3.

DESCRIPTIONS OF THREE SYSTEMS

3.

DESCRIPTIONS OF THREE SYSTEMS

Because of the different goals, impacts, and costs of existing medical information systems, no single system can be considered representative. In order to illustrate this diversity, three systems are described in detail. One system, the Technicon Medical Information System (TMIS) at El Camino Hospital, is specifically designed for the acute care hospital. Another system, the Computer Stored Ambulatory Record (COSTAR) system at the Harvard Community Health Plan, is designed for ambulatory care. The third system, the Problem-Oriented Medical Information System (PROMIS) at the University of Vermont Medical Center Hospital, is a developmental project that attempts to guide, as well as to support, the provision of medical care. The prototype operates in an inpatient setting, but the system is designed for use in any kind of medical care delivery site.

These three systems were chosen for discussion in this report because they represent different technical and conceptual approaches to handling information and are considered exemplary by professionals knowledgeable in the computer and medical fields. In no way does inclusion in or omission from this report support or criticize any system.

TECHNICON MEDICAL INFORMATION SYSTEM (TMIS)

El Camino Hospital in Mountain View, Calif., was the demonstration site for the Technicon system. El Camino, a 450-bed community general hospital with a medical staff of 340 physicians, serves patients under the care of their personal physicians. The hospital does not have an internship or residency program. It provides no outpatient services except diagnostic procedures for patients referred by staff physicians. It does have an emergency room.

The Technicon Medical Information System (TMIS) has been in operation at El Camino Hospital since 1972. Three years of development at the institution preceded the actual implementation. Implementation of the system throughout the hospital took 9 months. The Technicon Corporation and its predecessor, the Lockheed Corporation, bore the costs of development (over **$25** million). The National Center for Health Services Research later awarded funds to El Camino Hospital for evaluation of the project.

System hardware, a large IBM computer, is located at Technicon's regional computer center, several miles from El Camino Hospital. A second IBM computer is available at the regional center for backup support. Data are maintained at the central processing facility using disks and tapes for storage. The hospital's **58** video and

31 printer terminals are linked to the computer center via high speed telephone lines. For the most part, software is written in assembly language, and COBOL is used for financial reports.

The Technicon Medical Information System is a hospital-wide system. It is designed to store patient data and send appropriate data, either upon request or automatically, to personnel who need them. Objectives of the system include more efficient hospital operations, improved patient care, and reduction or containment of hospital costs. A major goal of the system is to facilitate nursing activities.

Capturing Patient Data. Physicians, as well as nurses, ancillary service personnel, and admitting clerks, enter data through video terminals, which consist of a television screen, a keyboard, and a light-pen for rapid selection of information presented on the screen. Direct use by physicians distinguishes TMIS from several other hospital-wide systems. Alternatively, nurses can enter data for physicians. Terminals are located at each nursing station and in ancillary service departments. Each authorized person gains selective admission to the system by typing a unique identification code on the keyboard. This procedure ensures that hospital personnel can enter and obtain only information appropriate to the performance of their jobs.

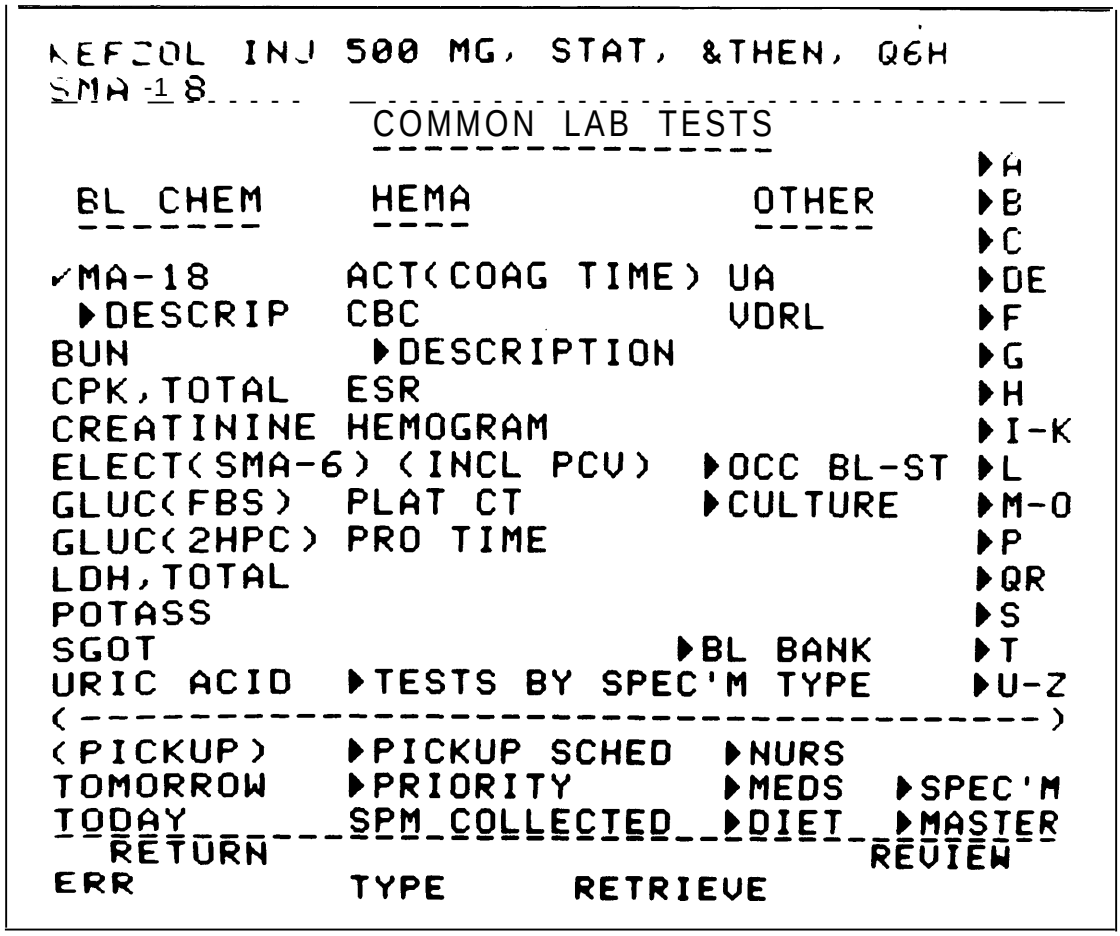
The television screen displays a list of items, for example, laboratory tests that the physician might wish to order (see figure 2). A specific item is selected and entered into the computer system by pointing the light-pen at the desired phrase and pressing a switch on the barrel of the pen. Using the light-pen, a physician can enter a full set of medical orders (laboratory work, medications, X-rays, diet, activity, etc.) for a specific patient. The displays remind physicians to make orders complete; for example, when a medication is ordered, the display notes the need to specify scheduling and method of administration (oral, intravenous, or intramuscular) in addition to dosage. The keyboard may be used to enter any information that is not displayed in the display frames. TMIS prints copies of new orders for verification by the physician or nurse at the nursing station and automatically routes the orders to the appropriate hospital department (see figure 3). Orders to be carried out in the future are held in the system until the time designated.

