Development and implementation of a medical/management information system at the Harvard Community Health Plan

by NORMA JUSTICE, G. OCTO BARNETT, ROBERT LURIE and WILLIAM CASS

Massachusetts General Hospital and Harvard Community Health Plan
Boston, Massachusetts

The Harvard Community Health Plan (HCHP) is a multi-clinic prepaid group practice currently serving 37,000 greater Boston subscribers. The original clinic in Kenmore Square, Boston opened in October, 1969. A second clinic opened in Cambridge in July, 1973, in order to meet a projected subscriber population of 75,000 by 1977.

DESIGN GOALS

Since the founding of HCHP, representatives of the Laboratory of Computer Science (LCS) at Massachusetts General Hospital and the Harvard Plan have participated in a joint effort to design and implement an optimal computer-based medical records system. The objectives they accepted were those of any traditional medical record system:

1. to provide a mechanism for the recording, storage, and retrieval of information necessary for patient care;
2. to meet the administrative needs of health care management.

Over the last fifty years, medical practice has changed from the single family physician to the concept of a team of medical care specialists, working in a co-ordinated fashion. Because of the multiple physician/patient relationships this implies, the medical record has come to occupy a key role in care delivery. This is particularly true in a prepaid group practice where there is strong emphasis on health maintenance and continuity of care, and where medical services are rendered by a number of specialized health care professionals. Similarly, the need for accurate and timely information collection and analysis are essential for the health plan management to determine eligibility and to assess patterns of care being delivered.

Measured against the needs of both the providers and the administrators, the classical paper-based medical record is often grossly deficient, cumbersome, and expensive to maintain and control. The over-all objectives of the project are to develop a computer-based system that can serve both primary patient care and administrative needs, be less expensive both in terms of provider time and medical record room costs, and provide a base for expansion to eventually support all the information processing needs of the HCHP.

The particular advantages a computer-based system offers include the following:

1. An accurate, up-to-date, and readily accessible registration and patient identification system is maintained. The membership file is the source of administrative data which provides health center management with statistical and billing information for successful management and planning.
2. The medical record information is not stored in a single physical document which is available at only one geographical location at any single point in time; instead, the information is stored in a dynamic information base which can be instantaneously updated and displayed from many different locations simultaneously.
3. The computer system can be used to organize the medical information by any of a number of different rules or algorithms. The information can be summarized to correspond to the particular problems of the patient or the particular needs of a specialty in sharp contrast to the strict chronological organization of the classical paper-based system.
4. The computer system assists in the primary care process by collecting existing data which should be brought to the provider's attention, e.g., reports of all abnormal laboratory test results, identification of patients receiving certain medications which should be discontinued, and identification of patients with certain characteristics warranting special consideration.
5. The computer-based system facilitates the HCHP commitment to an active program of quality assurance by monitoring particular case activities as to conformance to pre-defined standards of patient care. When deviations from the specified standards occur, the computer system can flag this information, and bring it to the attention of the provider.
6. The importance of supporting services such as laboratory test reporting, patient scheduling activity, and claims processing is recognized in this unified system since data need be collected and entered only once to be available for all functions.

7. The availability of a comprehensive, accessible data base is an essential factor to facilitating research into the delivery problems of ambulatory care, the promise of which was one of the essential motivating factors which originally led to the establishment of the HCHP.

8. The management, filing, assembling, and distribution of paper medical records can be a costly procedure, since it is labor-intensive, and since above a certain level even marginal improvements reflect significant cost increments. The expectation is that the computer-based system will prove to be a less expensive method of collecting, storing and retrieving this information.

In summary, the computer-based medical record system developed at HCHP satisfies the dual goals of providing both the data necessary to keeping valid, timely, and readily accessible information needed for routine and emergency care in an ambulatory practice, and the data necessary for management and supervision of a health care delivery system. It must be emphasized, however, that the computer-based system is a developmental activity. The essence of the system is not just its technological challenge, but its radically different approach to the combination of data recording and retrieval patterns by its users.

