OCCASIONAL PAPER 13

Computers in Primary Care

Report of the Computer Working Party

Royal College of General Practitioners

Published by
The Journal of the Royal College of General Practitioners
ISBN 850 840 732

June 1980

Journal of
The Royal College of General Practitioners

The British Journal of General Practice

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The Editor of the *Journal of the Royal College of General Practitioners* thanks the Department of Health and Social Security for financial help in publishing this *Occasional Paper*.

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Interim Report

Copies of the Interim Report are available from Mrs J. Mant, Central Information Service, 14 Princes Gate, Hyde Park, London SW7 1PU.

The Royal College of General Practitioners

The Royal College of General Practitioners was founded in 1952, with this object:

"To encourage, foster, and maintain the highest possible standards in general medical practice and for that purpose to take or join with others in taking any steps consistent with the charitable nature of that object which may assist towards the same."

Among its responsibilities under its Royal Charter the College is entitled to:

"Encourage the publication by general medical practitioners and others of research into medical or scientific subjects with a view to the improvement of general medical practice in any field and to undertake or assist others in undertaking such research.

"Diffuse information on all matters affecting general medical practice and establish, print, publish, issue and circulate papers, journals, magazines, books, periodicals, and publications and hold such meetings, conferences, seminars, and instructional courses as may assist the object of the College."

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Foreword

The development of general practice during the past decade has been characterized by an increasing appreciation of its complexity in both its clinical content and organization. To achieve effectiveness and efficiency as a branch of medicine, it is important that general practice can rely on its information systems. Computerized systems are therefore particularly relevant to general practice as a discipline.

The Council of the College invited Dr Clifford Kay and his colleagues to form the Working Party with the object of assessing the implications of computers for general practice now and in the future, and on behalf of the Council I would like to thank all of them for producing this excellent report which assesses so realistically the relevance of this new technology to the work of the general practitioner.

ALASTAIR DONALD
Chairman of Council

May 1980

Introduction and synopsis

THE Working Party first met on 28 July 1978 and adopted the following terms of reference:

"To consider the desirability and practicability of the use of computers for general practice clinical and other records; to review current progress and to report recommendations for future development, with particular reference to the introduction of microcomputers."

Desirable characteristics

Our first task was to define the characteristics of general practice systems that we believed to be desirable, and to do this without prejudice to the method to be employed. We quickly realized that we were discussing more than is normally associated with the word 'records' and so we refer to the totality of records and the use that can be made of them as an 'information system'.

Our views are detailed in Chapter 1, and appear at first sight to be comprehensive. Nevertheless, we have deliberately excluded, at present, any consideration of an information system that interacts directly with the patient without the intervention of the doctor, or other member of the primary care team. Such a development is by no means inconceivable, but requires more detailed consideration at a later date.

Potential of manual systems

In Chapter 2 we discuss the extent to which manual systems could fulfil the desirable criteria we had formulated. We conclude that they cannot do so, for manual systems require a multiplicity of entries into the various special registers which are required, and the results are difficult to analyse. All this would entail more work by the doctor and staff than any but a tiny minority would be prepared to tolerate. Moreover, a manual system is entirely passive—it provides no help to the primary care team unless they seek information from it. It cannot prompt them into activity. Finally, we should recall that both the profession and the Department of Health and Social Security (DHSS) have agreed, in principle, that the present 'Lloyd George' envelope is wholly inadequate and needs to be replaced. At present replacement by a computerized system is almost certainly more appropriate than replacement by A4 records, and at a comparable cost.

Computer systems

Given that a manual system cannot fulfil our requirements, our next task was to consider whether an electronic system would do so. At this point the Working Party began to run into difficulties. The pace of technological development is rapid, and yet the widespread introduction of sophisticated computer systems into general practice requires the resolution of medical, economic, and political problems which must take years rather than months to achieve.

Should we then be considering tomorrow's system in terms of today's technology, or should we try to anticipate tomorrow's technology for tomorrow's system? And when is tomorrow?

We finally agreed that it ought to be possible to introduce wide-scale computerization in five years' time, but this must be a guess.

This decision left us with a further problem. Is there a worthwhile role for today's technology for immediate use? We were aware that many general practitioners were interested in their use and wanted guidance. We therefore produced an interim report last year directed solely to this problem. This report was distributed through the general practice Central Information Service and was greatly appreciated. However, it is already out of date. With our major concern firmly fixed on the near future rather than the present, we have decided to keep the interim report available separately from this report, and to update it at frequent intervals.

Current microcomputer systems

For the sake of completeness, we now summarize the status of currently available small systems which are comprehensively discussed in the separate interim report.

Microcomputers and ancillary equipment available in the Spring of 1980 cannot provide simple and convenient practice information systems, but they allow enthusiastic pioneering general practitioners to gain valuable experience and expertise in system design and programming. What can be done only with difficulty and ingenuity on today's equipment will be much more easily done with the more powerful machines with better memories about to come on the market. By the end of the year it is probable that the equipment available will be able to carry out several, but not all of the functions described in Chapter 1.

The use of such systems will require of the doctor and staff the same order of extra work in data entry as is required in manual information systems (e.g. age/sex register, disease register, and the other logs and indexes) and the same acceptance of discipline and precision. However, in terms of data analysis and information retrieval, they will provide enormous savings of time, and indeed allow some work to be done that could not be undertaken in an ordinary practice.

Practices now interested in the installation of computer systems are faced with a choice of strategies. They will soon be able to buy systems (hardware and software delivered as a 'package deal') that will be able to carry out a limited range of important functions (including chronic disease surveillance, defaulter identification, repeat prescription control, preventive medicine applications, as well as such extras as book-keeping and PAYE) but which will be unlikely to be expandable to provide all the functions described in Chapter 1. Currently they would cost between £5,000 and £10,000 and (like a motor car) would probably need to be replaced as better models became available. Potential purchasers would have to consider whether the benefits in terms of job satisfaction of such a system would justify the cost.

Comprehensive computer systems

The alternative strategy is to wait until systems become available that will be capable of step-by-step growth, as envisaged in Chapter 3. In this chapter we describe a system in considerable detail, in order to illustrate its potential. The detail is otherwise unimportant, but we think that the main principles would provide a basis for discussion and the initiation of feasibility studies.

Principles

1. The basic computer should have sufficient power to allow its use to be gradually extended by the addition of data storage capacity and peripheral devices (visual display units and printers) until our total system is achieved. In terms of present technology this would require a minicomputer, but there is no essential difference between a mini and a micro and as minis become physically smaller and micros become increasingly powerful, the distinction will disappear.

2. The early uses of the machine should interfere minimally, if at all, with the doctors' work, but should be sufficiently ambitious so as to avoid grossly under-using expensive equipment. (It would be nonsense to install a powerful computer and use it like a pocket calculator.)

3. All the data required by the practice for entry into the computer should be acquired during the normal and essential activity of the practice. It should not be necessary to copy manual records for computer entry. This principle cannot be universally applied immediately. In our Phase 1 system diagnoses have to be copied from clinical records, but in our 'total' system this duplication entirely disappears, since all transactions take place directly with the computer.

   The appointment system is an important example of this principle of 'single entry'. The appointment system records workload. Given that it is important for effective practice management to have analyses of the character and distribution of the workload, this implies that if 'multiple entry' is to be avoided the appointment system itself should be computerized.