Nurses use the system to enter physicians' verbal or telephoned orders, to report vital signs, and to record medications administered. Nurses must indicate by light-pen selection whether an ordered medication has been administered and, if it has not, provide a reason. Several nursing stations are experimenting with a computerized plan for nursing care that enables nurses to enter their patients' actual and potential problems and prognoses as well as nursing orders.

Other personnel also use the system. Admitting clerks enter a complete admission record through the video terminals. Clerks or technicians in ancillary services enter patient data. For example, clerical personnel type in dictated radiologist reports in the X-ray department. Results of high volume laboratory tests are entered by linking automated laboratory instruments directly to the TMIS computer.

Retrieving Patient Data. Once data are entered into the system, authorized personnel can review them immediately on the videoscreen terminals. Printer terminals also provide paper copies (printouts) at the nursing stations and in the ancillary service departments. The video terminal can display all data that have been entered from any point in the hospital up to the moment of retrieval.

Figure 2–TMIS Laboratory Test Order Display



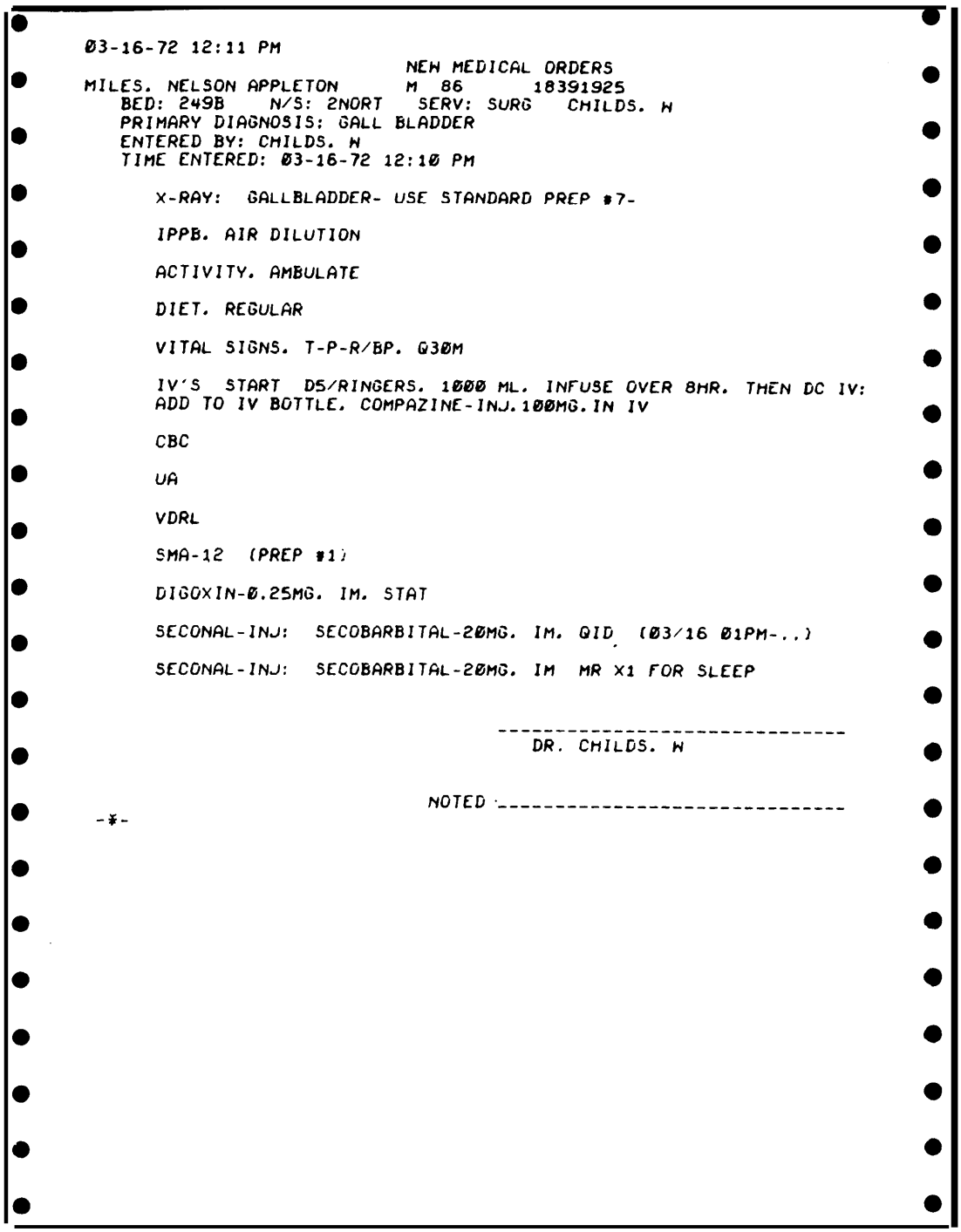
SOURCE Technicon Corp

Physicians and nurses can retrieve the following information about their patients: admissions data, laboratory test results, X-ray reports, medications given, current orders, all orders since admissions, nursing notes, diagnoses, and allergies. Information in any category can be broken down to isolate desired data as, for example, cumulative results of a specific laboratory test. In addition, before each nursing shift, TMIS prints out a Patient Care Plan for each patient that lists all current orders to be carried out during that shift (see figure 4). "Medications due" lists are printed automatically throughout the shift.

Physicians can also obtain displays on general medical information compiled by staff physicians. TMIS currently stores information about subjects of interest in approximately **2,000** display frames. The "medical library" includes such information as abstracts of current articles from surgical journals, lists of antibiotic sensitivities, and interpretative aids for laboratory test results.

