A COMPUTER-BASED GENERAL PRACTICE AND HEALTH CENTRE INFORMATION SYSTEM

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EVER-INCREASING medical and sociological knowledge leads to an ever-increasing volume of information which may be recorded about a person's health. Because of this the present paper-based record systems are becoming difficult to manage and are fragmented into a number of different parts within each branch of the health service. Integration of these parts into a single comprehensive health record for each individual could lead to improvements in medical care, but such an integrated record would be impracticable in any paper system. Modern computer science, however, makes this idea feasible, and the present paper describes how this can be done for general practice, local health authority, and dental records, and indicates additional far-reaching advantages which are only made possible by a computer-based system.

The use of computers within the health industry is increasing rapidly but mainly as applied either to research projects or to administration. For example, the Oxford record linkage study (Acheson and Evans 1964) and the Exeter project (Nuffield Provincial Hospitals Trust 1967) aim to collect information for epidemiological research from a number of different sources and use a computer to analyse it. In this case automation assists the health professions indirectly by enabling more rapid analysis of large volumes of data, but it plays no direct part in the actual consultation process. Similarly, computers used for administrative purposes can improve health care indirectly by enabling more efficient management of hospitals and by such functions as keeping a record of immunizations. Computers are also being used in the analysis of some pathological investigations, electrocardiograms and electro-encephalograms, and are valuable in calculating radiotherapy dosages.

Their use in providing record systems to assist the doctor directly

during his contact with patients is in its infancy. Barnett (1967), Hall (1967), and Anderson (1967) are all planning such systems for hospitals, but apart from specialized projects such as the Kaiser Permanants Multiphasic Screening Clinic (Collen 1966) and the Madison Allergy Clinic (Slack *et al.* 1966) the possibilities of automated health records in general practice have received little attention. It is with proposals for a system for use in health centres and general practice that this paper is concerned.

Some of the most telling evidence of the lack of integration in the health service is brought out by an examination of existing records. Under the present system, data about the health of any individual may be recorded by a number of different professional workers on a number of different forms which are kept in a number of different places. The result is that there is much unnecessary duplication and in spite of this a large amount of relevant material is often inaccessible. Individual parts of the existing record frequently suffer from illegibility, incompleteness and an excessive volume of obsolescent material. These factors hamper communication about the individual patient and burden the workers concerned with unnecessary clerical tasks, both of which probably have a deleterious effect on the quality of care given.

Medical records result from contacts of an individual with the health services. An approximate breakdown of the location of these contacts, based on consultation rates per person per year, is given in figure 1, from which it can be seen that about two thirds of these occur outside the hospital setting. This figure does not attempt to give the quantitative relationship between the sizes of different parts of the record but merely an idea of the relative number of times a record is likely to be used in the different areas of the health service.

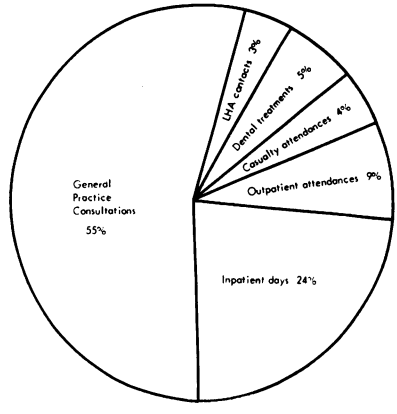

Figure 1

Approximate distribution of patient contacts with the health service, at which a record of the contact is made. (For this purpose one hospital day is equated with one contact.)*

General-practitioner records are kept on small buff cards fitting

Sources: Annual report of the Ministry of Health, 1966; Hospital inpatient enquiry report, 1964; *The health of the school child*, 1965–66; Reports from General Practice, II, Present State and Future Needs, College of General Practitioners (1965).

