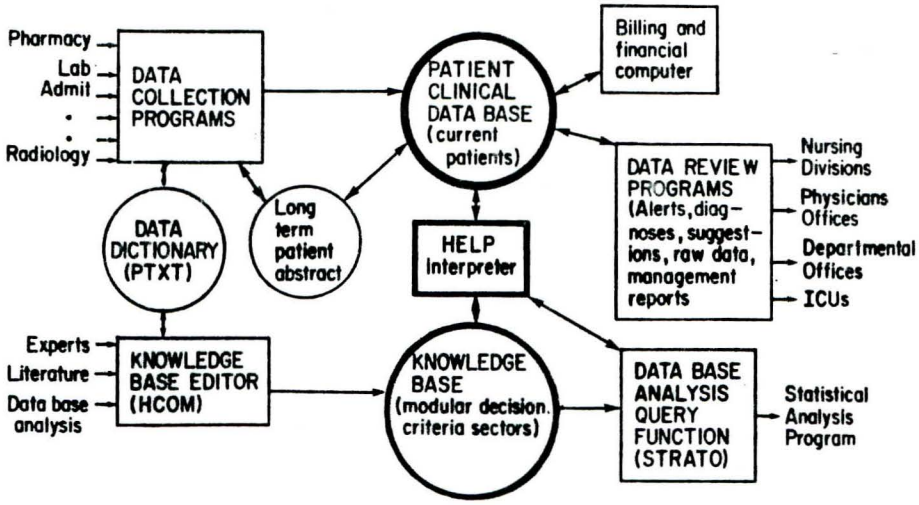
HELP is a medical information system which is routinely used to collect and review patient data, to provide financial, administrative and management information and to produce computer generated medical decisions. Although the HELP system was developed at the LDS Hospital and University of Utah in Salt Lake City, it has now been successfully transported to other institutions. The system (see figure) consists of three main components: 1. A comprehensive clinical database for all patients in the hospital. 2. A separate, modular medical knowledge base which contains criteria necessary to make specific medical decisions (alerts, interpretations, diagnoses, or therapeutic suggestions). 3. The HELP interpreter. This module provides the control function to decide which logic modules should get evaluated and then evaluates the appropriate medical logic. In the following sections, each of these components will be described in greater detail.

HELP DECISION SUPPORT SYSTEM



The On-line Clinical Database

The clinical data base consists of two elements: long term abstract of demographic and clinical information likely to be useful if the patient is readmitted to the hospital and a short term comprehensive collection of all data gathered during the current hospital admission. All data are stored in coded form (as opposed to free text) so that data can be retrieved and analyzed for use in research and

decision logic. Hierarchal codes are defined using a system called PTXT which is basically a computer based dictionary. Using this program, a user defines the codes for a data item, as well as the associated text to be used for reports and terminal display, and key words which are appropriate for the data item. Key words enable users who are constructing data retrieval items for decision logic sectors to easily specify the codes which should be sought.

The data are entered automatically in many instances through digital or analog interfaces (ECG, catheterization laboratory, pulmonary function laboratory, clinical laboratory, etc.) or by interaction with a terminal (pharmacy, radiology, nurses notes, etc.).

A general question asking program (GQAP) makes it possible for technical personnel without programming skills to construct data entry questionnaires. To develop a questionnaire, it is necessary to type a free text question, specify the type of answer expected, and define codes which should be associated with the answer. Follow-up questions which depend on previous answers and error-detecting logic are system capabilities which are routinely used to construct branching type questionnaires for data entry.

The database generated while the patient is in the hospital is generally complete except for physician derived data such as a complete history and physical examination. We are currently attempting to develop ways in which the physician can conveniently enter these missing data. Because the database is presently hospital oriented, information from the private physician's office and post-discharge outcome measures are generally not available except in specific research areas.

The Medical Knowledge Base

The most unique aspect of the HELP system is the ability to construct modular decision sectors. These sectors are analogous to frames in symbolic processing systems. This medical knowledge base supports a variety of logic models (If... Then... rules, patient specific probability revision, data driven activation, query for missing data, etc.) for medical decision making and allows the medical expert to enter the logic criteria by using a high level language knowledge base editor. To date we have implemented only a portion of the total medical knowledge in our knowledge base. However logic sectors have been implemented and are in current use in the following areas:

Pharmacy sectors principally deal with drug-drug and drug-laboratory interactions as well as other alerts given to the pharmacist as drug prescriptions are entered into the computer. These alerts have been evaluated and found to be cost effective.

Radiology sectors predict the pretest likelihood that a given finding will occur.

Blood gas sectors interpret the measurements and indicate whether there is hypoxemia, hyper-or-hypoventilation, or respiratory or metabolic acidosis or alkalosis and the direction of any change in the patient's status.

The ECG sectors interpret parameters derived from the waveform to assess morphologic abnormalities, arrhythmias, and serial changes.

Clinical laboratory sectors generate alerts and interpretations based upon electrolytes, blood chemistries, hematology, and drug levels.

Decision analysis is used to assess decisions regarding treatment of patients-with suspected coronary artery disease.

Diagnostic sectors have been written for specific areas of internal medicine, the most detailed emphasis to this point has been upon pulmonary disease.