Communications, Administrative, and Business Functions. TMIS routes orders from nursing stations to the clinical laboratory, pharmacy, radiology, and dietary departments. At the same time that orders are printed in the pharmacy, the sys-

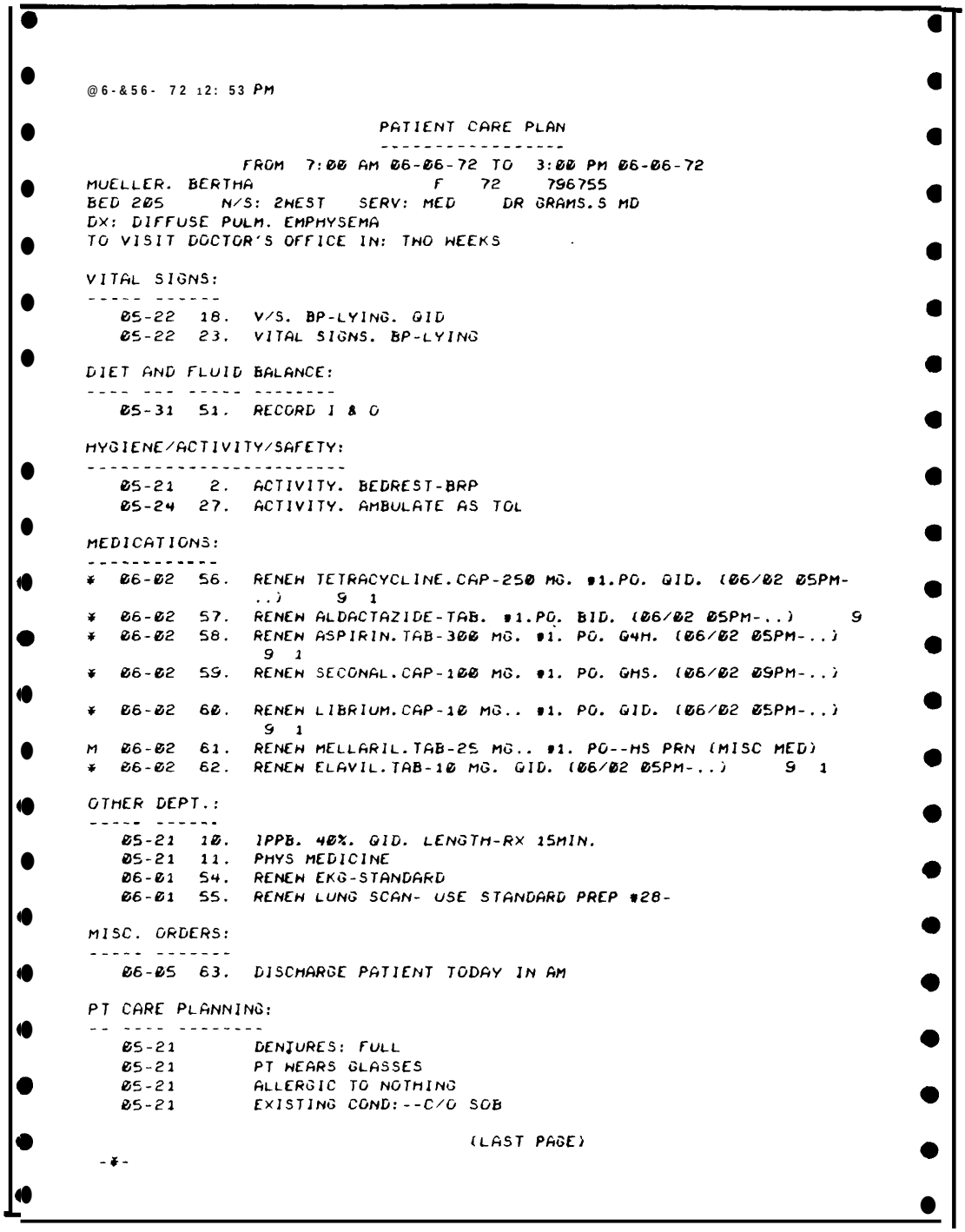
Figure 3–TMIS Printout of New Orders



```
03-16-72 12:11 PM
                              NEW MEDICAL ORDERS
MILES. NELSON APPLETON        M  86       18391925
   BED: 249B     N/S: 2NORT    SERV: SURG    CHILDS. W
   PRIMARY DIAGNOSIS: GALL BLADDER
   ENTERED BY: CHILDS. W
   TIME ENTERED: 03-16-72 12:10 PM

      X-RAY:  GALLBLADDER- USE STANDARD PREP #7-

      IPPB. AIR DILUTION

      ACTIVITY. AMBULATE

      DIET. REGULAR

      VITAL SIGNS. T-P-R/BP. Q30M

      IV'S  START  D5/RINGERS. 1000 ML. INFUSE OVER 8HR. THEN DC IV:
      ADD TO IV BOTTLE. COMPAZINE-INJ.100MG.IN IV

      CBC

      UA

      VDRL

      SMA-12  (PREP #1)

      DIGOXIN-0.25MG. IM. STAT

      SECONAL-INJ:  SECOBARBITAL-20MG. IM. QID  (03/16 01PM-,,)

      SECONAL-INJ:  SECOBARBITAL-20MG. IM  MR X1 FOR SLEEP

                                    ------------------------------
                                       DR. CHILDS. W

                                NOTED ------------------------------
-*-
```

SOURCE Technicon Corp

Figure 4--TMIS Patient Care Plan



```
@6-&56- 72 12: 53 PM

                              PATIENT CARE PLAN
                              -----------------
                  FROM  7:00 AM 06-06-72 TO  3:00 PM 06-06-72
MUELLER. BERTHA                    F    72     796755
BED 205      N/S: 2WEST    SERV: MED     DR GRAMS.S MD
DX: DIFFUSE PULM. EMPHYSEMA
TO VISIT DOCTOR'S OFFICE IN: TWO WEEKS

VITAL SIGNS:
----- ------
   05-22  18.  V/S. BP-LYING. QID
   05-22  23.  VITAL SIGNS. BP-LYING

DIET AND FLUID BALANCE:
---- --- ----- --------
   05-31  51.  RECORD I & O

HYGIENE/ACTIVITY/SAFETY:
------------------------
   05-21   2.  ACTIVITY. BEDREST-BRP
   05-24  27.  ACTIVITY. AMBULATE AS TOL

MEDICATIONS:
------------
*  06-02  56.  RENEW TETRACYCLINE.CAP-250 MG. #1.PO. QID. (06/02 05PM-
               ..)     9  1
*  06-02  57.  RENEW ALDACTAZIDE-TAB. #1.PO. BID. (06/02 05PM-..)     9
*  06-02  58.  RENEW ASPIRIN.TAB-300 MG. #1. PO. Q4H. (06/02 05PM-..)
                9  1
*  06-02  59.  RENEW SECONAL.CAP-100 MG. #1. PO. QHS. (06/02 09PM-..)

*  06-02  60.  RENEW LIBRIUM.CAP-10 MG.. #1. PO. QID. (06/02 05PM-..)
                9  1
M  06-02  61.  RENEW MELLARIL.TAB-25 MG.. #1. PO--HS PRN (MISC MED)
*  06-02  62.  RENEW ELAVIL.TAB-10 MG. QID. (06/02 05PM-..)     9  1

OTHER DEPT.:
----- ------
   05-21  10.  IPPB. 40%. QID. LENGTH-RX 15MIN.
   05-21  11.  PHYS MEDICINE
   06-01  54.  RENEW EKG-STANDARD
   06-01  55.  RENEW LUNG SCAN- USE STANDARD PREP #28-

MISC. ORDERS:
----- -------
   06-05  63.  DISCHARGE PATIENT TODAY IN AM

PT CARE PLANNING:
-- ---- --------
   05-21       DENTURES: FULL
   05-21       PT WEARS GLASSES
   05-21       ALLERGIC TO NOTHING
   05-21       EXISTING COND:--C/O SOB

                                    (LAST PAGE)
 -*-
```

SOURCE TechniconCorp

tern automatically produces labels for medications. Worksheets are printed for each ancillary service department; for example, the laboratory periodically receives lists of specimens to be picked up from patient care areas. TMIS automates the administrative tasks of admitting, transferring, and discharging patients. The system also provides reports on current bed status, that is, occupied and unoccupied beds.

