

## A Microcomputer-Based Computerized Medical Record System for a General Practice Teaching Clinic

David H. Chan, MD, CCFP, Stuart P.B. Donnan, FRCS, FFCM,  
Nang-fong Chan, MSc(PH), FRACFP, and Gary Chow  
Shatin, Hong Kong

*A low-cost and user-friendly computerized medical record system that includes patient demographic data, family genogram and social information, problem list, medication list and repeat prescription, progress notes, and laboratory data has been developed for a general practice teaching clinic. The system also has an automated health maintenance and disease management package, a number of research report programs, and a basic accounting package. The computerized medical record system has provided a very valuable tool for improving patient care, teaching, and general practice research. A standard software package has been developed for other small to medium-sized practices to use without having to redevelop their own software.*

The Department of Community Medicine, Chinese University of Hong Kong, began a General Practice Teaching Clinic in 1984 that was set up as a model general practice for teaching undergraduate and postgraduate students. The general practice team includes three lecturers in general practice, two nurses, and a receptionist. The clinic is run on an appointment system similar to a group practice. A maximum of six patients are booked each hour for every physician. From time to time both undergraduate and postgraduate students also take part in consultations. To maintain continuity and comprehensive care, the original manual record system was organized into the following major sections: (1) patient demographic data, (2) a three-generation family genogram and social data, (3) problem list and past health history, (4) medication and drug allergies, (5) health maintenance record, (6) progress notes, (7) laboratory data flow sheet, and (8) correspondence. To facilitate ease of conversion from the manual record, the design of the computerized medical record system uses the same logical breakdown of data. Since January 1986, patient records have been entered into the computerized medical record system.

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*From the Department of Community Medicine, The Chinese University of Hong Kong, Shatin, Hong Kong. Requests for reprints should be addressed to Dr. David H. Chan, Department of Community Medicine, The Chinese University of Hong Kong, 4/F1., Lek Yuen Health Centre, Shatin, Hong Kong.*

### METHODS

#### System Design

The basic system unit is a Sigma PC (IBM-PC compatible) with a 640 k-byte memory and a 32 M-byte hard disk. Backup of data is done using a cartridge tape unit. Three software systems were evaluated prior to selection of a suitable system: Revelation, dBASE III, and MicroMUMPS. Only Revelation met the software selection criteria (Table 1). Revelation is a powerful database package that includes a number of user-friendly program development tools.\* Most programs were written without actually having to write a program code. Most program documentations were also automatically generated by the system, giving uniformity and allowing easy program maintenance. The system was in operation one month after the software arrived in January 1986.

The database was designed with considerations taken to facilitate the conversion from manual records. Data are organized into eight major components: (1) patient demographic data, (2) family genogram and social information, (3) problem list, (4) medication list, (5) progress notes, (6) disease management record, (7) health maintenance record, and (8) laboratory data and correspondence

\* Information concerning the software Revelation can be obtained from Cosmos, Inc, 3633 136th Place SE, Suite 106, Bellevue, WA 98006.

TABLE 1. SOFTWARE SELECTION CRITERIA AND EVALUATION OF REVELATION, dBase III AND MicroMUMPS

Criteria	Revelation	dBASE III	MicroMUMPS
File transportability File created by the database system should be transportable to other software systems either by direct conversion of data or via communication link	Yes	Yes	No
Variable-length record and unlimited fields Medical record data are entered either in coded form or free alphanumeric text; the number of pieces of information (eg, consultation notes or medications) must not be limited by the initial design; disk storage should be optimally utilized for such a diversified data structure	Yes	No	Yes
Multi-user capacity and performance The system should allow one or more terminals to be operated simultaneously with response speed sufficiently fast for on-line operation	Yes	Yes	No
Maintenance support and user friendliness The system should provide structured program development and documentation; operation should be friendly to allow unskilled operator with little training	Yes	Yes	No
Data security The system should provide different levels of data protection against illicit access	Yes	No	No

TABLE 2. DATA ELEMENTS IN EACH MAJOR COMPONENT OF THE DATABASE

Storage Component	Data Elements
Patient demographic data	Identification number, name, date of birth, sex, marital status, address code, name, telephone number, occupation, physician, accounts payable
Family genogram and social information	Three-generation genogram: each member's age, sex, medical condition, occupation and other information; other significant social information
Problem list	Problem number, ICHPPC code, date of onset, date resolved, problem summary
Medication list	Medication number, problem number, formulary code, dosage, quantity, date begins, date ends, adverse effects
Consultation record	Date, physician, problem number, ICHPPC code, summary
Disease management record	Disease management maneuver number, date, result
Health maintenance record	Health maintenance maneuver number, date, result
Laboratory data and correspondence	Specific for hematology, biochemistry, serology, etc

summary. Data can be manipulated within each individual component or cross-referenced between different components. Individual data elements of each component of this computerized medical record system are listed in

Table 2. Other users can modify these entries to suit their particular practice requirements.