into small buff envelopes, designed some 60 years ago and looking every year of their age. It is small wonder that the actual notes kept on these cards often seem inadequate and give little information to anyone except the doctor who wrote them, who presumably, can decipher his own personal shorthand. By the time a few hospital letters and reports, of assorted shapes, sizes and dates are crammed into the envelope alongside the increasing volume of cards, the task of sorting out current data becomes intolerable. As the management side of general practice gains recognition, various improvements are being tried by individual practices. These include keeping the records in family folders rather than individually (Fletcher 1968), summarizing the whole records intermittently (College of General Practitioners 1966) and transcribing relevant hospital information onto executive council cards instead of keeping all hospital letters (Adams 1967). These schemes do help in retrieving relevant information but are restricted by the inability to sort it by any criteria other than the chronological order in which it was written. The basic problem is that of presenting clinically important data prominently at the time when it is needed. The time and effort involved in this task makes it an ideal which it is impracticable to achieve with conventional record keeping.

There is, however, one advantage in general practitioner records which is not shared by those of hospitals or local health authorities. This is that the patient's record follows him for life so that, theoretically, the entire medical history of that person, as known to his family doctors, is recorded in it.

Local health authority records are confused because of the large number of staff who record their notes about one individual on separate forms. Thus a person may have separate child welfare, school, and antenatal medical records, health visitor's record, district nurse's record, midwife's record, chiropodist's record, dentist's record, social worker's record, and so on. Added to this is the disadvantage that there is no standardization of any of these forms between different administrative areas so that as a person moves from place to place he may accumulate a number of different records about the same health problem. When a person moves, it is usual for any continuing records to be sent from the old authority to the new.

Hospital records, particularly those relating to inpatients, are kept in considerable detail and have the advantage that almost all information about a particular patient is stored in one place. One problem frequently encountered is the difficulty of sorting out a particular item of information from reams of unstructured illegible scripts, and sheaves of investigation reports, sometimes extending back over decades. The sheer volume of an accumulating number of records

causes problems to the hospital administration in filing and storage; this has led one hospital to take the simple but revolutionary step of embalming everything except inpatient summaries, outpatient letters and electrocardiograms six years after a patient's last attendance (Mitchell *et al.* 1967). Another problem is that some relevant information which ought to be considered by the hospital personnel is not recorded. This information relates to the patient's medical history leading up to his admission and following his discharge. The hospital record depends for these on correspondence with the other branches of the health service.

Towards an ideal personal record

Detailing the deficiencies of existing records leads to a consideration of the structure and content of the ideal personal health record. In order to fulfil the various criteria which are not met by present records it must be single, complete, accessible, legible, and easy to store. In addition it must be confidential and yet its contents should be available for research purposes. The aim of producing a new record should be not merely to avoid the pitfalls of the past but also to provide further facilities to the staff who will use it in the future.

Everybody in the community should have a single record which could be used at every contact with the health service. A single record, continuous throughout his life, would ensure that a complete picture of the person's health was always available. It would also eliminate the need for duplication of much information such as patient identification and environmental data.

The vast amount of information generated by different workers which could accumulate in a single record would only be useful if it were so organized that particular sections could be rapidly obtained when needed and could be easily read. Because of the reluctance of the health profession to discard any information which might subsequently prove useful a storage system which allows large volumes of data to be kept without becoming inaccessible would be essential. To achieve this, a hierarchy of storage would be required into which parts of the record would be placed according to their priority of use. For example, allergies, current drugs, and recent consultations, would be available instantaneously whereas the record of minor episodes, say ten years old, might take longer to retrieve. The allocation of sectors of the record into different levels of storage should be automatic but capable of being overridden by the individual user's requirements.

A large number of workers would have access to the record and this could raise problems relating to the privacy of certain parts of it. Therefore safeguards would be needed for keeping these parts confidential to the recorder and other staff authorized by him. At

the same time the single complete record would be of enormous research value in epidemiology, medical care studies, sociology and economics, so that for these purposes a means of access to the complete record except for identification data should be made possible.