A comprehensive business subsystem is part of the total TMIS system. The computer system automatically generates charges for services and supplies ordered and bills patients. It also provides for accounts payable, general ledger, budgetary control, inventory control, employee payroll, labor distribution, and workload statistics.

Patient Record. The individual patient's medical record is composed of both computerized and noncomputerized sections. Physician orders, cumulative medications, laboratory and X-ray reports, postoperative summaries, and admitting and discharge records are computerized. Printouts are produced for the paper medical record. Physicians' progress notes, most nursing notes, patient history, physical examination, and other materials are still recorded manually. The paper medical record, including the portions printed by TMIS, is maintained by the medical record department.

Patient data are stored in the active computer data files for **48** hours after a patient's discharge. These data are then transferred to magnetic tape for permanent storage. However, at present TMIS has no capability for long-term retrieval of an individual patient's record. (The Technicon system has incorporated this capability at several other hospitals.) A new computer record is started if the patient returns for another hospitalization. The paper medical record is used for pertinent information on previous care.

Priorities. Although TMIS has been operational at El Camino Hospital for the past 5 years, both hospital and Technicon personnel consider the system as, in many respects, still being developed. Priorities for new applications of TMIS at El Camino Hospital include:

- medical care and nursing audits;
- management functions, such as patient scheduling for ancillary services and optimal nurse staffing; and
- information to help physicians reach clinical decisions.

COMPUTER STORED AMBULATORY RECORD (COSTAR) SYSTEM

The Harvard Community Health Plan (HCHP) in Boston, Mass., is a prepaid group practice of 50,000 members that provides comprehensive medical care, including medical, surgical, and nursing services, laboratory and X-ray facilities, and emergency care. Since its establishment in **1969,** HCHP has collaborated with the Laboratory of Computer Science (LCS) at the Massachusetts General Hospital to develop and implement COSTAR at its Kenmore Center facility. Costs for development during the first **5** years of operation were **$2.5** million **(23).** Development of the system was supported by Federal grants. Currently, operational costs are paid by HCHP. The Laboratory of Computer Science has been responsible for

the technical support of COSTAR. However, HCHP has recently decided to assume complete operation of the system in the near future.

The computers used in the COSTAR system are medium-sized Digital Equipment Corporation computers, located at LCS. Data are stored on moving head disk storage units. Application programs are written in MUMPS, a high level computer language designed by LCS. Over 30 video terminals and 3 printer terminals are located in the HCHP facility.

The Harvard Community Health Plan uses COSTAR to provide most of the information it requires for both patient care and program management. The system is primarily designed to improve the availability of information for patient care with modest increases in cost. It also is used to assess quality of medical care and to carry out administrative functions.

Capturing Patient Data. Medical personnel are not themselves required to enter data into the computer. Instead they enter data on a sheet of paper called an encounter form at the time of a patient visit. Clerical staff use video terminals in the medical record department to enter all data from the encounter forms into the computer, Because items are preceded on the encounter form, these clerks do not need to extract appropriate data, and problems of transcription are minimized. By checking off items on the encounter form, the provider (either a physician or nurse) records the patient's problems, medications or other therapies, and disposition. Different encounter forms have been specifically designed for each of the major specialties. Information on the forms is organized according to a carefully defined and limited vocabulary (see figure 5).

The physician or nurse can add a line of text to any of the coded entries. To add more detailed comments, the provider can dictate findings regarding a problem. All additions will be associated with that problem and appear with it whenever the record is produced. For an initial health assessment or a routine checkup, the provider records the patient's vital signs and completes a checklist of demographic data. Including a brief statement about the patient's personal and social background is also an option. X-ray and electrocardiogram reports are recorded on separate encounter forms. Laboratory test results are entered through a terminal located in the clinical laboratory.

Retrieving Patient Data. The medical record department enters appointment lists for each provider into the computer. For **each** patient, COSTAR automatically produces a paper printout of summary data that is distributed to the physician prior to the scheduled appointment. The information included in the summary depends on the specialty group to which the physician belongs. A limited amount of text about each diagnosis is always included in the summary. For visits to some kinds of specialists, extensive text about the patient's major problems is also included.

The basic printout is a Status Report on the patient and includes (see figure **6**) **:**

- identification data;
- up to three lines of background information;
- . a problem list with the total number of visits for each problem and the date of the last visit;
- current and past medication therapy;

Figure 5–HCHP Encounter Form for the Internal Medicine Department

4) SITE
A____ MH-PH
B____ CAMBRIDGE
C ✓ KENMORE
D____ KEN. TRIAGE
E____ CHMC
F____ PBBH
G____ BLI
H____ BI
J____ HOUSE CALL
K____ OTHER_____

5) TYPE
A ✓ SCHEDULED
B WALK-IN
c TELEPHONE
D____ CANCEL LEO
E____ DNK
F____ CALL-IN
G____ IN-PATIENT
H____ EW
I NON-ENCOUNTER
J GROUP

NAME: Record, Sample Enr
UNIT: Ø7-39-Ø7 I
DATE: 4/4/75 DOB:
PROV #1: Plotkin
PROV #2: Imbernino
(if seen)

ABOVE MUST BE COMPLETE FOR INPUT

6) Hospital or EW Visit Approved: — Yes — No

********** THIS INFORMATION FOR FIRST VISIT PRIMARY PROVIDER ONLY **********

7) PRIMARY MD Plotkin 8) PRIMARY RN Imbernind

9) RACE: A X CAUCASIAN B BLACK c SPANISH SPKG o OTHER____

10) MAR.STATUS: A SINGLE B X MARRIED C WIDOWED D____ SEPARATED E____ DIVORCED

11) # OF CHILDREN Ø 12) PT. OCCUPATION Staff acct. - Boston based consulting firm

PERSONAL BACKGROUND OF PATIENT - Only for primary providers
(To change, rewrite entire section; max. three lines. Do not repeat above data.)