It was decided not to enter all clinic patient records, only those records of patients seen after January 1, 1986. The receptionist was trained to enter patient data as well as the ICHPPC-2<sup>1</sup> code table. The nurses were taught to enter the medication code table and laboratory data. Because the system is user friendly, the basic training was completed in less than one week during the free time when the clinic was not open. All of the ordinary data entry, file maintenance, and reporting functions can be selected by menus (Table 3). The basic day-to-day operation of the computerized medical record system can be mastered in a matter of hours, even for a computer illiterate. The programs for data entry, reporting, and file maintenance and backup were automatically generated by Revelation. Likewise, documentation was also generated by the system in a highly standardized format.

Only three programs were written for the computerized medical record system: the automated health maintenance program, the disease management program, and the encounter sheet program. These programs were written in Revelation BASIC, which is a powerful database language that is also easy to use and to maintain.

**Operation**

An encounter sheet (Figure 1) is generated by the receptionist for every consultation. During the clinic visits, the nurse checks for health maintenance and disease management items to see whether anything is needed to be done, for example, measurement of weight and height, blood pressure check, immunizations, etc. After these items have been completed, the patient is seen by the

physician, who writes the progress notes longhand in a problem-oriented format. The receptionist then makes a repeat appointment, if necessary, and enters the consultation data into the computer. The average new patient spends about 20 minutes with the physician and a follow-up patient spends about 10 minutes. The on-line system performs well within these time limits.

### Automatic Coding

Both the patients' problems and their medications are coded before they are stored in the computer. The procedure is simple but efficient. All that is required are the first three letters of the name of any disease, or disease-related system, or symptom, or even shorthand notation of common problems (for example, COA for chronic obstructive airway disease). The ICHPPC-2 codes have been extended to include more detailed descriptions of primary care problems and procedures in such a way that the original ICHPPC-2 code is not lost and the international standard is maintained. The medication is also coded in a manner that allows future additional international coding.

### Automated Health Maintenance

For each patient visit, the computerized medical record system searches the patient's health maintenance file to determine whether immunizations and screening procedures are current and makes prompts on the encounter sheet (Figure 1 under the Health Maintenance section). The health maintenance recommendation is based on the patient's age and sex, and follows the Canadian Task Force on Periodic Health Examination recommendation.<sup>2-4</sup> The health maintenance items have been placed in a table in order of priority and can be modified at any time (Table 4).

When a procedure is performed (eg, a Papanicolaou test), the date and the result are entered into the laboratory data file; at this time the health maintenance file will also be updated automatically. The nurse also has the option of periodically listing health maintenance items for the purpose of recalling patients. When an abnormal result of a screening test is detected that requires a follow-up action on a suggested date, the computerized medical record system will also allow an entry to be made on a pending file, which the nurse reads periodically for recalling patients for follow-up.

### Disease Management Protocol

For follow-up of chronic diseases, the general practice team designed a management protocol based on current literature evidence and personal research interests. For each follow-up visit, the computerized medical record

TABLE 3. SAMPLE MENUS FOR THE SYSTEM

Computerized Medical Record System	Patient Data Maintenance
Patient data maintenance	Patient demographic data
Table maintenance	Family and social history
Encounter menu	Health checklist
Reports	Consultation record
Test result menu	Medication record
Miscellaneous menu	Disease management record
Exit system	Health maintenance record

system searches the patient's file to determine whether standard management procedures are completed and makes prompts on the encounter sheet (Figure 1 under the This Consultation . . . Management section). Only patients with certain chronic diseases (eg, hypertension) will have prompts. The prompts include questions regarding symptoms, physical signs, and periodic laboratory investigations. The nurse asks all the questions in a standardized fashion and prepares the laboratory test request forms. The physician checks further for any positive symptoms and examines the patient, if necessary. The protocol is built into a table according to the disease ICHPPC-2 code (Table 5). The table can be modified at any time.