EVOLUTION

It should be understood that the HCHP M/MIS is not the result of a recent one-time project. Rather it is an evolutionary development effort that is dedicated to a continuing improvement in health care services through the use of computerized medical records.

This record system has evolved in phases, with the latest enhancements reflecting the fourth phase. Each step has allowed the realization of additional record system objectives while maintaining established system reliability and while simultaneously, the feasibility of the next evolutionary step was being explored.

The first phase, which began in 1969, was in essence a duplicate system using both a paper-based medical record and a computer-based information system. Originally, this redundancy was required because the reliability and provider acceptance of a computer-based system had yet to be demonstrated.

Initially only data entry was on-line, being executed from Teletype terminals in the medical records room. All retrieval of computer-based records was in batch mode. Although it obviously had far to go to be ideal, the first phase did allow the achievement of several record system objectives. A structured, organized, legible medical record was instituted as the basis for peer review activities. In addition, it was firmly established that a computerized medical record was acceptable to physicians and nurses at the HCHP.

Significant difficulties, however, were encountered in maintaining the duplicate system. Whereas data collection procedures for the computer system worked well, the paper-based system never kept up-to-date the assembling and filing of the profusion of patient transactions. Neither could the paper record be delivered in time for non-scheduled visits or telephone encounters. The paper record was often incomplete, particularly regarding care activities in the recent year. When complete, it was too frequently unavailable to the provider. In addition, it became obvious that the manual collating, filing, and assembling of information necessary to the maintenance of an up-to-date record was one of the most expensive activities of the record system.

In 1972, a second phase of development introduced Cathode Ray Tubes into the clinical areas for the first time, thus allowing a physician or nurse to directly recall a summary subset of a patient's medical record from the computer's files. In 1973 a phase was introduced allowing providers to search through all encounter reports (a record of the patient's visit) and to flow chart (chronologically list) diagnoses, test results, and vital signs. This offered providers the opportunity of directly accessing a patient's complete computer medical record when the paper record was unavailable or incomplete.

A vital benefit of phase one through three was to prove that it was possible to realize a high degree of real-time system reliability and that the HCHP providers could work successfully with a computer-based system. With this encouragement, a fourth phase was begun—a system designed to maximize the use of computer-stored information and to minimize the use of the paper-based document. The most significant enhancement was the approval to greatly expand the medical content of the computer-based information system by including the physician's dictated comments and use the computer data bank as the primary storage repository for medical records information.

MEDICAL SYSTEM

The fourth and latest phase of development will be implemented in February, 1974. Basically this phase includes the addition of dictation provisions and new expanded encounter forms. The primary objective of the new medical system is that the relevant medical information be available to the provider at or before patient arrival (encounter).

This information will be made available to the provider in two different formats: (a) as computer-generated reports when there is several hours notice as in the case of scheduled visit, or (b) on the CRT for all telephone consultations, walk-in visits or when additional information is desired to supplement computer-generated reports.

Patients cause an encounter report to be added to the medical record by a visit or a telephone consultation with a provider or other health center professional. In each case,
**NUCRSS-5**  
**CLINICAL RECORD SUMMARY**  
**NUMBER 5**

Please look at the last page and consider the comments and suggestions. Feel free to correct or comment on this summary.

Thank you,  
Dr. Olga M. Haring

---

**TABLE OF CONTENTS**

### PROBLEM LIST: PAGE 3
- Vital Signs: Page 4
- Cardiac-Pulmonary-Renal Diagnoses: Page 4
- Treatment: Page 5
- Routine Lab Tests: Page 6
- Other Lab Tests: Page 7
- Suggestions: Page 8

### PATIENT IDENTIFICATION

John Doe  
37 y/o, O/B: Black  
0000 Nowhere, U.S.A.  
Phone: XXX-XXXX

- First Visit to NUC: 04-13-73  
- Last Visit to NUC: 08-16-73  
- Last Complete P.E.: 04-13-73