4. The system must be capable of extension at a pace which is determined solely by the doctors who use it. It should accommodate a mixture of manual and computer clinical records without confusion, and thus permit the doctors to change over gradually from the one format to the other as they gradually become confident and familiar with the use of the visual display unit. In a single practice one doctor may never wish to use the computer for his clinical records, but this will not prevent his partners from doing so. The practice computer will monitor the situation and impose order on what would otherwise be chaos.

5. The ultimate requirement for computerization of the clinical record must be accepted, for only then can the machine prompt the doctor with information specifically relevant to that patient at that consultation.

   Much work needs to be done, however, before this desirable aim can be achieved. The example on page 10 of a consultation for oral contraception was chosen deliberately because this is one of the few areas of general practice in which, at the moment, a fairly simple régime of management can be based on the outcome of intensive research.

Computers and clinical standards

Progress with sophisticated use of the computer depends on progress with the definition and validation of the clinical activities of our discipline. The converse is also true. Progress with the monitoring and validation of clinical care will be substantially dependent on the analyses of data that can be collected on a wide scale only by the use of computers. Thus, the development of general practice computer systems and the parallel development of clinical standards to which the whole profession is already committed are closely interrelated.

Computers and research

The National Health Service provides for a lifetime clinical record for each patient. The unlocking of the vast store of clinical information that will follow the computerization of the record has the potential for advances in knowledge of patterns of care and biomedical processes that could hardly be exaggerated.

Link with other NHS computers

It is important to recognize that a practice computer must not be considered in isolation. Practices have to relate to family practitioner committees (or Scottish equivalents) for administration and to transfer clinical records. Similarly, communication must be maintained with hospital services. It is unrealistic, at present, to recommend an overall strategy, but all parts of the NHS must be constantly aware of the need to interrelate with others, since developments in isolation can only lead to chaos.

Computers and continuing education

A particular requirement for external communications is with the GPO Prestel system, since it can provide an essential source of important information to be accessed by the practice computer. Indeed, this will probably add a totally new dimension to the continuing education of the primary care team.

Technical solutions and financial problems

In Chapter 4 we consider a technical solution of the system described in Chapter 3. Here again the details must be regarded as merely an illustration of the possibilities. Nevertheless, these indicate that our tentative suggestions are technically feasible, but are they economic? The current cost of the hardware is over £40,000, but in five years' time this cost could well be down to £10,000 at today's prices. It should be noted that we envisage that the technical and economic feasibility will depend upon the development of cheap solid-state bulk data stores to replace the currently available electromechanical hard-disc drives.

£10,000 for the average partnership practice does not seem impossibly high, but it is unlikely to be economic for the practice. However, it may well be economic for the NHS. Some method of subsidy is obviously implied, and in Chapter 5 we discuss the problems of implementation applicable to the independent contractor status of the general practitioner. These are matters which are properly the concern of our colleagues in the General Medical Services Committee, and we look forward to a profitable collaboration with them.

Location of the computer

Although much of this report is based on the concept of a practice-based computer, we must stress that it is by no means clear what the final structure will or should be within the National Health Service.

There is still considerable discussion about the advantages and disadvantages of holding information centrally with adequate safeguards for confidentiality. With information remaining in practices the confidentiality of the record remains the sole responsibility of the doctor and the computer will be operated by existing practice staff. On the other hand, centralization of information (or shared computers, possibly owned by family practitioner committees) might lead to easier communication between practice and practice, practice and hospital. This arrangement might facilitate epidemiological research.

Although we hope general practitioners will agree on what they want from their computer, they may not agree on the best method of acquiring it. Some may wish to own their own machines. Some may wish to rent or lease space on machines owned by others. Some may wish to keep everything under their own roof, others may not worry about this. In view of these and other uncertainties, we believe it would be premature to close any options at present.

Need for a professional steering committee

It is easy to overlook that the major cost of a computer system is not the hardware, which is rapidly becoming cheaper, but the development of the highly sophisticated software (the programs) which requires many person-years of dedicated work from highly specialized individuals, and is becoming dramatically more expensive as increasing demand is made on a relatively limited workforce. This is one of the main arguments for compatibility of systems, for the software could be economically developed only on a national basis. This in turn suggests the need for a professional body to guide development, since we have seen that clinical evaluation must progress hand in hand with software evolution.

The challenge

Reference to the microchip revolution has been made so frequently in recent years that the phrase has lost its impact. It nevertheless describes what will soon be a reality. The information revolution on which we are about to embark will have an influence on society at least as great as that of the Industrial Revolution two hundred years ago. Changes in the provision of the primary health services will be only a tiny part of the major changes occurring elsewhere, but it is essential for our patients that we adapt in a manner which meets their needs. The adoption of appropriate new technology is a necessary part of that change, and the purpose of this report is to initiate an informed debate by the profession on the essential issues. It is a challenge that we cannot afford to ignore.

A short glossary of computing terms

Back-up copies Magnetic data storage media such as tapes or discs are extremely vulnerable to data corruption, e.g. by external magnetic fields, spilled cups of coffee, or equipment failure. Good computing practice demands that at least one copy of all data and programs is made to guard against these contingencies. These copies are termed 'back-up copies'.

Bit *B*inary dig*it* acronym for the basic unit of computer data. A binary digit can have only one of two values, 0 or 1.

Byte 1 byte = 8 bits.

This is a convenient unit which can be related to external data sizes since byte corresponds to one alphabetic or numeric character, such as A or 7.

Kilobyte (K byte or just K)

1 kilobyte = 1,024 bytes.

This unit is used to indicate data storage capacity. For example a microcomputer would typically have a fast random access memory of 32 K bytes and read-only memory of 16 K bytes with disc drives of 200 K bytes capacity.

Megabyte (M byte)

1 megabyte = 1,000 kilobytes = 1,024,000 bytes.

A typical hard disc drive would have a data storage capacity of 5 M bytes.

Computer *Micro*

These are the latest type of cheap computers which were developed from the simultaneous availability of relatively cheap large-scale integrated circuits for central processors, random access memories, and read-only memories. They differ from minicomputer and main frames essentially only in price, size, and speed. Their chief limitations are that they are slower and have smaller data capacities than conventional computers.

Mini

The traditional distinction between microcomputers and minicomputers is rapidly vanishing and now exists mainly in performance, price, and in the quality of the software associated with them. Microcomputers are tending to resemble more and more the standard minicomputer. It would not be unreasonable to expect to obtain in five years' time, for the present day cost of a microcomputer, the performance specification associated with a minicomputer.

Drives The generic name for devices using moving magnetic media for bulk data storage.

Cassette—acoustic

Conventional cheap tape recorder on which digital information is recorded as two tones: 0 = low frequency, 1 = high frequency.

They are very cheap and very slow. For example data at one end of a tape could have an access time of 30 minutes since they are read at the same speeds as the normal cassette recorder. They will have about 250 K bytes of data per side of tape.

Cassette—digital

The mechanisms are similar to those of acoustic tape drives, but they are much faster with data-packing densities much greater. Access time is about four minutes. The digital information is held as magnetic zones of opposite polarity: 0 = N, 1 = S.

Discs—floppy

The magnetic medium used in these devices resembles thin 45 r.p.m. gramophone records placed within cardboard sleeves. The discs are spun within the disc drive and the data recorded on 20 or more concentric annular tracks. The reading/writing head moves radially across the tracks. The maximum access time for a single item of data is about 1/10th of a second. Storage capacities range from 50 K bytes to 500 K bytes per side of disc.

Discs—hard

These work on a similar principle to floppy discs, but the discs are much larger and thus have much greater data capacities, typically 5 M bytes. The access times are also much faster with a speed of 1/100th of a second.

