Test Ordering and Medical Decision Making: A Synergistic Relationship

By T. Allan Pryor, Paul D. Clayton and Keith G. Larsen

Historically, the development of hospital information systems has tended to emphasize either administrative or clinical applications. Administrative systems have concentrated on implementing the admit-discharge-transfer function, automating test ordering, capturing patient hospital charges and compiling financial requirements. Clinical systems have concentrated on capturing and recording clinical data on patients served by the system. In the development of both systems, however, little has been done to implement automated decision processing.

The Health Evaluation through Logical Processing (HELP) system developed over the last 15 years at the LDS Hospital in Salt Lake City, Utah, has combined the administrative and clinical attributes of traditional hospital information systems with a generalized decision structure available to users for making on-line medical decisions. The majority of the medical decisions defined in the HELP system are data drive. That is, the criteria is automatically processed as the data associated with the decision are captured and stored by the system. This feature ensures that the recipient of the information may review the most current decisions with minimal interaction with the system.

While many of the decisions written for HELP concern the medical evaluation of patients, decision processing can be added to any function incorporated in the system. In particular, ordering drugs and procedures, such as laboratory tests and x-rays, provide opportunities to create decision logic that controls the order and suggests clinical decisions. In the data driven mode, the order is the data that triggers the appropriate decision criteria.

Figure 1 illustrates the general mechanism followed in the HELP system for the processing of an order. When the order is completed, it is stored in the patient data base and that input triggers the decision processing. The information processed includes the order, other patient data base items, and medical knowledge pertinent to the specific order. Following the processing, the order—together with any decisions—is forwarded to the appropriate locations.

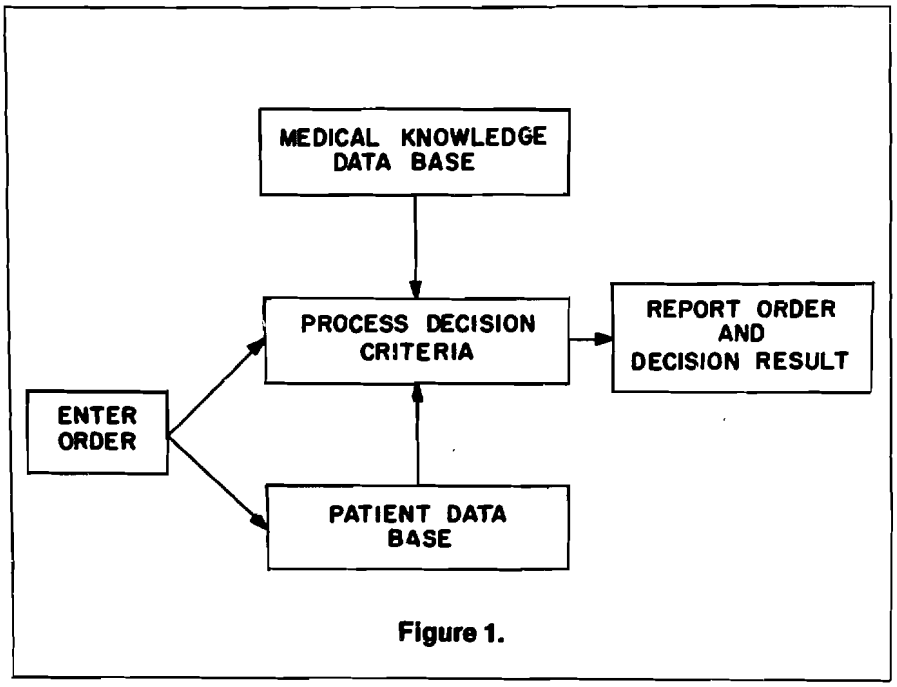


Figure 1.

Interrelation of Medical Logic

One example of the interrelation of medical logic in the HELP system used to enhance test ordering and reporting occurs in our radiology sub system. In developing the sub system, we wanted to automate the order, and ensure that clinically pertinent radiology findings from the patient's x-ray could be easily entered into the computer data base. The goal resulted in two major constraints being placed on the subsystem design. The first constraint was that the radiological findings had to be coded so that the stored data could be reviewed by clinicians and analyzed by medical decision logic. The second constraint was that the system had to be unobtrusive to radiologists so that they would readily cooperate in entering findings into the computer.