## RESULTS

The selection of Revelation as a database system proved to be well worth the money. With only one programmer doing most of the programming work, it has been possible to design and operate a powerful computerized medical record system. (That one author, D.H.C., has a degree in computer science and worked as a systems analyst before entering medical school also helped in the development.) The system is virtually self-maintained. Future modification and enhancement are expected to be carried out without any programmer support. The total hardware and software cost of the system is under US \$5000 (purchased in Hong Kong). The initial software development and training has taken approximately nine months of a programmer's time. The ongoing upkeep of the system should be nearly the same as using the original manual record system.

The initial conversion process demanded extra time on the part of the physician to summarize records of patients seen after January 1, 1986, and it was necessary that medical personnel learn to write legibly so that a nonmedically trained receptionist could enter the data. The effort proved to be worthwhile, as the new record system helped improve the communication process among the general practice team members. The process also revealed the quantity and the quality of collected data in a general practice setting.

NAME: CHUNG CHOI YAU

AGE: 67

SEX: MALE

MS: MARRIED

OCC: RETIRED

FAMILY HISTORY: 9 CHILDREN 4TH SON DIED AT AGE 20 DUE TO ACCIDENT, NO FAMILY HISTORY OF HT, DM, IHD, TB.

SOCIAL HISTORY: ON PENSION

\*\*\*\*\* ACTIVE PROBLEM LIST \*\*\*\*\*

NO.	ITEM	ONSET	COMMENT
3	HYPERTENSION	01-01-83	DX ON ROUTINE CHECKUP, INITIAL WORKUP NEG.
6	GOUTY ARTHRITIS	01-01-84	DX WITH PROB 5 AT PWH, RIGHT BIG TOE, URATE=.43, NO REGULAR MEDICATION.
5	DIABETES MELLITUS	05-02-86	PRESENTED 'UNWELL' + SYMPTOMS OF KETOSIS, SENT TO A/E PWH-STARTED ON INSULIN.
8	ANGINA	01-10-86	ECG-LVH BY VOLT. NO DEFINITE ISCHAEMIA

\*\*\*\*\* PAST RESOLVED PROBLEMS \*\*\*\*\*

NO.	ITEM	ONSET	RESOLVED	COMMENT
4	GASTROINTESTINAL BLEEDING	01-01-76	01-01-76	UNKNOWN CAUSE, HOSPITALIZED AT QEH CONSERVATIVE RX

\*\*\*\*\* MEDICATIONS (NEXT MEDICATION# = 6) \*\*\*\*\*

\*\*\* ALLERGIES \*\*\* :

NO.	PROBLEM	ITEM	QUAN	DOSAGE	DATE ON	COMMENT
3	5	DIABETES MELLITUS	INJ. INSULIN LENTE 100 U / ML	BID	01-03-86	
4	3	HYPERTENSION	TAB. ALDOMET 250 MG (METHYLDOP 6/52	250MG BID	01-03-86	
5	8	ANGINA	TAB. ANGISED 0.25 MG (GTN)	30 TAB 1 PRN	08-10-86	

\*\*\*\*\* LAST 3 CONSULTATION RECORDS \*\*\*\*\*

DATE	DR.	PROBLEM	MANAGEMENT
08-10-86	CNF	ANGINA	ANT.CHEST PAIN PAST 10 DAYS.-DULL ACHE, NO DEFINITE RELATION TO EXERTION, LASTS UP TO FEW HRS. OCC. ASSOC. WITH EPIG. PAIN WITH SL. RELIEF BY ANTACID. PR. 80/MIN REG. ECG-LVH BY VOLTAGE. NO DEF. ISCHAEMIA
08-08-86	CC	FAINT	2 MOS AGO, DIDN'T EAT MUCH SUPPER, FAINTED FOR 10MIN AFTER GOING TO BR, WENT TO PWH, IM, NOT ADMITTED, OK SINCE THEN; ALDOMET DEC SINCE THEN; P80REG, 140/100, N EXAM, A: PROB HYPOGLYCEMIC ATTACK
01-05-86	DC	NOCTURIA DIABETES MELLITUS GOUTY ARTHRITIS COUGH	4K, GOOD STREAM; PROSTATE MOD SIZE, N CONSISTENCY FEELING WELL CHILDREN GIVING INJECTION BD. FOLLOW-UP AT LKS. DIAGNOSED AT PWH, URATE=.43, NO REGULAR MEDICATION COUGH