Tapes

These resemble large reel-to-reel tape recorders and hold information in a similar manner to digital cassette drives. They also have long access times, but large data capacities—typically 20 M bytes of data per tape.

Hardware All the electronic and mechanical equipment which forms the computer system.

Input/output The generic term for the process of entering data into the computer and retrieving data from it. A typical input device is the computer keyboard. A typical output device is the visual display unit.

Language A computer language is an artificial code by means of which the binary data patterns within the computer are related to human logical processes. The computer works in machine language which has a structure related to the electronic architecture of the machine. Each type of computer has its own peculiar machine language. Manufacturers use interpreters and compilers which translate their peculiar contribution to the machine language Babel to a high level language, which is usually a very restricted subset of the English language. Unfortunately they do not do this in accordance with universally agreed protocol and thus a high level language such as BASIC has many dialects.

A programmer trained in one dialect when using a machine using a different dialect is like a Cockney talking to a Glaswegian.

Memory *Random access*

A random access memory is an electronic device in a computer which will store either data or program instructions. The information is volatile and can be changed whilst the computer is running. The contents of the memory are completely lost when the computer is switched off, unless the computer has a special 'non-volatile' memory.

Read only

These are semi-conductor devices whose contents cannot be changed under normal circumstances, even when the computer is switched off. They are used to store operating systems and interpreters. In simple cheap single-purpose computing systems, such as washing machine controllers, they are also used to store programs.

Microprocessors A microprocessor is a semi-conductor device which when used in conjunction with semi-conductor memories forms the central logical elements of a microcomputer. These devices together form a system which can carry out a pre-programmed sequence of logical operations according to the instructions stored in the computer memory as a machine language version of a computer program.

Modem A device which permits a computer terminal to communicate with a remote computer via the telephone system.

Multiplexer A multiplexer is a piece of hardware which will permit a set of computer terminals simultaneously to use a single mini, mainframe, or microcomputer. The consequence for the individual terminal user is that the terminal behaves as though each user had the computer entirely to himself. Thus, a multiplexer enables a single computer to behave as though it were a set of independently operating computers.

Network When several computers are linked together so that data can be directly communicated between them, the system is termed a 'computer network'.

Program A computer program is a set of instructions for a computer which tells the computer how it should perform a given task. There are two main types of program.

1. Machine language program

Machine language is the most primitive form of computer language and consists of a set of elemental instructions for moving data around the various parts of a computer's electronic anatomy. Each type of computer has a version of machine language appropriate to it. It is difficult to write programs in machine language.

2. High level language program

In order to facilitate writing of programs, high level languages were developed which resemble restricted forms of the English language: e.g. the BASIC instruction "100 PRINT X" would cause a number corresponding to X to be printed out on a VDU screen. Each statement in a high level language corresponds to a fixed set of machine language instructions. A microcomputer will have associated with it an 'interpreter' which will translate the statements of a high level program into a corresponding set of machine language instructions which the machine can understand and act upon.

Peripherals The devices by means of which a computer interacts with the outside world. Examples of peripherals are visual display units, keyboards, printers, and disc drives.

Visual display unit (VDU)

Strictly speaking the visual display unit is the device resembling a television set on which the computer can display characters, symbols, and graphical information. Usually there is a keyboard associated with the VDU and although it is a functionally independent device when both are contained in the same case the total unit is often referred to as a VDU.

There are two main types of VDU. The 'dumb' VDU can only display signals sent by the computer and any editing of the display must be done at the main computer. The 'intelligent' VDU contains a local microcomputer and editing of the display can be carried out locally as well as by means of the main computer. In an 'intelligent' VDU, data can also be stored locally and transmitted in a single burst of information to the main computer. With a 'dumb' VDU the keyboard communicates directly with the computer and data cannot be stored locally.

Software

The programs written for a computer are termed 'software' presumably because they are created on paper. If the programs are stored in read-only memories they are sometimes called 'firmware'. In the past the cost of software accounted for about 20 per cent of the total computing cost, whilst 80 per cent of the cost was hardware. In the future, owing to rapidly diminishing hardware costs, it is predicted that these figures will be reversed and 80 per cent of computing costs will be attributable to the cost of software preparation.

CHAPTER 1

Desirable attributes of a general practice record (information) system

1. The record system must be readily acceptable by doctors so as to facilitate and encourage the provision of a high standard of patient care.

   a. The system should assist the primary care team to apply good community medicine to the practice population. To do this it is desirable to identify groups of patients at risk, so that health education, screening, immunization, and other techniques of preventive medicine can be economically applied. For this purpose the team will require, for example, lists of patients of particular age ranges and sex; with particular illnesses; those undergoing treatment with particular drugs; or any combination of these specifications.

   b. It should be so structured that it prompts the doctor to undertake or avoid particular actions that he might otherwise overlook. This is especially important in the long-term surveillance of chronic illnesses, in preventive medicine, and in the avoidance of drug interactions and allergies.

   c. The record should remind the doctor at the time of the consultation of up-to-date practice in diagnosis, treatment, and management, relevant to the patient's needs.

   d. The system should provide a record of clinical material structured in a form which can be used for undergraduate, vocational, and postgraduate teaching, including self-assessment by the doctor.

2. The record must be stored in a manner which fully satisfies the demands for confidentiality.

3. The method of storage and transmission of the record must ensure that there is negligible risk of losing it temporarily or permanently.

4. The contents of the record must be readily accessible, legible, and easily updated by a doctor working under pressure.

5. It must be possible to remove redundant information and, if desirable, to summarize it quickly and easily during normal use of the record.

6. The system must be of adequate capacity for the storage of a lifetime record of relevant information for every patient.

7. The whole or appropriate parts of the record should normally be easily available whenever required.

8. With the total exclusion of any patient identification particulars, the system should be capable of providing accurate data for health service management at district, area, regional, and national levels.

9. Similarly, the system should facilitate clinical and organizational research.

10. A record must be rapidly and securely transferable when the patient registers with a new doctor. There must be no possible access to the clinical data during the transfer process.

11. The record system should assist practice management, including the most economical and effective deployment of staff. This would require the monitoring of variations in workload, and the efficiency of the appointment system. Financial management should be facilitated, including stock control, payment of salaries, and other expenditure, and the calculation of the optimal relationship of working capital, cash flow, and profitability. Maximum income must be ensured with a quick and accurate submission of claims for payment of fees and allowable reimbursement of costs.

12. The system must be capable of adaptation to provide new functions.

13. It must be capable of use throughout the National Health Service, including linkage with systems used by family practitioner committees.

CHAPTER 2

The limitations of manual practice information systems

Introduction

UNTIL recently all general practitioner records and information systems were entirely manual. Whereas the majority of general practitioners have attempted nothing more than the upkeep of their clinical records in Lloyd George envelopes, many have tried to increase their usefulness by the institution of various indexes, registers, and logs. Many of these practices could be said to have a 'practice information system' (a set of inter-related instruments whose effectiveness is greater than the sum of the effectiveness of each individual component). The question may, therefore, be raised, if it is possible to operate a manual, and therefore cheap and simple information system in general practice, whether consideration should be given to mounting such a system on a computer.

The first response to this challenge is, of course, that although it may be possible, its uptake by the majority of the profession has been so small that its practicability can be called in question. It has been an achievement reserved for obsessional and fanatical exponents of the art and science of general practice. This is not to denigrate the contribution that these people have made, first in pioneering the systems on which more sophisticated developments could be based, and secondly in pursuing and publishing much valuable research by means of such systems. However, lack of reproduction can be held to be a failure of these systems to make an impact on general practice as a whole.