How computers can help

It is immediately obvious that the implementation of this concept would not be practicable in any paper system, though it is quite feasible to do all this and more by using computers. The aim of the present study has been to design an integrated, automated record system for use during the two thirds of health consultations which occur outside the hospital. However, it is hoped that ultimately it will be interlaced with and be complementary to the hospital information systems being developed elsewhere.

The purpose of the study is to provide doctors and other health workers with a system which they find both easy to use and also an improvement on the present one. It must be so easy for them to insert information during the course of a consultation and to obtain rapid access to any part of the record that their consequent willingness to use the system will result in records of a significantly higher standard.

Not only can this aim be realized with a suitable computer system but also other advantages may be offered to the user. It can, for example, assist him on the clerical side by simultaneously entering the drug he prescribes on the patient's record and printing out the prescription itself, complete except for his signature and date. Similarly when he orders an investigation it can be entered in the record and the request form printed out at the same time.

The computer can also act as an *aide-mémoire* in that it can link certain facts together in much the same way as the human memory. For example, it should be possible to suggest a specific investigation for a provisional diagnosis or a particular drug for a final diagnosis. Ultimately it may even suggest a differential diagnosis on the basis of the symptoms, signs and history. It can also link up the current record being generated at a consultation with the medical, social and environmental data recorded in the past. Thus it could warn the doctor that a certain drug was contra-indicated due to previous disease, or that illness in one member of the family was liable to precipitate a social crisis in the home. In screening and surveillance clinics, the computer can immediately analyse the results of tests and questionnaires and make certain basic decisions about the need for further tests or for urgent treatment. Thus, as well as making possible a really comprehensive and readily accessible health record, an automated system can actually take positive steps towards helping the doctor to make decisions about his patient.

It is not difficult to imagine the benefit to epidemiological and other research workers of such a computer system. Instead of having to organize the collection of data and its coding and punching, they are here presented with complete (but for this purpose anonymous) integrated records in a form ready for data-processing.

Using a computer system

The actual storage of information is a relatively simple matter but the retrieval of specified items within an acceptable time-limit and the addition of further patient data to the integrated record in a form acceptable to the general practitioner present more difficulty.

First the question of input is considered, for which a number of criteria must be met:

1. Acceptability by doctor or other user
2. Minimal possibility of undetected error
3. Suitability for subsequent retrieval and analysis

Two basic methods of input have been considered: first, narrative and, secondly, coded selections from check-lists or coded answers to questions.

Narrative, on first sight, seems to satisfy most of the above criteria. It is the normal means of making current records and is acceptable to the doctor but is not necessarily best suited to his needs. Although suitable for information retrieval it is not clear at this time how satisfactory syntactic analysis can be done on free narrative generated in the consulting room (Korein *et al.* 1966).

On the other hand, it is thought that a more suitable form of input for the major part of the record is to make use of structured lists (check lists) from which the doctor can make a definite selection. As an example of this, if a doctor wishes to make a brief record of the progress of his patient, he could rapidly select a suitable term from the list:

CURED
BETTER
SAME
WORSE
VERY MUCH WORSE
DEAD
OTHER

If none of the first six is suitable, the proposed system allows the doctor to use the other form of input (narrative) in indicating that OTHER is his choice. The narrative then entered (whether by the doctor typing, writing or using a dictaphone) would be included in the patient's record and would be available for any subsequent retrieval, but not necessarily for analytical purposes.

The usefulness of these checklists will depend largely on whether

the user is satisfied with their contents. The system therefore must allow for the individual tastes of different doctors and should be very easily changed without recourse to re-programming. It is hoped that these checklists, which will contain a vast amount of medical information will help doctors to keep painlessly abreast of the latest developments in medicine.

More complex structures, in which the list contains references to further sublists can be built up, and the selection of one item from such a list will cause prompt display of the appropriate sublist. Structures such as these are frequently referred to as 'trees'.