We found that the salient information in a large majority of x-ray examinations can be reported with a limited list of possible findings. We further realized that for an individual patient with a specific ordered procedure, we could narrow the list of possible findings to the five most likely by using patient-specific data that was already part of the computerized data base at the time the examination was ordered. These realizations led us to conclude that the radiologists could conveniently report pertinent clinical results by selecting from an individualized list of likely findings for each patient. To implement this convenient coding scheme, we used HELP-based medical decision logic as part of the ordering process, so that the list of likely findings was appropriate for each individual patient. Requests for radiological examinations are processed in the

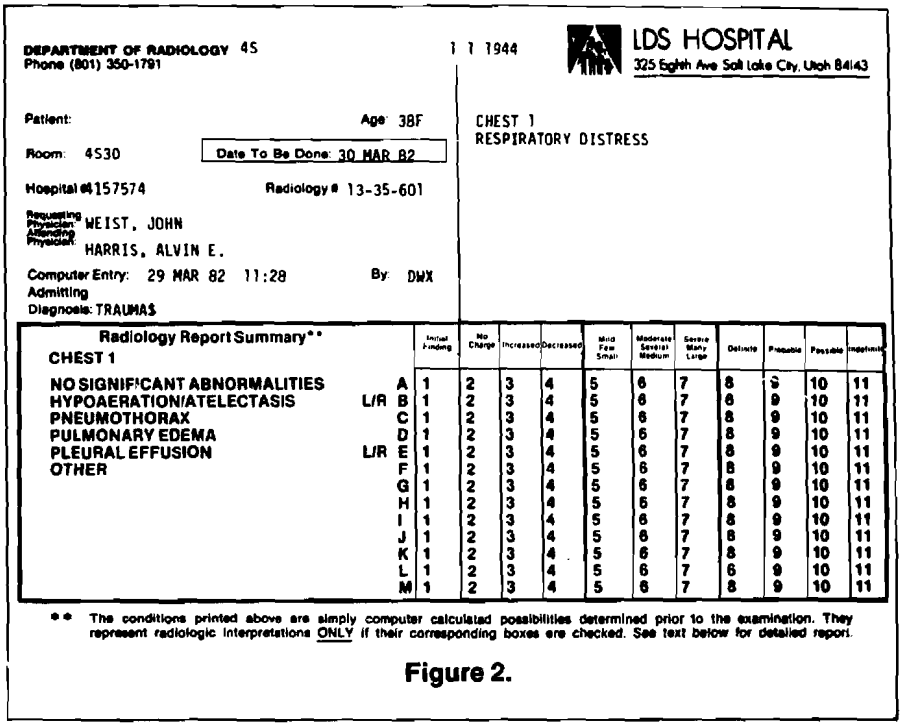
following way. After the ward clerk has entered the patient number, ordering clerk and requesting physician, the five most recent x-ray procedures ordered for that patient are displayed. This information reduces duplicate or unnecessary examinations. If this review does not alter the request, the clerk selects from a menu that lists 13 general categories of examinations. These categories range from chest x-rays to ultrasound, computerized tomography or nuclear medicine.

Choosing the general category of chest examination causes the next menu to display the common specific procedures for that category. The menus are used to obtain the reason for ordering the examination. The first question describes the general category such as postoperative, preoperative, follow-up known disease, symptoms only, and so on. The follow-up menu displays a list of common reasons for ordering the specific, previously ordered procedure. The selected reasons are coded and stored as part of the order string and are extremely important in the decision logic used to predict the most likely findings of the requested procedures. Free text may be entered to describe unusual examinations or reasons for ordering certain procedures.

Requisition Report

When the ward clerk has answered additional questions concerning time and patient transportation, the computer prints the paper work necessary to perform the examination and the requisition report form (Figure 2) that contains the individualized list of most likely findings for the requested procedure. In addition to the list of likely findings, the requisition report form gives other clinical data, such as admitting diagnosis and surgical procedures that may be of interest to the radiologist.

The system includes prewritten medical logic to predict the likelihood for 357 separate radiological findings. Whenever a chest examination is ordered, the logic sectors for 45 pertinent findings are evaluated and the five findings with the highest likelihood for that patient are printed on the requisition report form. The logic for the likely findings is based upon indicants that are found to be significantly correlated to a specific finding. Such items include age, sex and other clinical data in the computer. The most important item is usally the physician's reason for ordering the examination. The actual use of these indicants to predict the presence of a specific finding is based upon sequential applications of Bayes' formula.