There is, however, a second level of criticism, and that is that most manual systems are error prone, incomplete, and of inconstant longevity. Even the system on which John Fry based many of his publications is now in disuse! This section will seek to apply to such manual information systems as are in use the criteria set out in the previous chapter as a basis for discussion of needs.

The clinical record

The main data bank of a general practice is its file of individual patient records. This is the only, and only justifiable, store of clinical information about a registered population. Each record should provide a longitudinal record of the patient's health and the health care from womb to tomb. The demise of the full-time single-handed practitioner who could carry much information about his patients in his head and his replacement by partnership, group practice, and team care have made good clinical records essential. While it has not yet been shown that good clinical records improve care, it has been shown that bad care is often associated with bad records. The Medical Defence Union has again and again said that good clinical records are one of the soundest defences against negligence suits.

The NHS record is comprehensive in two dimensions: it accepts data from a very wide range of diseases and problems; it is also comprehensive in that it accepts data about every phase of illness from the first presentation to the end result. This catholicity, combined with the totally obsolete format of the Lloyd George records, while providing easy input and convenient storage, militates against any easy retrieval of pertinent information for good clinical decision making. Those general practitioners who strive for excellence have sought to overcome this by the inception of structured records, problem lists, data bases, flow sheets, but above all by ordering the record and the tide of paper that flows into it. Thus, when the patient is seen, relevant data have some chance of being retrievable. The price paid is behaviour modification among general practitioners who do this. The extra time taken in structuring and entering should be saved by the smaller amount of time taken in retrieving information.

To what extent do even restructured, pruned, and carefully maintained conventional records meet the criteria laid down (Chapter 1)? These state:

> "1. The record system must be readily acceptable by doctors so as to facilitate and encourage the provision of a high standard of patient care.
>
> b. It should be so structured that it prompts the doctor to undertake or avoid particular actions that he might otherwise overlook. This is especially important in the long-term surveillance of chronic illnesses, in preventive medicine, and in the avoidance of drug interactions and allergies."

Only a formal problem-orientated record will meet this criterion. The conventional record records but does not prompt care. It is passive rather than active. In unstructured records, however, the facts which should give warning of drug interactions, allergies, and other potential hazards are probably buried, not only deeply, but scattered throughout the various components of the record (doctors' notes, hospital letters, laboratory and x-ray reports).

> "1. c. The record should remind the doctor at the time of the consultation of up-to-date practice in diagnosis, treatment, and management, relevant to the patient's needs."

The current record, however carefully structured, does not do this. Some drug companies admittedly provide FPC 6 size inserts to act as *aide-memoires*, but it is doubtful if these are used with any frequency. There is obviously the danger that such inserts will be corrupt; in other words, they will prompt the use of that company's drugs. The criteria also require that the record is "stored in a manner which fully satisfies the demands for confidentiality." The record itself does not contribute or protect confidentiality but may be stored in a variety of secure cabinets, or locked shelving. However, once the record is available to the unauthorized reader, it has no intrinsic safeguards, other than bulk, illegibility, and jumble!

"3. The method of storage and transmission of the record must ensure that there is negligible risk of losing it, temporarily or permanently."

Misfiling in the practice, retention of the record out of file by doctors for various purposes, central losses during transfer from one family practitioner committee to another, and the delay of the latter, fail to meet this criterion.

"4. The contents of the record must be readily accessible, legible, and easily updated by a doctor working under pressure."

As has already been pointed out, data entry, provided the record can be found, is relatively easy. Legibility is poor, and a complete perusal of the contents of all but the slimmest of records is impracticable within the usual consultation time.

"5. It must be possible to remove redundant information and, if desirable, to summarize it quickly and easily during normal use of the record."

Few doctors are prepared to expend the effort, or display the courage, to cull out of the record unnecessary paper. It certainly cannot be done within the normal consultation. It is possible to control the accumulation of unnecessary paper by restraint at the original point of filing. There are mistaken fears as to legal obligations for keeping material, and a general inability to formulate operational rules for what can be dispensed with and what cannot.

"6. The system must be of adequate capacity for the storage of a lifetime record of relevant information for every patient."

'Gussetted envelopes' account for only about 10 per cent of the average practice file. Those patients whose records require storage in gussetted envelopes are usually not the very old, who have accreted a large volume of data over an unhealthy lifetime, but much younger people with complex and chronic problems. To this extent, the conventional manual record in most cases meets this criterion, except for those people in whom retrievability and accessibility of information are most important: those with chronic and complicated diseases!

"7. The whole or appropriate parts of the record should normally be easily available whenever required."

In most well-run practices the conventional record is available whenever and wherever required, but it is usually thought to be fatal to extract parts of it, as they tend never to be put back in the main record.

It can be seen, therefore, that even among those doctors who have expended considerable energy and imagination in improving the conventional manual record as much as possible, many of the criteria laid down cannot be effectively met. The average doctor and the average record are still further behind. However, when taking a systems approach to general practice, there are more components than merely the clinical record to consider. The extent to which manual systems can meet the remaining criteria laid down will be further considered.

Cross-indexing

However much effort and discipline go into the individual patient record, no advantage can be taken of the unique feature of the NHS: the identifiable registered population. The potential benefits in this field are in preventive medicine and in quality control of the process of care. Both these functions require that the doctor should be able to identify groups of patients who have in common one critical feature. This requires various forms of cross-indexing of the main clinical record file. Such cross-indexes are commonplace and have been widely described. Most of them were pioneered in the early days of the Royal College of General Practitioners as research tools. These include the age/sex and various disease registers such as the E Book, F Book, and W Book. These two tools allow the identification of groups of patients either by age or sex, or by disease. Indeed, the disease register is often extended into a partial therapeutic register and groups such as those on birth control pills and those on steroids can also be identified. Some practices have been found who augment their age/sex index by a geographical register of patients, but none have been found that can easily stratify their population by occupation or social class (despite the fact that these are perhaps the most potent indicators of risk). The criteria applied to these aspects of the information system include:

"1. a. The system should assist the primary care team to apply good community medicine to the practice population. To do this it is desirable to identify groups of patients at risk so that health education, screening, immunization and other techniques of preventive medicine can be economically applied. For this purpose the team will require, for example, lists of patients of particular age ranges and sex; with particular illnesses; those undergoing treatment with particular drugs; or any combination of these specifications."

Those practices who have age/sex indexes and disease registers do have this capability. If asked, however, most will admit that their group identification is not accurate: it is easy for patients to get missed out (e.g. emergencies seen at night tend not to be entered in the disease register the next day); on the other hand, small clerical errors of numerals in the date of birth or letters in a name can create a 'new patient'. Nevertheless, there is considerable feeling in the Health Visitors' Association that the existence of a workable age/sex index is one of the few justifications for attachment of primary care teams!

"8. With the total exclusion of any patient identification particulars, the system should be capable of providing accurate data for health service management at district, area, regional, and national levels."

The Birmingham Research Unit of the Royal College of General Practitioners, with its associated 'spotter' practices, have shown the value of this for years, and have gained the benefits that have accrued with manual systems. The extraction of the data to be made available for such analysis is not easy, however, and involves the practice in a large amount of work to prepare aggregated data that protect confidentiality but which are of use for planning. On the whole, district and area management teams have not yet appreciated the value of general practice as a source of useful planning data.

> "9. The system should facilitate clinical and organizational research."