Not only are such trees suitable for the input of parts of the record, such as progress and diagnosis, but they lend themselves to the retrieval of information from any part of the patient's record. In the next section the content of a complete record is outlined and it can be seen to be suitable for structuring in a similar way. As a simple example, a patient's blood group could quickly be ascertained by successive selection of 'General Information' and 'Personal Medical Data' at which level the patient's blood group (if ever recorded) will be displayed (*see* below). A further advantage of this structured approach is that linkages such as those previously described can be built in to assist the doctor in his management of the case.

Against these points must be set the disadvantages that checklists may encourage the doctor to put into a definite category vague information that may well belong elsewhere, and to omit to record vital information not covered by the checklist. It is hoped that the option of using narrative at all times will ensure that the system is sufficiently flexible to cope with the 'open-ended' nature of consultations.

In aiming to give the user satisfactory access times to various parts of the record it has been noted that it will be necessary to make some arbitrary classification of parts of the record depending on their priority. It is proposed to build into the system 'learning programmes' whose duty it will be to minimize delays by optimizing the classification. The purpose of this classification is to determine the best storage area in which to place a particular part of a record immediately prior to and during the consultation. This will be made practical in most cases by a computer-based appointment scheme. Thus the record will be optimally spread over the computer's magnetic tape, disc and core storage when the consultation begins. The main file of patient records must be held on magnetic tape since this is at present the cheapest form of storage.

There are two commonly used types of device through which information may be inserted into and retrieved from the computer. The first of these, the tele-typewriter, has a keyboard essentially

similar to that of an ordinary typewriter. Input is achieved by typing a message which could be narrative or some code which identifies an entry in a printed checklist. It can print out data from the computer store at moderate typing speeds, and thus a 'conversation' with the computer can be held. It is not very suitable for use in the consulting room because it requires some typing skill and is rather noisy when printing out. It is envisaged, however, that it could be of use in the practice office for printing out requests for investigations, prescriptions etc., and for the secretary to input any written or dictated notes for inclusion as narrative in the record.

The other device is the Visual Display Unit (VDU). This resembles a television set and may have an integral typewriter or special keyboard (figure 2). Output on a VDU appears on the screen in

Figure 2
A visual display unit

printed form. Its advantages include speed, silence, legibility, and the fact that it does not produce yards of confidential wastepaper. Information can be put into the computer store as with the teletypewriter, but certain types of VDU offer a more useful method, especially in connection with checklists. It is possible to associate with a VDU a special means of input which responds to the user pointing to a certain part of the screen. Since the computer knows what is printed on each part of the screen, it can use the message or information in that part selected, as its next command or item of data for input.

It must be emphasized that at all times the doctor or other worker

would be free to choose between entering the information in structured form by way of the VDU or in narrative form. Structures can be devised for the great majority of normally recorded items, but, until the system is tried, it is impossible to say how acceptable these would be for use in the average consulting situation.

The proposed method of handling a large volume of checklists, trees and a limited amount of narrative, is to use a self-generating dictionary so that words can be replaced in storage by a shorter unique code number. Thus the computer checklists will consist largely of code numbers pointing to the relevant dictionary entries. The dictionary itself will be organized by a learning programme, similar to the one which optimizes record storage, and will probably be held on a drum/disc hierarchy; the more frequently used words being held on the more accessible drum.

Patient's records, when held in a computer store, are more confidential than when kept in any paper-based system. To guard against unauthorized access, as each user begins a session he must identify himself by giving a private code to the computer. In store there will be a table giving precise details of what parts of a record he may refer to. Any attempted violation will be immediately monitored and, only with the express permission of the patient's personal doctor, will the computer allow access.

The content of a complete record

The various records kept about patients outside hospital have been studied and it is thought that they could be integrated into a single record with a number of subdivisions. Throughout a person's lifetime the record would progressively expand and it is probable that some of the detailed information from previous years would be relegated to storage not immediately accessible 'on line'. Where items of information change (e.g. address, or immunization status) the relevant part of the record would be updated to show the most recent information.