Pt is a fairly active person, generally healthy and feeling well. More physically active in summer - tennis, swimming. Commutes from southern New Hampshire during summer

********** TO BE COMPLETED FOLLOWING EACH VISIT **********

40) DISPOSITION
Future appt w/ _____ in
(provider's full name)

A____ DAYS B____ WEEKS C____ MONTHS D____ PRN

E____ PT to call MD G____ PT to call RN
F____ MD to call PT H____ RN to call PT
I____ Other _____

REFERRALS

42) INTERNAL HCHP CONSULTATION

Consultation w/ Urology #L993
(enter specialty and provider's last name, if specified)

Consultation w/ _____
(enter specialty and provider's last name, if specified)

(IF A CONSULTATION NOTE IS NECESSARY, INCLUDE REASON FOR CONSULT IN ROUTINE DICTATION)

43) REFERRAL TO OUTSIDE AGENCY - NON-HOSPITAL

_____
enter full name & address of physician and/or agency)

DOCUMENTS TO BE FORWARDED : _____

44) HOSPITAL ARRANGEMENTS (make a choice in each column)

A____ BETH ISRAEL
B____ PBBH
C____ BOSTON HOSPITAL FOR WOMEN
D____ CHMC
F____ UNAFFILIATED

1.____ EMERGENCY WARD
2.____ URGENT ADMISSION
3.____ SCHEDULED ADMISSION

Date of Admission (if known) _____

45) SUPPORTIVE SERVICES

A____ HOMEMAKER C____ HOMECARE
B____ VNA D____ TRANSPORTATION

46) DICTATION _____ 47) REVIEW OF CHART _____

48) FOLLOW-UP IMPORTANT _____

(continued)

Figure 5 **(continued)**

INTERNAL MEDICINE DIAGNOSES & PROBLEMS

(M=Major, O=Omit from Status Report, P=Presumptive, S/P=Status Post, R/O=Rule Out, I=Place on Inactive List. Simple check=minor)

60, Height 69 ins. 61. Weight 176 lbs. 62. Pulse/Min 72 63. Temp. ———

64. Blood Pressure 1. 120/75 2. ——— 3. 4. ——— 5. ———
(state whether lying standing, sitting, etc.

GENERAL

✓	A6ØØ	IHA generally healthy P.E. WNL
	A8ØØ	PHR
	A99Ø	Dx deferred (state features)
	A8Ø1	No demonstrable disease (explain)
	A8Ø2	Exam for certificate
	A128	Rx refill only
	AØØ3	Immunization only
	A8Ø3	Test results only
	AØ19	Positive family Hx (specify)
	A81Ø	Health education
	AØ2Ø	Abnormal t. result (specify)
	A8Ø4	Lab test not performed (specify)
	A811	Pt. left without being seen
	A812	Pt. refused Rx (specify)

THYROID

	B21Ø	Goiter
	B151	Hyperthyroid
	B152	Hypothyroid
	B153	Thyroid nodules(s)

ENDOCRINE METABOLIC

✓	A15Ø	Obesity would like to lose at least 10#
	B12Ø	Diabetes mellitus
	B18Ø	Hypoglycemia
	B16Ø	Hypercholesterolemia
	BØØ5	Hyperlipoproteinemia
	B178	Hyperuricemia
	NØ11	Gout

URINARY

	L1Ø1	Urinary tract infection
	L1ØØ	Bacteruria, asymptomatic
	L29Ø	Urethritis
	L22Ø	Benign prostatic hypertrophy
M	L993	Hematuria

OTHER DIAGNOSES

S/P	ODØ1	Appendectomy - 1957
	ODØ2	
	ODØ3	
	ODØ4	

FREE TEXT COMMENTS ON DIAGNOSES, PROBLEMS & PROCEDURES

DIAGNOSTIC CODE	Comments (6Ø characters each)
1. L993	No previous hx prior 1 wk. In process of evaluation
2. ———	
3. ———	

SOURCE Laboratory of Computer Science, Massachusetts General Hospital

. laboratory test and X-ray results; and

• consultations requested but not yet recorded.

The individual provider can request data in other formats as well, such as the report of a previous visit, laboratory results not associated with a previous visit, or a flowchart of a particular problem, laboratory test, or medication.

In addition to the printed record, videoscreen terminals located in every area of patient care allow the provider to obtain immediate access to any part or all of the computer record. The video terminal is most often used for reviewing an extensive record or obtaining information about patients without scheduled appointments. Entry to terminals does not require a password or other identification. However, they are located in areas where they can be monitored by professionals.

Administrative and Business Functions. Managerial requirements for data at HCHP are determined by both its organization as a prepaid plan and its highly mobile population; there is a 20 percent membership turnover each year. COSTAR provides data on current enrollment, certification of claims, and appointments. The computer produces a variety of administrative reports and statistical analyses for reviewing utilization, budgeting, and manpower and facility planning. Although COSTAR itself produces bills for the few patients who pay fee-for-service, other computer systems perform business services such as cavitation billing, payroll, and financial reports.

Patient Record. The COSTAR system stores all patient data generated at HCHP. Parallel information is not kept in a paper medical record. The medical record room maintains files, however, for copies of letters or discharge notices from other physicians or hospitals, electrocardiogram tracings, and other materials that are not computerized. Patients' records are stored on computer disks in the COSTAR system indefinitely for all current members. For permanent storage, former members' records are put on disks that are not connected to the central processing unit.

Priorities. HCHP's priority is to expand its use of COSTAR for reviewing the quality of medical care given to patients. Under a current experimental program, COSTAR monitors the data files of patients with several specified conditions, Standards for treatment were developed by a committee at HCHP and programed into the computer. If the care being given deviates from these standards, reminders are printed out to physicians. Work is in progress to add computer protocols for additional medical treatments. HCHP also plans to duplicate the COSTAR system at another HCHP facility in Cambridge, Mass.