DEPARTMENT OF RADIOLOGY 45
Phone (801) 350-1791

1 1 1944

LDS HOSPITAL
325 Eighth Ave Salt Lake City, Utah 84143

Patient: Age 38F

Room: 4530 Date To Be Done: 30 MAR 82

Hospital # 157574 Radiology # 13-35-601

Requesting Physician: WEIST, JOHN
Attending Physician: HARRIS, ALVIN E.

Computer Entry: 29 MAR 82 11:28 By: DWX

Admitting Diagnosis: TRAUMA$

CHEST 1
RESPIRATORY DISTRESS

Radiology Report Summary**
CHEST 1

		Initial Finding	No Change	Increased	Decreased	Mild Few Small	Moderate Several Medium	Severe Many Large	Definite	Probable	Possible	Improbable
NO SIGNIFICANT ABNORMALITIES	A	1	2	3	4	5	6	7	8	9	10	11
HYPOAERATION/ATELECTASIS	L/R B	1	2	3	4	5	6	7	8	9	10	11
PNEUMOTHORAX	C	1	2	3	4	5	6	7	8	9	10	11
PULMONARY EDEMA	D	1	2	3	4	5	6	7	8	9	10	11
PLEURAL EFFUSION	L/R E	1	2	3	4	5	6	7	8	9	10	11
OTHER	F	1	2	3	4	5	6	7	8	9	10	11
	G	1	2	3	4	5	6	7	8	9	10	11
	H	1	2	3	4	5	6	7	8	9	10	11
	I	1	2	3	4	5	6	7	8	9	10	11
	J	1	2	3	4	5	6	7	8	9	10	11
	K	1	2	3	4	5	6	7	8	9	10	11
	L	1	2	3	4	5	6	7	8	9	10	11
	M	1	2	3	4	5	6	7	8	9	10	11

** The conditions printed above are simply computer calculated possibilities determined prior to the examination. They represent radiologic interpretations ONLY if their corresponding boxes are checked. See text below for detailed report.

Figure 2.

By providing the radiologist with a limited patient-specific list of coded findings, clinical data is captured from this major source of ancillary tests. The radiologists use a check-the-box format to report coded findings for more than 90 percent of the procedures performed in our hospital. With our present level of decision logic, we are able to include all of the appropriate findings on the predicted list 73 percent of the time. An additional 25 percent of the examinations can be reported using key words in combination with the findings that appear on the list.

Ordering Medications

Another example of the interaction between medical decision processing and computerized order entry is illustrated in the ordering of medications at the LDS Hospital. This action is initiated by the physician with a written order on the patient's medical chart. A direct copy of the medication order is given to a pharmacist, who is then responsible for entering the order into the patient's computer record. The order may be entered at a terminal located on the nursing station or at a terminal located in the pharmacy department.

The order information entered into the medication profile includes the name of the medication, prescribed dosage, route of administration and scheduled times the medication should be given. As with most traditional order entry systems, this information is used for generating medication labels, capturing billing information, updating the patient's medication profile and updating a narcotics utilization file.

In addition, medical decision processing results are reported back to the pharmacist before the order is

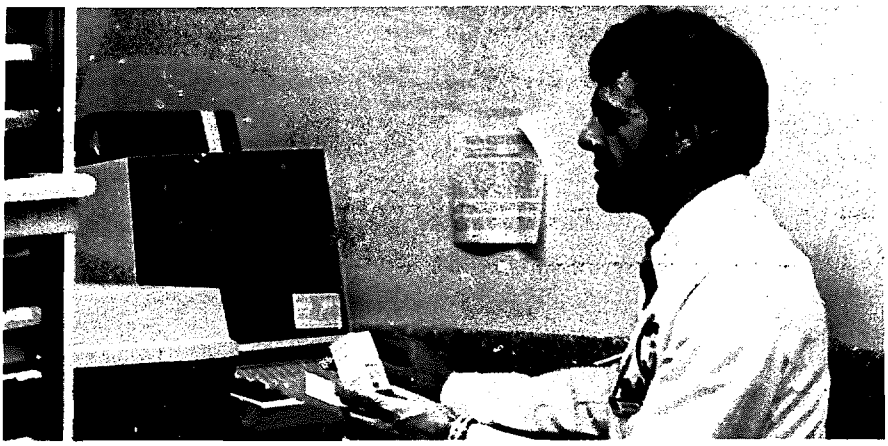


Figure 3.

completed (Figure 3). The computer decision-making criteria screens for allergy contraindications, drug interactions and drug contraindications as indicated by laboratory and medical diagnoses. The decision logic integrates the medication information with other patient clinical data such as medical diagnosis, laboratory results, bacteriological data and so on.