The record may be subdivided into seven sections:

1. *General information.* This section would contain patient identification, family medical data and basic personal medical data such as blood group, known allergies and drug reactions, immunization status and results of certain frequently used measurements (weight, height, blood pressure, haemoglobin, etc.).

2. *Medical history.* This section would consist of a summary of the person's episodes of illness, for parous women a summary of their obstetric history and for children a summary of their birth and neonatal record.

3. *Consultations.* This would be the record of episodes of illness, each episode being made up of a series of contacts or consultations between patient and health staff. The record would indicate whether different episodes were running con-

currently. At each contact, some or all of the following data would be recorded about each complaint the patient might have:

(a) Presenting complaint
(b) Progress since last contact
(c) Specific and related symptoms
(d) Signs
(e) Investigations
(f) Provisional or final diagnosis
(g) Treatment
(h) Outcome

In addition, the record would indicate who it was that the patient had consulted and the place of the consultation. It is thus possible to amalgamate the nurse's record, for example, with that of the doctor so that a complete continuous account of the episode is given.

4. *Health surveillance.* This would contain the records of the various screening and surveillance clinics attended throughout life. These may be divided into the following groups according to the conditions being sought: child welfare, school children, antenatal, male adult, female adult and geriatric. In each of these screening clinics a standard set of procedures is performed which makes the automation of these records relatively simple. Any variation from normal discovered in these clinics would be managed as an episode of illness and would be recorded in the consultation record.

5. *Social information.* The social record would have three parts. The first would be demographic data such as those collected in a census, defining the person's marital status, occupation, economic activity etc. The second would give factual data about the person's environment and way of life such as the type of dwelling he lived in, his smoking habits and alcohol consumption. The third section would be the record of episodes of 'social illness' and would be treated in much the same way as medical episodes. Social workers and health visitors who provide the bulk of this information, record almost entirely in narrative, but experiments are being conducted to see how far these records can be structured.

6. *Hospital information.* This would consist of information from specialists about a patient's care in hospital, derived from inpatient discharge summaries and outpatient and casualty letters.

7. *Other professional records.* Of the many allied health professions, it is anticipated that nurses, health visitors, midwives, medical and psychiatric social workers will each make a record of their contact with a patient in one or more of the sections already described. For certain other workers, however, the records kept are highly specialized and would not easily fit into any of these. This section would therefore be used for the records of staff such as dentists, chiropodists, physiotherapists and orthoptists.

The content of each of these sections has been studied in detail to determine the quantity of information likely to be generated and hence the storage needed. The number of 24-bit computer words required to record each item in each section has been estimated. Using these, and taking into account the average annual consultation rates for each service, the total amount of information per person per year has been calculated to be approximately 300 computer words. In addition to these patient records it has been estimated that the system for the storage of programmes, tables and dictionaries will require about 300,000 computer words. A health centre, serving 60,000 people, would require some 200 magnetic tapes to store the

personal medical records. These would occupy about 25 cu ft of storage space compared to some 200 cu ft for the present record envelope with its contents.

Ultimately, it is hoped that the system will be applicable to all organizations providing care for patients. However, in the first stages of the development, health centres, where integration of staff has already taken place, seem the best place to start. The health organization proposed for the new area of Thamesmead will provide such a setting (Smith *et al.* 1966). An integrated health service for the whole population of the new development is planned and from the start of practice a new approach to records can be instituted in this experimental environment.

It is estimated that it will take about three to four years to develop the complete system. During this time, work will continue in parallel on the various medical and computer problems which need to be resolved. Of particular importance will be a pilot scheme for the trial of VDUs by general practitioners in their consulting rooms. The emphasis of this pilot scheme will be to gain experience of the general practitioners' reactions to the new recording method and it is hoped that a number of different doctors will be able to try it out. The various parts of the consultation record will be modified according to the doctors' comments. Their opinions on the computer's ability to retrieve relevant data will be used to assist in improving this part of the system. In addition, on the computer side, the general problems of file organization, real time and supervisory aspects, appointments system, and confidentiality will be studied. Similarly, on the medical side, the studies will include drug descriptions, the records of paramedical workers and suitable checklists and questionnaires for surveillance clinics.