Practices with manual age/sex indexes and disease registers are nearly always teaching practices at undergraduate or postgraduate level. They have used their registers and indexes largely for research and only with the increasing use of project teaching, both undergraduate and postgraduate, has the disease register come to be seen as a teaching tool.

Much practice activity, however, takes place at the interface between general practitioner and hospital (referrals, admissions, laboratory and x-ray facilities) and the interface with the rest of the primary care team (referral to nurses, health visitors, and social workers for their professional input). Many practices have found it useful to record actions across these interfaces by setting up appropriate process logs. Finally, for the purposes of planning and control, some overall analysis of workload with regard to both pattern and volume is essential. This necessitates some form of 'score book'.

> "11. The record system should assist practice management, including the most economical and effective deployment of staff. This would require the monitoring of variations in workload, and the efficiency of the appointment system. Financial management should be facilitated, including stock control, payment of salaries and other expenditure, and the calculation of the optimal relationship of working capital, cash flow, and profitability. Maximum income must be ensured with a quick and accurate submission of claims for payment of fees and allowable reimbursement of costs."

Certainly none of the manual systems in use at the moment meet the whole range of functions stated in this criterion. The most useful ones are score books for functions such as planning sessions or reception counter staffing, but there are few other than perhaps contraceptive claim form filing that link the fiscal and clinical activities of the practice. Again, particularly in financial terms, the accuracy of the manual practice information systems is insufficient to meet the standards required.

> "12. The system must be capable of adaptation to provide new functions."

Manual systems are, of course, readily adaptable: just add another penny notebook! However, each new function in a manual system is usually implemented at the expense of an existing function, which begins to decay in terms of completeness and accuracy. There is a limit to the number of ledgers, looseleaf books, card indexes, and penny notebooks that even the most obsessional general practitioner can keep up with. The new toy is often implemented at the expense of the old and the system thereby loses completeness.

The above items constitute the components of a practice information system. The crucial three are: good clinical records, an age/sex index, and disease register. Secondary ones include process logs and score books. It could be said that with an information system comprising these components the doctor could be reasonably sure of being 'on top of' his practice, rather than 'underneath' it: to be able to plan activity rather than merely to respond to the 'seven-minute metronome'. The achievement of individuals in developing and using manual information systems has been one of the growth points of general practice since the National Health Service. Much useful research and good teaching has come from it. It has, however, neither become general among all general practitioners, nor prosecuted with consistent accuracy and completeness, even by the enthusiasts. Disuse atrophy is a cardinal feature of manual systems, unknown in computer systems.

Shortcomings of manual systems

Most of the above components can and are worked competently and effectively in notebooks, looseleaf books, and card indexes. Very few practices mount a complete set of such components. It is unrealistic to expect their wholesale adoption by the profession in general. There are three main shortcomings about such a manual system:

1. It takes much more effort than the average general practitioner can be expected to invest in it. A single consultation with a new patient with significant problems might require entries made in five or more different components. Moreover, and crucially, the use of such a system for the purposes outlined above requires further work. To extract all the known hypertensive patients for audit, or patients with chronic lung disease for a vaccination programme against influenza, or the group who have had bacteriological investigations for a survey of completeness of therapy, requires even more effort than the original data input involved.
2. Inevitably accuracy is poor. Names, dates of birth, addresses, and other data are all subject to error. In a manual system it is unlikely that time will be available to check previous entries to avoid duplication. Minor errors in spelling or enumeration produce 'new' patients! The use of such raw data therefore requires considerable work in terms of hand-sorting and pruning.
3. Such a record system is passive. It sits on the shelf waiting to be used, waiting for the general practitioner to have the idea of looking at some feature of his practice or his population, and having the energy and time to do so. The system cannot take the initiative or prompt care or changes in care.

It seems reasonable to suppose, therefore, that a comprehensive manual practice information system will be adopted only by the exceptionally energetic and enthusiastic general practitioner, will not contribute to his quality of care unless he has surplus energy after setting it up for using it, and will waste some of that energy by its requirement of pruning, sorting and checking data.

The feature card system

Only one system has been developed which attempts to minimize the input energy required. It avoids the plethora of indexes, cards, looseleaf books and notebooks by having a single instrument. It allows the doctor to cross-index a given patient or a given consultation under a large variety of headings in a way that is relatively easily set up. This is the feature card system in use in Livingston. It is important to note that it does not avoid either of the second and third problems described above, namely, accuracy and activity. While it allows a relatively large number of features such as age, diagnoses, and many items of process to be cross-indexed, it becomes cumbersome for large populations. There are only 5,000 identifiable positions on each feature card and therefore each set can pertain to only 5,000 patients. Two sets, therefore, would be required to deal with a four-doctor practice of 10,000 patients. This can and is dealt with by different coloured cards, but the opportunity for error is obvious. It also requires the attribution of a code number between 0001 and 5000 to each patient, and therefore there are inherent difficulties because of patient turnover. In summary, although it is an improvement on the multiple penny notebook system, it has serious disadvantages except in a small single-handed practice.

The present state

The rarity of good records and the greater rarity of other components of a practice information system bear witness to the following:

1. The complete lack, hitherto, of any proper education—undergraduate or postgraduate—about information handling for clinical care.
2. The lack of any application of information and communication theory to medical records.
3. The lack of insight among general practitioners about the value of practice information systems.
4. The lack of any instinct for 'population medicine' among the first doctors in the world to have defined populations.
5. Lack of available methods which do not detract from the energy available for direct patient care.
6. The failure of the Royal College of General Practitioners to present the tools that it has developed as practice management tools rather than research tools.

It is more than 20 years since the College pioneered the elements of a rudimentary practice information system. It is more than 10 years since Lawrence Weed (1969) promulgated the philosophy of problem-orientated medical records. For the last five or six years, medical records and medical information systems have secured an ever-increasing number of presentations in both vocational training and continuing education courses. Yet apart from a relatively tiny number of enthusiasts, medical information handling is no better now than it was at the inception of the National Health Service. The inescapable conclusion is that no available manual system is cost-effective in the sense that the cost is seen as a doctor's input of energy and the effectiveness as the increase in his feeling of being in control of his practice.

Reference

Weed, L. L. (1969). *Medical Records, Medical Education and Patient Care*. Cleveland, Ohio: Case Western Reserve University Press.

CHAPTER 3

A computerized general practice information system

IN Chapter 2 we have shown that only a minority of the desirable characteristics which we have listed in Chapter 1 can be achieved with a manual system. There are few who would deny that a computerized system is ultimately inevitable, but there is much disagreement as to when this could be achieved. In our view the advantages of computerization are sufficient to justify the major effort that would be required to overcome the problems of introduction.

Computer technology is advancing so rapidly that today's solution may appear naïve tomorrow. However, this must not be used as an excuse for doing nothing. We believe that a compatible computer system could, and should, be in widespread use in general practice within five years and adopted by virtually all practices within 10 years. This means the profession needs to make its commitment now, for there is much development work to be done.

There can be only one ultimate justification for such a major change, and that is the provision of a better service for our patients. We have no doubt that a system that encompassed all the attributes described in Chapter 1 would achieve this. However, the first requirement of the system is that it must be "readily acceptable by doctors", and we believe that the total system would require too great a modification of general practitioners' current methods of practice to be acceptable in a single step. There are also good technical and economic reasons for the gradual introduction of computerization.

As we have discussed in the Introduction, there is a real prospect that practice systems based on inexpensive microcomputers will soon become available with facilities that will add considerably to the degree of control in the average practice. However, we feel that their potential for further growth is limited, and so we will consider them in detail in our updated interim report. Our concern here is with a more sophisticated system capable of expansion to accommodate totally computerized practice records.