### LAST HOSPITAL ADMISSION

- Hospital:  
- Date Admitted: 12-29-68  
- Date Discharged: 01-10-69

### PROBLEMS IN ALL ORGAN SYSTEMS AND VISITS TO MANAGING CLINICS

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>DATE NOTED</th>
<th>MANAGING CLINIC</th>
<th>LAST NOTED</th>
<th>STATUS</th>
<th>DISPOSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>01. Hypertension</td>
<td>07-10-68</td>
<td>CPR</td>
<td>07-12-73</td>
<td>ACTIVE</td>
<td>RX on P5</td>
</tr>
<tr>
<td>02. Alcoholism</td>
<td>05-27-69</td>
<td>CPR</td>
<td>05-21-71</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>03. Lymphoma</td>
<td>07-36-66</td>
<td>CPR</td>
<td>08-02-73</td>
<td>ACTIVE</td>
<td>RX on P5</td>
</tr>
<tr>
<td>04. Sprain LT. ANKLE</td>
<td>08-30-71</td>
<td>ORTHO</td>
<td>---</td>
<td>RESOLVED</td>
<td>---</td>
</tr>
<tr>
<td>05. Osmolality, LT. HAND</td>
<td>08-13-68</td>
<td>DERM</td>
<td>08-13-68</td>
<td>RX on P5</td>
<td>---</td>
</tr>
<tr>
<td>06. Obesity, Mild</td>
<td>09-04-68</td>
<td>CPR</td>
<td>09-09-68</td>
<td>ACTIVE</td>
<td>---</td>
</tr>
<tr>
<td>07. Tinnitus</td>
<td>04-13-73</td>
<td>CPR</td>
<td>10-13-72</td>
<td>ACTIVE</td>
<td>RX on P5</td>
</tr>
<tr>
<td>08. Headaches</td>
<td>09-10-71</td>
<td>NERVO</td>
<td>10-25-73</td>
<td>RX on P5</td>
<td>---</td>
</tr>
</tbody>
</table>

### TEMPORARY PROBLEMS

- Inflammatory skin changes

### VITAL SIGNS AT RECENT VISITS

<table>
<thead>
<tr>
<th>DATE</th>
<th>MEASUREMENTS</th>
<th>CLINIC</th>
<th>DOCTOR</th>
<th>STUDENT</th>
<th>WT</th>
<th>BS-S</th>
<th>PULS</th>
<th>TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>04-13-73</td>
<td>174/130/92</td>
<td>BROWN</td>
<td>CPR</td>
<td>174</td>
<td>130/92</td>
<td>---</td>
<td>98.4</td>
<td></td>
</tr>
<tr>
<td>01-19-73</td>
<td>176/140/110</td>
<td>LEVINE</td>
<td>CPR</td>
<td>176</td>
<td>140/110</td>
<td>---</td>
<td>98.8</td>
<td></td>
</tr>
<tr>
<td>10-13-72</td>
<td>177/149/114</td>
<td>WALKER</td>
<td>CPR</td>
<td>177</td>
<td>149/114</td>
<td>SIT</td>
<td>98.0</td>
<td></td>
</tr>
<tr>
<td>08-11-73</td>
<td>175/140/118</td>
<td>SMITH</td>
<td>CPR</td>
<td>175</td>
<td>140/118</td>
<td>SIT</td>
<td>98.6</td>
<td></td>
</tr>
<tr>
<td>01-14-12</td>
<td>173/130/92</td>
<td>BROWN</td>
<td>CPR</td>
<td>173</td>
<td>130/92</td>
<td>SIT</td>
<td>98.2</td>
<td></td>
</tr>
<tr>
<td>06-16-72</td>
<td>175/150/104</td>
<td>BROWN</td>
<td>CPR</td>
<td>175</td>
<td>150/104</td>
<td>SIT</td>
<td>98.0</td>
<td></td>
</tr>
<tr>
<td>06-09-72</td>
<td>174/150/98</td>
<td>BROWN</td>
<td>CPR</td>
<td>174</td>
<td>150/98</td>
<td>SIT</td>
<td>97.8</td>
<td></td>
</tr>
<tr>
<td>06-14-72</td>
<td>179/160/120</td>
<td>BROWN</td>
<td>CPR</td>
<td>179</td>
<td>160/120</td>
<td>SIT</td>
<td>98.0</td>
<td></td>
</tr>
<tr>
<td>01-21-72</td>
<td>175/150/108</td>
<td>MUNTER</td>
<td>CPR</td>
<td>175</td>
<td>150/108</td>
<td>SIT</td>
<td>98.6</td>
<td></td>
</tr>
</tbody>
</table>