PROBLEM-ORIENTED MEDICAL INFORMATION SYSTEM (PROMIS)

The demonstration site for PROMIS is the Medical Center Hospital, a 450-bed teaching hospital at the University of Vermont in Burlington. The PROMIS Laboratory, located at the University, designed and implemented the system. Development began in **1967,** and PROMIS was installed and used in a 20-bed gynecology ward in the hospital from 1971 to 1975. During the 4 years of its operation on the ward, PROMIS was also implemented in the ancillary service departments most frequently used: radiology, the clinical laboratory, the pharmacy, and in the doctors' lounge where surgeons entered their notes after operations. Secretaries on the ward acted

Figure 6–COSTAR Patient Status Report

```
                                RECORD, SAMPLE ENR-(M)
EFF 1/75              PRIMARY MD PLOTKIN          07-39-87-I
GRP FFS               PRIMARY RN IMBERNINO        56 YRS.-DOB:1/2/1919

LCS MGH, BOSTON 02109 TEL:726-3933
RACE:CAUCASIAN
MAR STATUS:MARRIED
# OF CHILDREN:0
PT OCCUPATION:STAFF ACCOUNTANT, BOSTON BASED CONSULTING FIRM
PT IS A FAIRLY ACTIVE PERSON, GENERALLY HEALTHY AND FEELING
WELL.  MORE PHYSICALLY ACTIVE IN SUMMER - TENNIS, SWIMMING.
COMMUTES FROM SOUTHERN NEW HAMPSHIRE DURING SUMMER.  4/4/75

9600  INITIAL HEALTH ASSESSMENT  GENERALLY HEALTHY, P.E. WNL
                                                  4/4/75 (PLOTKIN: M.D.)


MAJOR PROBLEMS
1993 HEMATURIA NO PREVIOUS HX PRIOR 1 WK. IN PROCESS OF EVALUATION
                                  4/1/75-2-4/4/75  (PLOTKIN: M.D.) #D


MINOR PROBLEMS
A150 OBESITY WOULD LIKE TO LOSE AT LEAST 10 POUNDS
                                                  4/4/75  (PLOTKIN: M.D.)
P666 TOBACCO ADDICTION 1 PACK PER DAY              4/4/75 (PLOTKIN: M.D.)


INACTIVE  PROBLEMS
S100 S/P APPENDECTOMY 1957                        4/4/75 (PLOTKIN: M.D.)


CURRENT THERAPY
R010 FLUIDS 8 GLASSES PER DAY                  4/1/75 (GOLDSMITH: R.N.)


TEST RESULTS
4/4/75   R070  PYELOGRAM (IVP)
                NORMAL, NO EVIDENCE STONE, CALYCES NORMALLY VISUALIZED
         N204  URINALYSIS INCL MICRO  10-20 RBC/HPF  (2) #A
4/1/75   B100  URINE CULTURE        NO GROWTH
         A156  WHITE BLOOD COUNT    8900
         A128  HEMOGLOBIN           14.1
         A127  RBC                  4.4
         A126  HEMATOCRIT           39

CONSULTATIONS AND REFERRALS
UROLOGY 4/4/75 (PLOTKIN) FOR L993

. . . . . .
```

SOURCE Laboratory of Computer Sciences Massachusetts General Hospital

as intermediaries for departments that were not included in the computer system.

Hardware used when the system operated on the gynecology ward included two large Control Data Corporation computers and 14 touch-sensitive video terminals. Program languages (MACRO assembly, HIP, and SETRAN) developed by the Control Data Corporation were used. The PROMIS staff itself did the application programing. The entire system was updated by the PROMIS Laboratory in 1975 and implemented on an internal medicine floor at the end of 1976. The new system uses Varian minicomputers and high-speed Megadata touch screen terminals. Data are maintained on disk storage. Application programs are written in PPL, a new language developed by the PROMIS Laboratory.

Support for development of PROMIS has been provided under grants, and currently a contract, from the National Center for Health Services Research. Total funding through FY **1976** was approximately $4 million. Additional resources have been provided by the Robert Wood Johnson Foundation and the University of Vermont College of Medicine.

Capturing Patient Data. PROMIS is unique in two respects. It not only radically restructures the medical record, but also directs the process of clinical care. The PROMIS Laboratory staff developed these capabilities in order to address problems hindering the provision of medical care: dependence on the physician's memory, ineffective organization for massive amounts of medical data, and lack of meaningful feedback about the appropriateness of care.

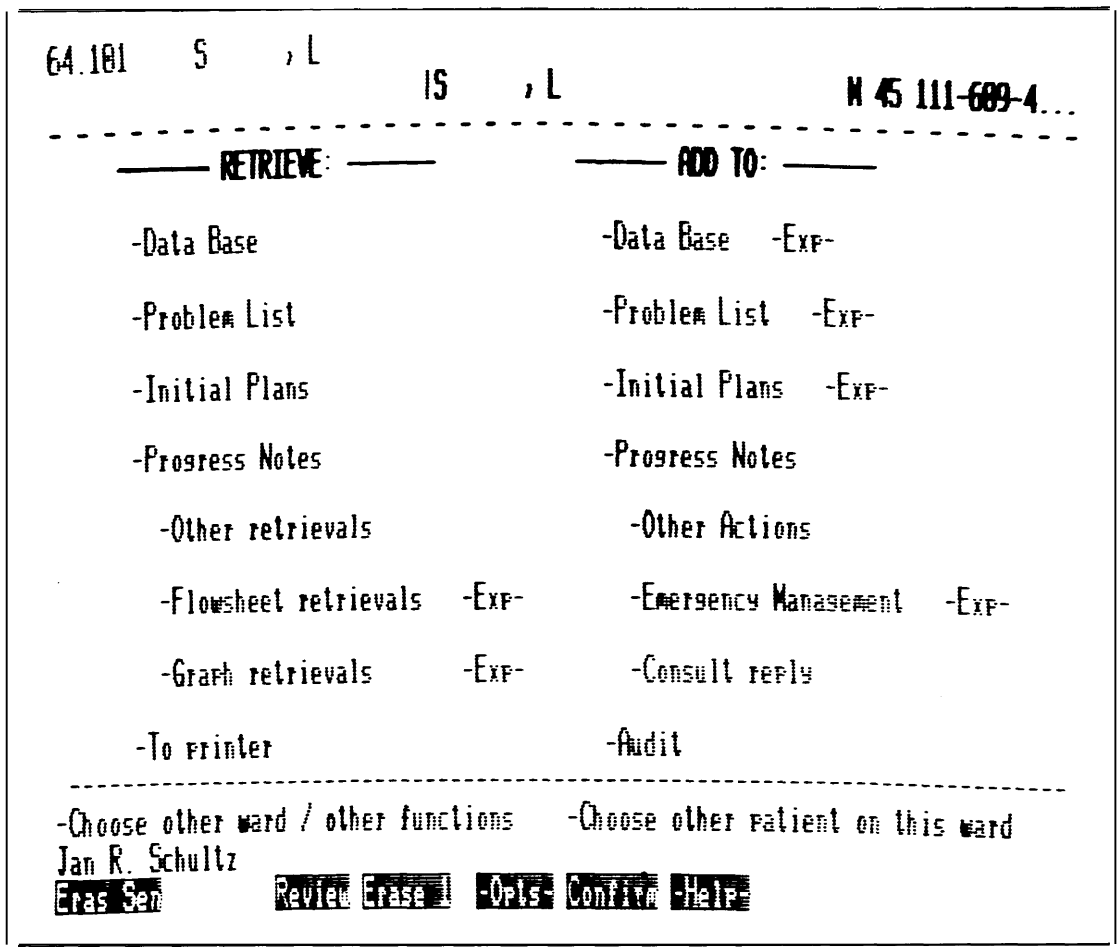
In PROMIS, data are organized by patient problem. The computer record is structured around four phases of medical action: an initial data base on each patient, including medical history and physical examination; a list of the patient's problems; diagnostic and treatment plans for each problem; and *progress notes* **on** each problem indicating how the patient is progressing during therapy. Except for the initial data base, every entry into the computer record is associated with a particular problem of the patient. Thus, when a technician enters the result of a laboratory test, the data are entered under the problem for which the test was initially ordered. By structuring the record in this way, all information pertinent to a problem is organized logically for review by the physician and other medical care professionals.