The system we now describe is intended to illustrate the way in which such computerization might be introduced on a wide scale in a few years' time. Each step needs to be developed and validated, and no doubt would be modified in the light of experience and the advent of new technology. We have no reason to believe that the underlying philosophy will be outdated.

The principle of the system is that the hardware installed in the first phase is capable of extension to the point at which all of our Chapter 1 criteria are met, and this is achieved only when the clinical record is handled entirely on the computer. We refer to this stage as the extended system.

Location of computer

The recent availability of low cost micro- or mini-computers leads us to favour practice-based machines at present. There are two important reasons for this conclusion. First the confidentiality of patient records remains the responsibility of the doctors, with the added advantage of the greater security provided by the computer. Secondly, it is likely to be more economic than the provision of large district machines, not only because the hardware is cheaper, but also because we envisage that the practice machine will be operated by existing practice staff. It is possible that several practices could share a machine. Eventually, with the development of efficient electronic communications, the physical location of the computer may be unimportant as long as its *control* is firmly based within the practice.

THE PHASE 1 SYSTEM

The basis for the Phase 1 system must be a computer record for each patient registered with the practice. The practice register of patients is a better description for what has previously been called the age/sex register. It represents the potential demand (and need) for primary care. The organized response to that demand is the appointment system (and we include in this term the list of home visits). Computerization of these two aspects of practice activity forms the logical basis for the system, and will generate a substantial body of data to enhance clinical management and practice administration. The addition of a diagnostic register would greatly expand the potential value of this Phase 1 system by providing easy access to clinical data for patient management and quality control. It would also facilitate teaching and research.

Outline specification

We are primarily concerned here with the development of an independent (stand-alone) first phase computerized information system for use with manual clinical records. As discussed later, however, we believe that this design would have important advantages in a totally computerized practice record system ('the extended system').

The present Phase 1 proposals can be considered under three headings: the patient register and the appointment system which interact to provide patient identification. These can be simply and economically extended to include the disease register, repeat prescription control, and the preventive medicine system. It is assumed that the system has been designed to accommodate 12,000 patients.

1. An on-line patient register

This would require for each patient the following minimal data: surname, forenames (initials?), date of birth, gender, abbreviated address (house number and road usually, and possibly the postcode), NHS number, registration status (date of registration in practice, date of acknowledgement by family practitioner committee, date of receipt of medical record envelope).

It would be important, however, to make provision for other uses of the patient register of acknowledged value—

for example, as a diagnostic register, for surveillance and follow-up for at-risk patients, immunization status, and social status. We estimate the required storage capacity on the basis of 100 characters per patient to be 1,200 K bytes.

In the extended system, the register would carry the code of the electronic data store in which the patient's clinical record was held. During the transitional period it would indicate whether the patient's clinical record was manually or computer stored.

Updating the patient register

This would be a secretarial duty, which would involve:

1. Addition of new patients.
2. Change of patient characteristics—for example, name, address, registration status.
3. Deletion of patients leaving the practice.

It is important that information on the diagnostic register (see below) is not lost when a patient is deleted from the patient register, otherwise disease incidence and prevalence rates will be impossible to calculate.

2. Patient identification

When an appointment is requested, the receptionist will key in the patient's surname followed by initials. If the entry identifies a unique name by cross-reference to the patient register, the date of birth and abbreviated address will be displayed. If more than one patient with the same name is registered, the machine will display the same data for each of them. Although the date of birth would be the simplest way of identifying the person requiring the appointment, it would be tactless for the receptionist to request this in most cases. The address would be an entirely acceptable identifier, and the receptionist could ask, for example: "Do you live at 45 Broadway, or 19 High Street?". Having identified the correct entry, the receptionist would indicate the surname against the available appointment time, and the machine would enter the patient's surname, initials and, if these were not unique, the date of birth. In the extended system, the code number of the data store containing the patient's record would also be transferred to the appointment memory, though it need not be displayed.

In the Phase 1 system, the manual records required for a consulting session will be assembled from a print-out of the session's appointments which will give date of birth in those cases where the name is not unique for the practice.

In the extended system, the patient's computerized clinical records will be brought on-line, say twice a day, by means of the machine instructing the receptionist to feed in the relevant data stores in sequence. Since these stores will be direct access memories, this procedure could be completed within a few minutes for the half day's workload requirement. Last minute additions could also be easily effected.

During the transition to computerization of clinical records, the appointment display will indicate whether the patient's records are manually or computer stored, and the receptionist can assemble the records accordingly.

3. The appointment system

This must provide all the flexibility and speed of access of a manual system and, if possible, improve upon it. Because computerization of the appointment system has not previously been proposed as an initial part of a practice computer system, it is worth considering its advantages in some detail. It is important to note that computerization of the appointment system, when properly designed, would in no way diminish the essential personal relationship between patients and receptionists.

Extrinsic advantages

1. A computerized appointment system permits the automatic monitoring of workload.
2. Computerization of all general practice clinical records, as envisaged in the extended system, requires a large data storage capacity (at least 40 megabytes for a group practice with 12,000 patients) yet only approximately one per cent of these data are required on any one working day. A system which permitted a receptionist to bring on-line only the data required for the day's work would result in important economies in the provision of direct access facilities to the data store. With only a small proportion of the valuable store of clinical information on-line at any particular time, the chances of large-scale corruption of the data would be substantially reduced. Further advantages would be apparent if a distributed computer network system were adopted (see Chapter 4).

We therefore envisage the computerization of the appointment system as an integral part of a new design philosophy for the Phase 1 computerized system and its extension to a total computerized system.

Intrinsic advantages

It is obviously important that an electronic system should be capable of allocating an appointment to a patient with a particular doctor at an acceptable time on a particular date, at least as quickly as can be attained by turning pages in a book. We anticipate that this could be readily achieved with appropriately flexible software, but this is a key objective that needs to be tested.

Given this necessary speed of access, important advantages would follow:

1. The making of appointments by telephone could be carried out in a different location in the practice building from the reception area where appointments are given to those attending in person. This would reduce waiting time and congestion in reception, and similarly provide a speedier response to telephone requests. This separation of functions is impossible in a manual system.
2. As we have seen, by cross-referencing to an on-line patient register, patients can be identified as the appointments are made, so that two (or more) patients with the same or similar names are not confused. Identification numbers would not be required.
3. If patients are 'ticked off' as they arrive (or are visited) the system can automatically generate consultation rates specific for patient age, sex, social class; for

doctor, date, season, or any other variable desired. The punctuality of patients can also be determined.

4. A visual display unit will be provided in each consulting room, which will display the names and appointment times of patients who are waiting to be seen by that doctor. This information is generated by the receptionist who 'ticks' the name on the arrival of the patient.

   The doctor 'ticks off' the patients as they enter his consulting room. This permits doctor punctuality to be monitored, and duration of consultation determined.

   Regular access to these statistics (3 and 4) would permit improvements in the operation of the appointment system, which is currently the cause of some patient dissatisfaction (a clock and calendar are normally incorporated even in a small microcomputer).

5. Since time is one of the major constraints under which general practitioners have to operate, a system which regularly monitors the way in which the doctor spends his time with his patients should enable him to allocate his time more effectively.

6. For patients making appointments in person, the machine can rapidly print an appointment card for the patient, showing the time, date, and doctor, thus relieving the receptionist of the task of writing the information.

7. The machine must also print the appointments for each consulting session. These are, at present, copied by hand from the appointment book. The print-out of the sessional appointments is required for the assembly of manual records from file.