### CARDIAC-PULMONARY-Renal Clinic

- First Visit to CPR: 10-20-68  
- Last Visit to CPR: 04-13-73  
- CPR Visit Scheduled for: 11-10-73

### Diagnoses

- Heart Disease
- Essential Hypertension
- Asthma
- Renal Disease
- Chronic Kidney Disease

---

**Figure 1**

From the collection of the Computer History Museum (www.computerhistory.org)
new information is captured by the provider on an encounter form which has now been expanded to allow more self-
encoding and to include biographic information. Each en-
counter is maintained as a separate entry in the medical
record. All data, including dictation, from any encounter is
available upon request either on hard copy or as a CRT
display.

Information such as laboratory test results, X-ray findings,
and ECG results are, of course, recorded on separate forms designed to code the appropriate results.

The status report (Figure 1) is a summary of the patient's medical history and can be viewed as both a brief summary of important administrative and medical data which can be scanned in seconds and as a table of contents to the patient's complete medical record. Nine categories of information are contained in this important document:

1. Registration information
2. Primary provider
3. Social and demographic data
4. Diagnoses and problems list
5. Hospitalizations
6. Current therapy
7. Therapy history
8. Test results
9. Consultations and referrals.

This group of computer-generated reports provided before a patient visit will include all information deemed relevant by each specialty group. For example, in internal medicine, it will be comprised of the status report, the last encounter report to the primary provider, all intervening encounter reports, the last encounter report for each major problem, and a laboratory test summary. The service-level design goal is that for over 90 percent of the typical patient care visits, the computer reports generated and delivered prior to an encounter will be sufficient. If further information is needed, the CRT may be used to access all previously recorded medical information stored in the computer.

As a better understanding of the particular needs of each specialty group and of particular medical problems is reached through the use of the system and feedback from its users, other standard computer-generated reports will be created. For example, flowchart presentations—the chronological listing of the diagnoses, tests, or therapies related to a specific problem of a specific patient—will be provided routinely for pediatric visits (e.g., height and weight growth charts) and for prenatal visits. In process of development is a flowchart presentation for the routine management of the patient with hypertension.

No medical records system is adequate that has not provided for prompt updating of patient records. To be effective and establish credibility with the user, the record must be current and comprehensive in addition to being accurate. A control system has been developed by the HICHP management that ensures that an encounter form has been input within established time limits.

**MANAGEMENT SYSTEM**

In addition to medical information the patient file contains administrative data which provides health center management with statistical and billing information vital to successful management and planning. Enrollment in the Plan creates the demographic and registration portion of the patient's file. This nucleus, combined with the information entered from each medical encounter, establishes the basis for the management information system.

A variety of administrative and management functions are necessary and available. Mailing labels are generated to send medical history questionnaires and health center information to subscribers. Forms are produced which are used for the generation of membership identification cards. Membership information becomes the control system for capitation billing as well as fee-for-service billing of non-members.

Using the population as the denominator, utilization and membership statistical reports are available. For example, certain reports can provide data organized by age, sex, geographic location, medical specialties involved or any combination thereof.

Cost/Membership ratios allow management emphasis on specific cost centers. Facility utilization can be assessed via patient encounter statistics. Management, thus informed, can better plan for future requirements including "what-if" projections related to potential numbers of future memberships.

Special studies allow personalized attention. A simple ex-
ample is the production of mailings notifying members satisfying certain medical criteria of their need for flu shots.

These are some of the features which provide the HCHP management with the information services necessary to efficient, effective operations, controls, and planning.