Pulmonary function tests in pre-admission screening and the pulmonary laboratory are analyzed and interpreted using HELP logic.

Hemodynamic and cardiac function measurements in the intensive care units are also interpreted using HELP logic.

HELP logic is used to determine which specific history questions to ask an individual patient.

HELP logic is used to ascertain when a candidate satisfies explicit criteria for admission to a research protocols.

To objectively assess the status of patients in the critical care unit, criteria have been defined to create a multi-organ failure index.

Dietary and diabetic alerts based upon a brief history, pharmacy and clinical-laboratory information are run daily.

HELP logic has been developed to recognize patients with high risk pregnancies and prescribe management protocols for these patients.

Pathologic findings obtained by electron microscopy are classified according to explicit criteria defined in HELP sector logic.

When arrhythmias occur in patients in the cardiac intensive care unit, the extent to which the arrhythmia is judged to be life threatening and suggestions for appropriate conversion are presented.

Triage sectors based upon recently published protocols for deciding when an emergency room patient should be admitted to the cardiac intensive care unit have been developed.

Infectious disease/antibiotic monitoring sectors have been developed. The computer reminds physicians when there is a cheaper or more appropriate antibiotic.

Therapeutic suggestions and requests for diagnostic tests are made in a broad range of the applications which have been described. Requests for bronchodilators during a pulmonary function test, or a serum creatine measurement for patients receiving the drug gentamicin, and the suggestion that a specific drug be discontinued are examples of this feature. Most of the applicatations that have been discussed are used routinely in day-to-day clinical service. A few of the areas are being used only by one or two physicians to test feasibility of widespread application and to develop more extensive and sophisticated logic.

The HELP Interpreter

A HELP interpreter (the third major component of the system) acts as the interface between the knowledge base and the clinical database. It evokes the appropriate subsets of the knowledge base and interprets the logic found in each individual

logic module. The sectors themselves contain the logic which determines how they are evaluated, e.g. if....then..... rules or statistical probability calculations. An arithmetic item can be used to perform tasks ranging from Boolean logic to calculation of a value for a discriminant function. Chronologic statements can be used to retrieve the time of certain specified events so that these times can be used for search limitations or action flags. Existence items use the presence or absence of a piece of data rather than the value of the data as the basis for logical or arithmetic calculations. Search items are used to retrieve specific data within prescribed time limits from the clinical data base. Modifiers such as frequency, minimum, maximum, mean etc. may be appended to the search item as appropriate. Search items may also request the evaluation of additional HELP sectors by asking for the results of that sector. Because of the frequent use of Bayes' formula in some types of HELP decisions, this function has been explicitly defined; the logic for other types of statistical decision models is performed using arithmetic items.

Radiologist Assistance

As an example of the capabilities which the system provides, we shall describe a recent project in which the computer assists radiologists as they read chest roentgenograms. We developed medical logic which is used to present the radiologist with a synopsis of clinical information about the patient in the form of a differential list of likely diagnoses. After entry of the radiological findings, this list is re-evaluated to show the impact of the information obtained from the current examination.

We used a probabilistic model (sequential applications of Bayes' Theorem) to develop medical logic for diagnosing 29 different pulmonary diseases. The logic modules (HELP sectors) for each of the diseases consist of 4 parts: 1) the a priori probability of the disease, 2) a group of search items which direct the computer to ascertain the presence or absence of data items specific to the disease under consideration (history, physical exam, chest radiograph findings, and laboratory data), 3) a set of conditional probabilities for those data items referenced in the search items, and 4) a series of Bayesian constructs which generate posterior probabilities sequentially using the results of one data item as the prior probability of the next calculation.

Forty-one pulmonary diseases were identified in the discharge summaries of 82 control patients. Fifty-one of these patients fell into the category of "No Pulmonary Disease". An initial analysis of the disease modules was done prior to the addition of the x-ray findings to the patient records. Based on historical and clinical data which were available before the initial chest x-ray, seventy-eight percent of the diseases found in this group of patients appeared on the diagnostic lists generated by the computer. Sixty-three of 82 (77%) diagnostic lists were completely accurate i.e. contained all pulmonary diagnoses recorded for that patient. After the findings from the initial chest x-rays were added to each patient record the diagnostic modules were run again. 80% percent of the disease states were correctly included in the differential diagnostic lists. Sixty-seven of 82 lists (82%) contained all recorded diseases.

Summary

In summary, Help is a routinely used system for automated medical decision-making. A specific study of the alerts for contraindicated drugs showed that the system is cost-effective and that physicians normally agree with the computer generated

decisions. Another study of electrolyte abnormalities showed that patient care was improved when the computer alerted nurses and physicians to abnormal values. General purpose tools exist for entering clinical information and expert medical logic into the respective databases. Increased availability of the system will hopefully result in the development of additional amounts of appropriately formatted medical logic as well as improved patient care.

References:

1. Pryor TA, Gardner RM, Clayton PD, Warner HR. The HELP System. J of Medical Systems 7:87-102, 1983.

2. Gerard MJ, Haug PJ, Morrison WJ, Tocino I, Frederick PR, Crapo RO, Harada SK, Clayton PD. A computer system for diagnosing pulmonary disease. Proc. Am. Assoc. Med. Inform., San Francisco, p. 119-123, May, 1984.