Early extensions of Phase 1 system

Use of patient register to generate a diagnostic register

A diagnostic register is not an obligatory part of the Phase 1 system, but it can be achieved so economically and will be of such value that we believe that most doctors will wish to have the facility at an early stage. The word 'diagnosis' is intended to include those psycho-social assessments which are sometimes distinguished as 'problems'. The method we propose would be as follows:

1. At the end of each consulting session the total appointment list is displayed. The receptionist goes through the notes for each patient and, where an entry of a diagnosis is required, she types in the diagnosis and episode type (acute, recurrent, or chronic) against the patient's name. The machine automatically registers the date of the consultation. The patient information is then written across, by the machine, to the diagnostic register, where patient data are classified under diagnostic categories.

2. Diagnoses throughout the year are accumulated in this way on the patient register and in the diagnostic register, and it would be necessary merely to add analysis programs which would show age and sex specific incidence rates, provide lists of patients with specific diagnoses, and other analyses as required.

3. It will be possible to hold information on the diagnostic register for several years, but obviously not indefinitely.

   For those practices who wish to maintain long-term information, provision should be made for printing out (or transferring to magnetic tape) the whole of one year's diagnostic data for archiving and subsequent deletion from the computer file. This might be done every year for data for the sixth previous year. This would imply that five years' data would be kept on file for immediate access.

4. The patient register can be used as a patient summary. During the consultation, the doctor will be able to display the accumulated diagnoses and dates entered against the patient's name. If he wishes, the doctor can extend this list retrospectively, to enter events occurring before the introduction of the system.

   This function must be confidential, and will be made available only to the doctor, or, on his authority, to particular members of staff, by the requirement for prior entry of a secure pass code.

Repeat prescription control

Information about repeat prescriptions would be entered into the patient register. When the patient requests a repeat prescription, the practice staff will use the visual display unit to check drug, dose, frequency, and length of time since last prescription, and whether the patient should see the doctor. If appropriate, the computer will print out the prescription. Further programs could be employed to check for drug interactions and to print for the patient any necessary warnings about non-prescription drugs, forbidden foods, or other instructions.

Facilities provided by Phase 1

It is useful at this point to identify how far we have met the criteria set out in Chapter 1.

The system will fulfil most of the requirements of the primary care team for community applications, as summarized in 1a. Clinical material can readily be assembled for teaching purposes, including self-evaluation (1d). The demands for confidentiality of the limited clinical information stored in the computer have been met (paragraph 2). Since the clinical record is still in manual form, paragraphs 3, 4, 5, 6 and 10 are not entirely relevant. The system would provide important data for health service management and research (8 and 9). It would also provide valuable material for practice management, since it monitors workload and the efficiency of the appointment system, but it does not meet all the demands for financial management described in the remainder of paragraph 11. One of the predominant characteristics of the design of Phase 1 is that it should be adaptable to new and additional functions (12) and we are satisfied of the need for it to be wholly compatible with other general practice systems, and necessarily substantially standardized (13).

THE EXTENDING SYSTEM

The purpose of Phase 1 is to permit each practice to extend its system according to its own requirements and at its own pace. Only when the majority of general practitioners have computerized their clinical records will the remainder perceive how greatly it is in their own interests to do likewise. In the meantime, the extending system permits the use of mixed manual and computerized clinical records without prejudice to either format.

It follows that the order in which we now describe extensions to Phase 1 is not necessarily the order in which a particular practice would wish to extend its own system, nor is the list likely to be exhaustive.

Financial package

This would permit book-keeping and payment of salaries and wages to be undertaken on the machine. This is a readily available commercial function suitable for any small business. It probably would not monitor economically the claims for item-of-service fees, since ideally these should be generated from the single entry associated with the computerized clinical record.

Passive information packages

We discuss on page 10 how these packages can be obtained through the use of Prestel, or a similar system. We use the word 'passive' to imply the capability of the machine to provide information to the member of the primary care team who perceives the need for the information and then seeks it, using the computer as a more convenient and up-to-date source than printed material.

Drug information

This emerges as a priority with almost everyone. The advantages of computer-based systems over printed material may not be immediately realized, but as the cost of paper, printing, and distribution rises, the balance will tip in favour of electronic sources. Moreover, a computerized system should provide much greater flexibility in the provision of information in a form in which the enquirer needs it: for example, "What is the interaction between drug A and drug B?"; "List analgesics costing less than £1.00 for 50 tablets".

Special investigation information

The availability and particular requirements of pathological, haematological, biochemical, microbiological, and radiological tests, and the interpretation of the results.

Local specialist availability

Waiting times for inpatient and outpatient facilities at the local hospitals by specialty and by individual, named consultant.

Social services

Similar information in relation to social and other community services.

Immunization information

This would be of particular value in relation to overseas travel, since requirements frequently change.

Health education for the patient

Here we envisage that programs will be developed, possibly incorporating graphic displays, which will help the doctor to explain his proposed management to the patient. This function raises the possibility that the doctor may wish to make use of more than one screen (VDU) in his consulting room.

Computerization of clinical records

This is the step that requires a change of habit by the doctor, but it can be gradual. It is also the stage at which the full potential of computerization can be achieved. To summarize the existing manual records, transfer them to the computer, and thereafter require the doctor to lay aside his pen and transact directly with a machine sounds so daunting that many doctors would claim that it could not be done had not the feasibility of the procedure already been demonstrated in the Exeter project (Bradshaw-Smith, 1976).

The provision that we have proposed for the easy mixing of manual and computer records in each practice, and the ability of each doctor to change at his own pace, will, we believe, greatly increase the acceptability of the exercise. Clinical records for particular patients may well go through a stage of being partly manual and partly computer stored. Indeed, this is implied in our Phase 1 system. Later the doctor may wish to add his diagnosis and treatment to the computer record and continue to write his narrative notes. Only when he is thoroughly familiar with the input to the computer will he abandon his manual records and the inconvenience of a dual system.

If some method for communicating with the computer other than the keyboard can be introduced, it might well facilitate this change. The ability of a computer to recognize speech is clearly one possibility, but the development of a system with an adequate vocabulary is far from practicable for the foreseeable future.

When doctors start to receive computerized records from their colleagues for their newly registered patients, and these records are seen to be complete, comprehensive, presented in a standard format with clearly legible summaries, diagnoses, and treatments, we feel certain that the popularity of the electronic record will snowball.

We have one important reservation about this development. We do not know whether direct input to the computer during the consultation will have an effect on doctor/patient communication. Research on this problem is urgently required.

Advantages

These may be summarized as follows:

1. A single entry will serve multiple functions.
2. *Active* information systems now become possible. By this we mean that the machine will prompt the doctor when appropriate with, for example, interactions between drugs now proposed and others previously taken; drug allergies; the need for certain procedures or special investigations; the cost of the drug he is now prescribing together with the highest and lowest cost of other drugs in that group.
3. The availability of passive information relevant to that consultation can be brought to the doctor's attention and, if the doctor wishes, a single key depression will

display this without the need for the doctor to search for it.

4. Each doctor will be able to determine which of these prompting functions he wishes to retain, or suppress, and the machine will remember his instructions in association with his personal pass code.
5. The record will be easily legible and any part of it can be rapidly accessed.
6. Occasionally the doctor may wish the machine to offer a differential diagnosis on the basis of the history, signs, and symptoms he has entered. Such a service would be of obvious value. The clinical protocols on which the necessary software can be based are likely to take many years to develop, although a start has been made.
7. The computerized record can be rapidly transferred from doctor to doctor (probably via the family practitioner committee) when the patient moves. The present frustrating delays of up to six months must be reduced.