\*\*\*\*\* HEALTH MAINTENANCE \*\*\*\*\*

16:STOOL FOR OB (NORMAL/ABNORMAL)

\*\*\*\*\* TEST REQUEST \*\*\*\*\*

HAEM : \_\_\_\_\_ BIOCH: \_\_\_\_\_ URINE: \_\_\_\_\_ STOOL: \_\_\_\_\_ CULT: \_\_\_\_\_ PATH: \_\_\_\_\_  
 X-RAY: \_\_\_\_\_ SPEC : \_\_\_\_\_ REF : \_\_\_\_\_ FU : \_\_\_\_\_ MED: \_\_\_\_\_

\*\*\*\*\* THIS CONSULTATION (NEXT PROBLEM# = 9) \*\*\*\*\*

PROB#	S	O	A	MANAGEMENT
				1:NEW-HEADACHE(Y/N) CHEST-PAIN(Y/N) TRANSIENT-BLINDNESS(Y/N) 16:SIDE EFFECT OF MEDS( ) 3:BP( / ) 5:WEIGHT( KG) 6:FUNDI( ) CVS( ) 8:HEMATOLOGY( ) 9:BIOCHEMISTRY:( ) 11:CKR( ) 13:URINALYSIS( ) 2:CHEST-PAIN(Y/N) POLYURIA(Y/N) PRURITIS(Y/N) 17:RECORD OF URINE TEST(GOOD/POOR/NOT DONE) 7:PERIPHERAL NERVE TESTING( ) 10:FASTING BLOOD SUGAR( )

Figure 1. Encounter sheet showing the eight major data elements

TABLE 4. HEALTH MAINTENANCE TABLE: EXAMPLE FOR WOMEN AGED 40 TO 44 YEARS IN ORDER OF PRIORITY

Items	Intervals (months)
Examination of breasts	12
Blood pressure measurement	24
Papanicolaou smear	36
Weight (base line height)	12
Hearing assessment	12
Oral examination	12
Immunization status	12
Smoking	12
Alcohol and drugs	12
Exercise	12
Marital, family, and sexual adjustment	12

Automated health maintenance and disease management have become part of the day-to-day management of patients in the clinic. A significant step has been taken in patient care in the quality assurance program. Some physicians audit their performance by looking retrospectively into their medical records, and clinic personnel ensure that they are meeting the minimum standards set for themselves.

## DISCUSSION

With 7,500 patients and an average of three consultations for each patient per year (ie, 22,500 consultations per year) the 32 M-byte hard disk will last for more than six years before it becomes necessary to archive old unused data onto the backup cartridge. Furthermore, if a physician chooses not to enter the detailed consultation notes, the storage requirement for registering only the disease code in every consultation is then small indeed. Expansion of storage capacity can be further achieved by adding a bigger hard disk. In brief, a standard package for single computer operation has been developed that other small to medium-sized practices may find useful; it can be transferred onto a compatible microcomputer simply and without the new practice having to redevelop its own software.

Installation of extra computers is planned so that data can be shared with the computerized medical record system through a local area network. Network Revelation is available inexpensively and is compatible with the current system.

Ideally any computerized medical record system should be affordable, easily maintainable, and user friendly. It should be used as a tool to improve the quality of care to patients. After reviewing many of the popular medical record systems in the United States,<sup>5-8</sup> Australia,<sup>9,10</sup> and the United Kingdom,<sup>11,12</sup> it was found that a major obstacle is a lack of local maintenance support. Most systems

TABLE 5. DISEASE MANAGEMENT PROTOCOL FOR HYPERTENSION

No.	Maneuvers	Interval (months)
1	Family history of hypertension	Once only
2	New headache, chest pain, transient blindness	1
3	Medication compliance	6
4	Diet compliance	6
5	Side effect of medications	6
6	Blood pressure measurement	1
7	Weight	1
8	Height	60
9	Fundi and cardiovascular system examination	6
10	Complete blood count	60
11	Electrolytes, renal functions	12
12	Chest x-ray examination	Once only
13	Electrocardiogram	12
14	Urinalysis	6

currently in use are also expensive and do not have many of the features of this computerized medical record system. A powerful system has been developed that many small to medium-sized practices can afford and maintain.

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