QUALITY ASSURANCE—A FUTURE OBJECTIVE

The primary objective of the medical record system described in considerable detail in the preceding pages is to ensure that readily accessible, legible and accurate information is available for each and every patient seeking medical services at the Harvard Community Health Plan. An important by-product of this endeavor will be the potential of the system as a tool for monitoring the general quality of the services that are delivered.

As you are aware, the profession has entered an era in which it will not be enough to practice good medical care—it is now expected to demonstrate in rather precise ways that this is the case. The federal authorities have already enacted legislation designed to ensure that the services which they fund, such as Medicare and Medicaid, are of acceptable quality. It is therefore safe to predict that in the near future Blue Cross/Blue Shield and commercial insurance carriers will do likewise. Moreover, consumer groups, which are becoming organized at the Harvard Community Health Plan, will be making similar demands.

It is anticipated that, when properly used, reliable and comprehensive data available in the computer will enable almost complete obviation of the laborious process of individual manual medical record review when appraising the quality of care in various clinical situations.

Furthermore, numerous aspects of utilization, such as prescribing patterns, the keeping of appointments, over and under-utilization, membership turnover, the use of hospital facilities and many other matters will be available in a form more accurate, more comprehensive, and more accessible than was previously the case.

It seems probable that in the near future, the whole process of quality assurance, including peer review and utilization, will, with the help of the new record system, become part of the ongoing information system at the Harvard Community Health Plan.

TECHNICAL CONSIDERATIONS

A universal characteristic of information systems is that objectives and procedures will change with time. In part these changes are related to inadequacies in the initial planning stages. In a large sense, however, they are related to the inherent effect of a successful introduction of computer technology into a new field. It is the hallmark of such a system that the users modify their initial attitudes, raise their expectations and make increasing demands on information handling services. This general characteristic, and others unique to medical records systems, should prompt the systems designer to implement in a high level language. Certain specific characteristics of this language system should also be considered:

1. It should be procedural, one which can be easily modularized.
2. It should have powerful string processing capabilities. Much of the information in a medical system is textual in nature; names, clinical results, free text dictation.
3. It must be able to search and manipulate data quickly and easily. I/O should be flexible, allowing for experimentation in formatting and terminal selection.
4. It must have the capability for the development and maintenance of a large data base. A data management system for patient care requires a relatively complex data base for several reasons:
   (a) The data can assume a variety of types and formats.
   (b) The data items are dynamic in size; fixed dimensioning of data or data fields is unacceptable.
   (c) The file must be organized for rapid easy access of specific sections, e.g., one is often interested in a particular encounter or laboratory value rather than in a whole patient file.

The designers of the Harvard M/MIS feel that the MUMPS system meets or exceeds all these requirements. MUMPS (Massachusetts General Hospital Utility Multi-programming System) is a compact time-sharing system implemented at the Laboratory of Computer Science on Digital Equipment Corporation PDP-9's and PDP-15's. The interpreted MUMPS language includes extensive capabilities for string processing, terminal I/O and manipulation of a dynamic, hierarchical data base. For the project described here, if one also includes criteria of cost and availability, there is effectively no competition.

CONCLUSION

The joint Laboratory of Computer Science/Harvard Community Health Plan Medical/Management Information System venture represents a successful advancement in the use of one technology to enhance the effectiveness of another. Project experience indicates that, properly served, the goals of administration and the medical profession are not divergent but concurrently support quality health care. Careful consideration of the users needs succeeded in dispelling skepticism and has paid magnificent dividends in the user satisfaction realized since implementation.

Finally, credit must be given to a strong HCHP management commitment to the development of M/MIS. It took
this commitment and a generous ration of faith to overcome the obstacles, setbacks and frustrations of this long development and hold firmly to the goals they envisioned. The investment has been high, but it is our conviction that both the system presently in existence and the potential of the system yet to be realized justify this development. All of us envision the day when the paper medical record will be only a limited archival storage and an instantly retrievable computer medical record will be the operational mainstay of the medical profession.

REFERENCES