Personnel enter data about patients through video terminals. The videoscreen of the terminal displays an array of choices, and the provider makes a selection by touching the screen. Data are entered by the medical care professionals who originate them. For example, physicians and nurses enter notes about the patient's progress, radiologists enter notes as they read films, and technicians in the clinical laboratory enter results of tests. In addition, patients enter their own medical histories. Each staff member has a unique identification code that allows entry and access only to those parts of the computer record necessary for the provision of care.

PROMIS guides these medical care professionals in structuring the vocabulary, content, and organization for the patient computer record. This guidance is accomplished through the display frames viewed on the videoscreen that providers use to enter data. Sequential frames are displayed according to logic algorithms (decision trees) programed in PROMIS. The information **shown** in a particular frame depends on the choice selected in the previous frame. The answers a provider gives to questions, not the providers themselves, determines what frame appears next. The display frame sequences guide the provider through logical pathways and ensure that notes and orders are complete.

The videoscreen first shows the provider a master frame (see figure 7). From this frame, the provider selects a category of information and chooses whether data are to be added or retrieved from the computer patient record. To enter information about a new problem, for example, a physician would touch' 'problem list" from the "add to" column. A system of the body, cardiovascular for example, is then chosen. The subsequent frame would show possible diagnoses for the cardiovascular system (see figure 8A). If "hypertension" were chosen from the list of possible diagnoses, the frame shown in figure 8B would appear to request more information. This communication between the physician and display frames would continue until a complete narrative description of the problem had been generated. Figure 9 shows such a narrative that has been retrieved on the problem "cirrhosis. "