The output of the computer medication screening is a series of recommendations concerning drug therapy alteration if indicated. These recommendations are displayed to the pharmacist immediately following the scheduling of the patient's medication orders. The pharmacist is responsible for follow-up of the recommendation with the appropriate member of the patient's health team. If the severity of the anticipated reaction warrants, the pharmacist will withhold the medication until the patient's physician has been contacted.

While this incidence is low, the potential cost to the patients of unrecognized medication problems is greatly reduced. Between three and five percent of hospital patients have an alert generated on a medication order during their hospital stay. In each instance the patient realizes a four to one cost benefit from the medication ordering system. To accomplish the same screening for medication complications in a hospital the size of LDS pharmacists would have to review about 500 hospital charts per day. With the computer system, the pharmacists at LDS Hospital have been able to concentrate on the 15 to 20 patients a day for whom medication complications were indicated during the ordering process.

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Developing Decision Logic

The unique ability of the HELP system to interact with traditional hospital information functions and decision processing has been accomplished by providing a common integrated data and medical knowledge base, as well as by developing generalized user programs that provide an easy interface for creation and management of new data base items, entry systems, decision criteria and formatted screen displays. The availability of these user tools ensures that the system will remain dynamic, responding to changes in both the hospital data base and decision criteria necessitated by new medical knowledge.

Figure 4 illustrates the general model of implementing both the ordering function and the creation of the decision criteria using the HELP system. The first step is to define any new items to be added to the existing data base. The format and units of measure of the new data item, the key words to access the data, the cost accounting procedure number and the charge value are included with the data description. Once defined in the data base, an item may be used in the generation of entry questionnaires and decision modules.

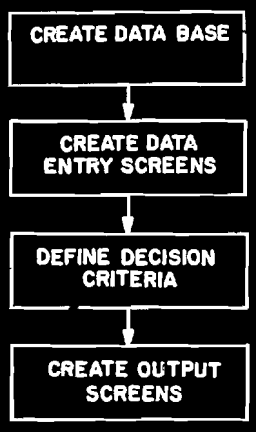

Figure 4.

The developer creates a data entry questionnaire using a screen definition system. The questions allow the user to enter fields of previously defined data items. The items consist of a series of data entry screens. Each screen has a set of attributes, including the type of data to be entered, diagnostic checks to be performed on the data in that screen, follow-up screens to be presented based on the results of data from that screen, the structure of the data to be stored and requests to perform specialized processing on any of the data items in the field. The questionnaire for obtaining the specific type of x-ray examination and the reason for performing the procedure is an example of how this tool is used.

Creation of the decision criteria is accomplished in a manner similar to development of the data entry questionnaires. The developer interacts with a set of system routines using key words to explicitly define the data items for the decision logic. This definition of the data set may include complicated time constraints and/or Boolean logic. Following the definition of the data items for the decision criteria, the developer defines the actual decision logic and determines whether the system will use logical or statistical constructs to evaluate data items.

Having defined the decision criteria, the developer of the medical decision logic specifies the locations where the output of the decision are to be transmitted. These locations may include the patient's medical record, special system files used to rapidly alert medical personnel, specific printer locations for the reporting of the decision results and so on. The final step in decision creation includes specification of the data items whose storage will cause these decision criteria to be processed.

the HELP system is a mechanism for the creation of screen formats for report and review of the entered data and any decision results. Again, system routines are provided that make it convenient for the developer to define the format of each screen and the destination of each generated

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report. In some instances, the system may be used in the laboratory to order tests, or it may be used on the ward when the user is requesting review of such information.

Range of Applications

The ordering examples given above illustrates only some of the current interaction between the medical decision-making and order entry programs in the HELP system. Similar interaction and decision logic is available for ordering blood gas, clinical laboratory tests and so on. Research is currently under way to make the system useful in determining the most likely set of test orders that should be requested in order to further the diagnostic needs and management of a particular patient.

As these applications grow, the indication is that hospital information systems of the future must be medical decision systems wherein items of data originate from numerous medical and administrative sources. □

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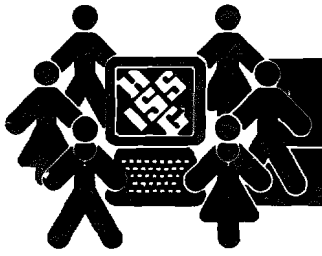

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