The complete population of Thamesmead will be achieved during the 1980's and will comprise 60–70,000 people. A computer system, of the complexity required for handling these records, would be under-used serving only 70,000 people. It is hoped that the system, if it has been shown to be successful, could be expanded to serve a population of about 250,000, when it would be fully utilized.

Evaluation of the benefits of the system

An automated integrated health record may be expected to benefit three categories of people: the patients, the staff and research workers.

The improved information about the patient's health which must result from such a system is likely to lead to earlier and more accurate diagnosis and to more efficient management of disease. As with all studies which try to measure the end-results of medical care there are few clear-cut indices whereby these postulates can be proved.

For evaluation of the system, however, surveys would be done comparing various factors in the population served by the system and a population matched in terms of age, sex, morbidity and organization of health services. The factors which would be measured over a given time include the following:

1. The duration of episodes
2. The number of contacts with different practice members
3. The time spent off work or school
4. The number of days in bed
5. The number of referrals to hospital outpatients
6. The total number of visits to hospital outpatients
7. The number of admissions
8. The length of hospital stay
9. Immunization status
10. Surveillance clinic attendance.

The automated record will benefit the staff using it in that it can quickly produce relevant information about the patient legible to any member of the team. The doctor will have access to more data (e.g. the current screening record or the health visitor's record) as well as a complete account of previous consultations by himself or others. The actual consultation record will almost certainly be more comprehensive although the time spent per consultation may be shorter than with a non-automated system. (The extra time spent in inserting full information into the record should be compensated by time saved in looking up past records, referring to *MIMS* or a formulary, writing prescriptions, certificates and so on).

Other professional workers frequently need to request doctors for information about their patients—e.g. a dentist needs to know when antibiotic cover should be given for extractions, a chiropodist needs to know whether or not his patient is diabetic. In an automated system these facts can be presented directly to the workers concerned, eliminating lengthier means of communication. Similarly it is hoped that the hospital can be directly linked with the system with consequent immediate improvement in communications about patients between hospital and general practitioner.

The possible benefits to the staff can be evaluated by measuring in comparative surveys:

1. The number of items recorded
2. The number of times different sections of the record were used
3. The delays in obtaining information requested
4. The average time of a consultation
5. The individual's views on both systems.

The benefits to research workers of such a system are obviously very great indeed. In any other situation the collection of data for research involves recording forms and either special staff for doing the recording or an extra load on people already doing a full-time job. It also usually requires coding and punching into some form

from which it can be processed. In the proposed system a wealth of data is available in a form ready for analysis, having been collected not as a specific research project but in the normal course of patient care. The possibilities for epidemiological, medical care, sociological and economic research are enormous. They are likely to be well shown by comparing the effort involved in collecting data for evaluation, from automated and conventional systems. A computer system capable of providing the services which have been outlined would be expensive. It is hoped therefore to carry out economic studies to determine whether these costs can be justified by reduction of other costs in the health centres and hospitals and by less working days lost among the population served.

Summary

A plan for a single comprehensive integrated record for all health care out of hospital is described. It is shown that this can be achieved by using a computer, and the advantages of such a system over the present paper records are discussed. The method of use is explained and an outline is given of the content and size of such a record. Plans for implementing this scheme are described and possible methods of evaluation are suggested.

Acknowledgements

The authors record their thanks to Mr M. P. Curwen, Dr T. G. Morell and Dr R. Smith of the general practice research unit, Guy's Hospital Medical School, for their continued assistance, suggestions and useful criticism. Thanks are also due to Professors G. A. Barnard and R. A. Brooker of the University of Essex and to Professor W. J. H. Butterfield of Guy's Hospital Medical School for their encouragement and support.

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