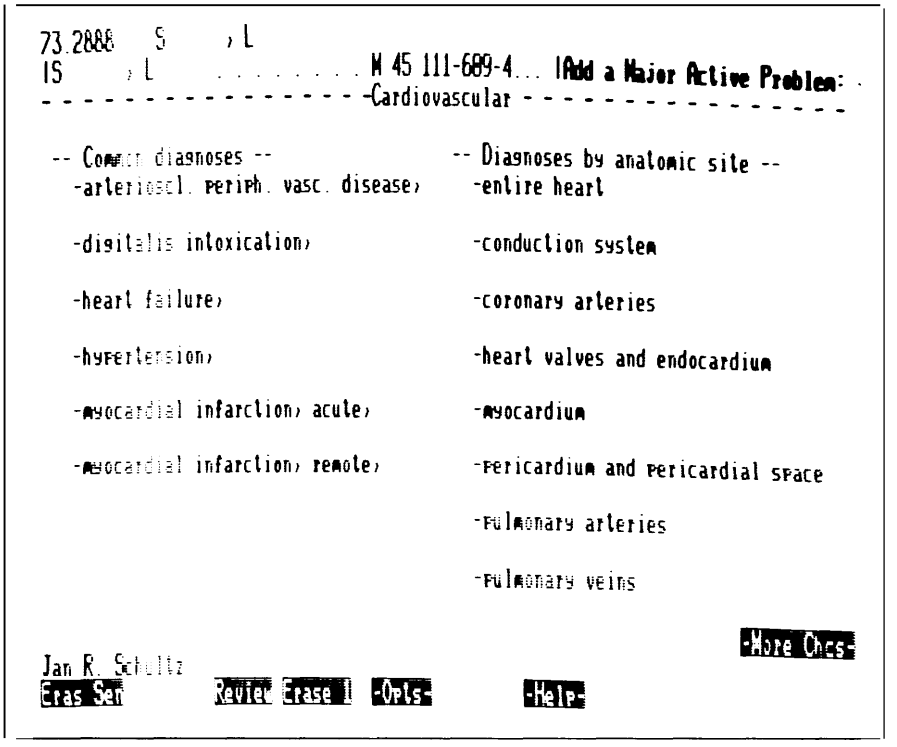
Figure 7– PROM IS Master Frame



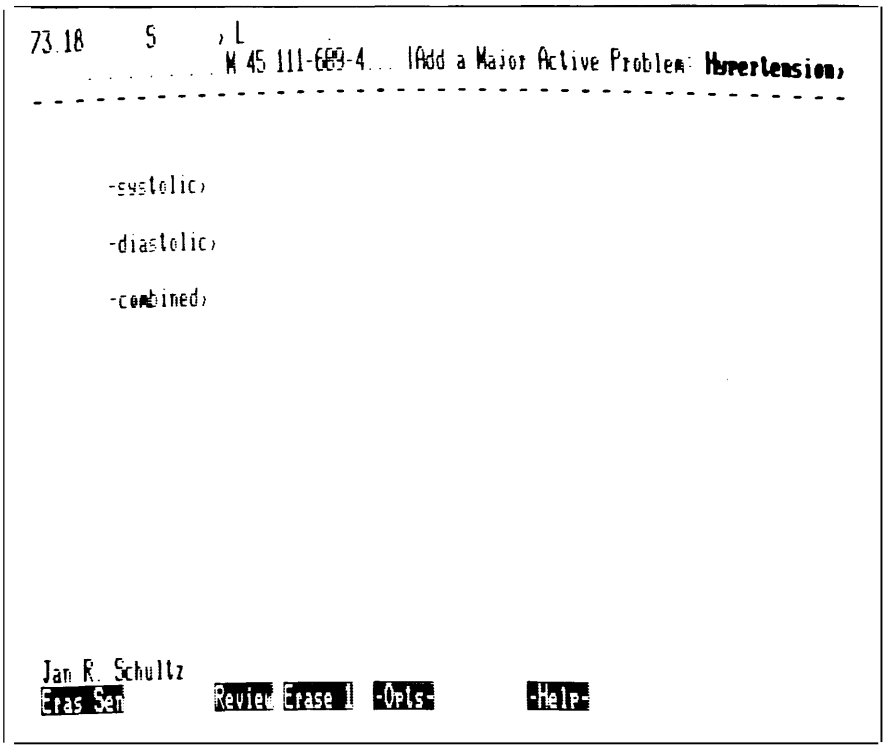
SOURCE PROMIS Laboratory

Figure 8– PROMIS Display Frames for Entering Data About a Patient Problem

8A

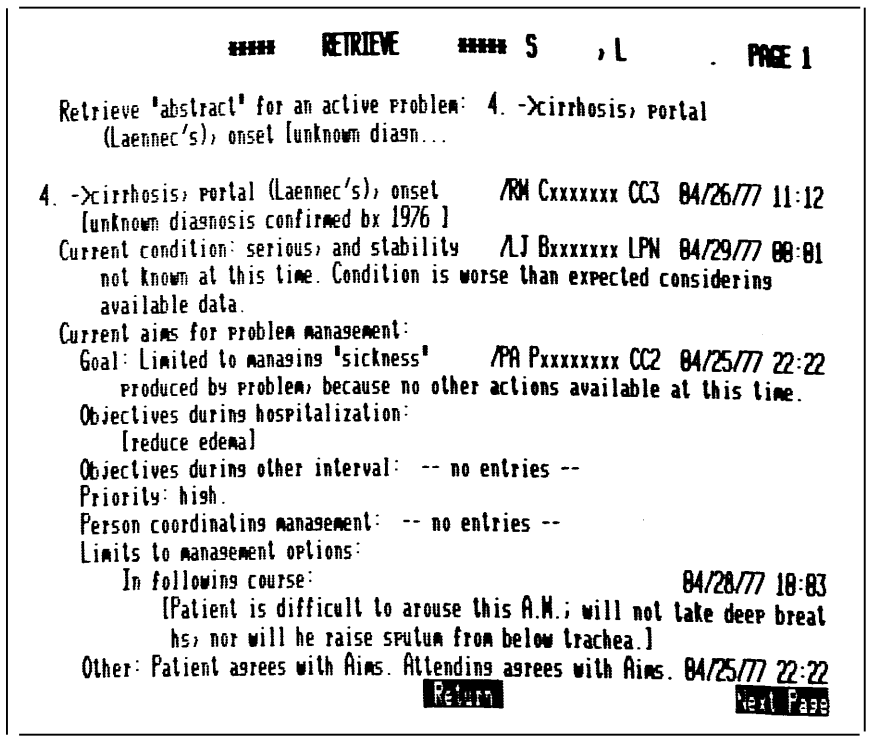


8B



SOURCE PROMISLaboratoty

Figure 9–PROMIS Narrative on a Patient Problem



SOURCE: PROMIS Laboratory

Along with the sequenced display frames that guide medical care personnel in entering data about the patient, PROMIS supplies display frames that present medical knowledge. Only medical knowledge appropriate to a specific problem and clinical action is shown because "medical content" frames are carefully programed and integrated with data entry frames. This integration ensures that physicians receive medical knowledge automatically.

When the physician orders a drug, for example, the ''medical content" frames would indicate such information as side effects, drug and test interactions, cost, and usual dosage. Display frames on laboratory tests list risks, normal ranges of results, costs, and contraindications. Medical content frames help to diagnose a particular problem by suggesting possible diagnoses and tests that would rule out some possibilities. Finally, medical content frames on treatment and follow-up care for particular problems or diagnoses give the physician options for action.

Medical content frames are rigorously researched before they are entered into the computer system. Recognized experts in the relevant field review the frames for completeness, accuracy, and currency. The display frames also include numbered references to medical literature available in the university medical library. Currently, the PROMIS "library" includes over **33,000** frames. Medical literature is constantly reviewed, and if recent articles dictate any changes, the PROMIS staff enters the new information on display frames.

Retrieving Patient Data. Patient data can be reviewed on the videoscreen terminals or on hard copy printed out by printer terminals. Because all data are linked to a particular problem of the patient, the information in the computer record is

well-defined and structured. Data can thus be obtained by almost any parameter required. A physician can review progress notes by problem over time, a pharmacist can review current medications, and a nurse can obtain all outstanding orders by problem for each patient. A display frame showing a patient's current outstanding laboratory tests is shown in figure 10.

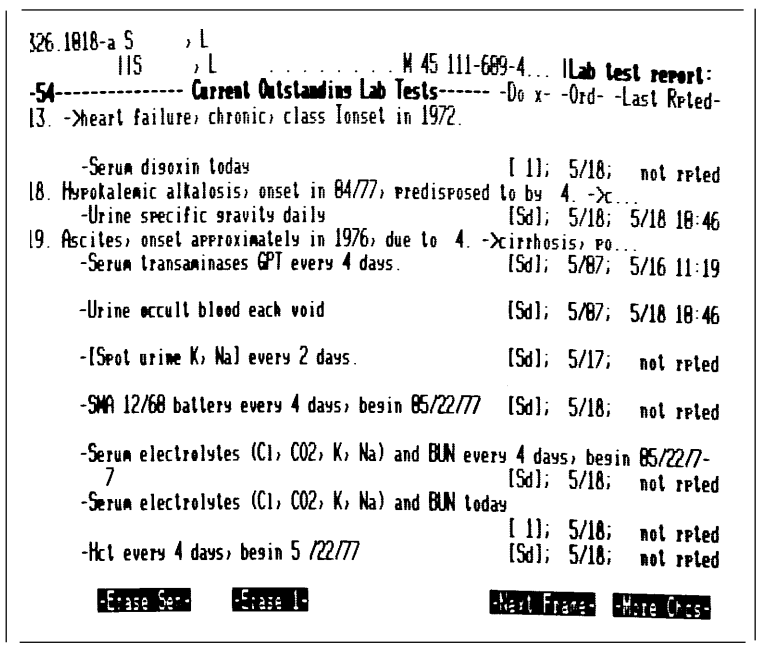
Communication and Administrative Functions. PROMIS routes messages between areas of patient care and ancillary service departments. Currently, PROMIS does not incorporate administrative functions, such as payroll and accounting. Because entries of procedures, services, drugs, and tests can be associated with charges, a business subsystem could be integrated into the computer system. The design of PROMIS could permit the addition of such functions as patient scheduling, automatic laboratory reporting, and other applications in the future.

Patient Record. All data that are recorded about the patient are stored in the computer record. In addition, because every entry shows date, time, and staff member who entered it, the process of medical care is clearly documented for future audit. Computer records are maintained indefinitely on disk storage. Because PROMIS was installed in only one service, paper medical records were also kept.

Priorities. PROMIS is still in the developmental stage, although it has been shown to be technically feasible. Priorities of the PROMIS Laboratory for the continued development of PROMIS include:

- implementing the system throughout a hospital;
- continued development, validation, and maintenance of the medical content display frame "library;" and
- incorporation of medical audits to ensure quality of care.

Figure 10– PROM IS Display of Outstanding Laboratory Tests



SOURCE PROMIS Laboratory