Thus, almost all of the remaining desirable attributes for a general practice information system described in Chapter 1 would now be fulfilled: prompting and updating the doctor (1b and 1c); legibility and accessibility of the record (4); pruning the record (5); adequate capacity (6); ready availability (7) and rapid transferability (10).

Example of use

An example will illustrate the way in which these facilities may be used:

> The doctor enters a prescription for an oral contraceptive. The machine immediately displays the patient's age and duration of previous oral contraceptive usage. It asks for her blood pressure and her current cigarette consumption, but the doctor is not obliged to respond. It also indicates that relevant passive information is available. The doctor displays this and learns that a new low-dose brand was marketed last month. Nevertheless, he decides to prescribe the brand he has already entered. The machine prints the prescription and enters the information on the practice drug register. The machine indicates that a new claim for contraceptive services is now due. It therefore prints all the relevant information on the form, and the patient and doctor need only add their signatures.

Structure of the record

Although it is important that the doctor should have great freedom to enter clinical notes as he wishes, we believe that a very limited standard structuring would be desirable.

We envisage that the standard display for a consultation should show the patient's name, address, date of birth, and an abbreviated display of summary diagnoses and problems across the top of the screen. Below this will be shown the last 'page' of the continuation record. Previous 'pages' can be readily displayed in sequence. The remainder of the screen is headed by the present consultation date, time, and place (surgery or home). Below this the doctor may enter whatever he wishes, but the diagnosis (if any) and the prescription (if any) have to be entered in designated parts of the screen. This enables entries to be written across to the diagnostic and drug registers respectively.

The complete patient summary is available for display, and redundant problems or diagnoses can be deleted. Similarly, previous continuation 'pages' can be scanned and redundant data deleted or abbreviated. It might be decided that 'pages' entered more than five years previously should be scrutinized in this way, and the machine can prompt the doctor when this needs to be done. This meets the requirement of paragraph 5 in Chapter 1.

Hospital reports

There is, at present, no ideal solution within the foreseeable future. We believe, because of the unfortunate history, that computerization of hospital clinical records is likely to lag substantially behind general practice systems, and we may have to accept manual hospital reports for many years.

This will entail either a practice secretary copying the report verbatim on to the practice computer, or copying only selected parts underlined by a doctor.

If the hospital staff were to use word processing machines compatible with the general practice computer, an electronic record (magnetic tape or, preferably, a solid state store, or by telephone) could be sent to the practice and the data transferred directly to the practice machine. The general practitioner would then have the opportunity of editing the report in the same way as he edits his own continuation pages.

Home visits

For day-time visits it would probably be sufficient to take a print-out of the patient summary and the last two continuation 'pages'. The doctor would dictate his notes for later transcription by a practice secretary. A similar system could be used for night calls, since unlike a main-frame computer the practice machine would be readily operated by the doctor if he wished to collect records on the way to visit his patient, in the same way that he can currently collect the manual records.

The possibility of a direct telephone link with the computer is discussed below. A radio link is also possible.

The use of Prestel

The Working Party has had discussions with Prestel scientific officers. They emphasized that the linked Prestel computers could act as a national communication system as well as providing information to the public. They offer facilities for 'closed user' groups which, with the use of a password, can have access to information not available to the public.

We believe that Prestel would provide several important facilities for the general practice information system:

1. The practice computer and its visual display units can be readily linked to Prestel.
2. Prestel computers will be capable of communicating with other main-frame computers. Communication with the British Library computerized medical

literature search system (BLAISE) is already being considered.

3. All the information packages required for the general practice system can be updated regularly from a national centre and entered for a 'closed user' group on Prestel. The practice will then simply call up Prestel and transfer amendments on-line to the practice data store.
4. Software (programs) can also be obtained, or amended, in this way.
5. Prestel have already produced a small solid state device which will 'scramble' any data transmitted on the telephone line, and this can be 'unscrambled' only by a recipient who knows the programmed password. This password can be modified by the sender at will. This facility will enable a clinical record to be transmitted in a code that can be decoded only by an authorized recipient. Thus, records can be transferred to family practitioner committees (or their Scottish equivalent) with only identification particulars accessible to the family practitioner committee staff (paragraph 10 of Chapter 1).
6. A most exciting potential development, for which mock-ups are already available, is a book-size portable Prestel receiver. This has a flat liquid crystal display screen and would permit a doctor to communicate with his practice computer using the patient's telephone. This would solve the problem of availability of records for home visits assuming, as seems likely, that telephones will be increasingly available in patients' homes.

Systems other than Prestel might be developed and, in particular, the National Health Service might wish to promote its own network.

Confidentiality

The procedure devised by the Exeter Project is comprehensive, and we would recommend its general adoption. Each member of the primary care team has a personal pass code which permits access only to those parts of the patient's record necessary for his or her work. Thus, all the doctors have access to the whole record (though particular doctors have the facility to retain access to highly confidential information solely to themselves) while receptionists would have access only to identification particulars.

The Working Party is satisfied that the confidentiality of patient data can be achieved in a computerized system at a higher level than that currently available on manual records.

Health service management and research

As implied in Chapter 1, totally computerized clinical records, with all identifying particulars deleted, would provide essential information for health service management without which no comparable large-scale commercial enterprise could hope to operate.

More importantly, the vast stores of clinical data that could then be tapped would open up hitherto unattainable evidence about the natural history of disease, the effect of treatment and its changing patterns. A major advance in bio-medical knowledge could be confidently predicted.

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CHAPTER 4

Technical considerations

General principles

THE model of the general practice system discussed in the previous chapter gives rise to technical requirements which can be only imperfectly realized at this stage of technological development. Even these imperfect solutions would cost more than the average practice could afford. The requirements defined by the model are as follows:

1. A computer with large fast random access memory and a fast central processor.
2. A means of storing and rapidly retrieving a large quantity of data ultimately more than 40 megabytes. The data base should be stored with a very high degree of security and when failure takes place the system should fail safe; that is, the contents should be retained unaltered by the failure.
3. The computer system should support from four to 10 users allowing them to transact with the system with response times not normally exceeding two seconds, and for certain exceptional transactions, not exceeding 10 seconds.
4. The practice system should be able to communicate with other systems outside the practice with a total control held within the practice on all outgoing data.
5. The system should be able to receive computer software and use it directly without any need for the practice to modify any part of it in order to make it compatible with the practice computer.

These requirements are now discussed in terms of current technological capabilities and an attempt is made to predict future developments which will permit the provision of an adequate general practice system.

The central processor and associated random access memory

The present generation of eight-bit microprocessors and their associated memories are essentially cheap, reliable electronic devices which go a considerable way to meeting the requirements as components of a cheap, reliable computer system.

Already in volume production are the next generation of 16-bit microprocessors and memories which are faster and can have associated with them very much larger fast memory capacities. Thus, it may be concluded that reasonable, economical solutions to the problems in this area already exist and, furthermore, it can be assumed that the cost of these components, in real terms, will fall.

Storage devices for large data bases

This area is the most unsatisfactory part of current computing technology. The devices which currently exist are audio-cassette drives, tape drives, floppy disc drives, and hard disc drives. These range in storage capacity from 100 K bytes and 10 M bytes per drive.

All of them are electro-mechanical devices and are, for that reason, unreliable. For example, both types of disc drive can have catastrophic failures which can make the data stored on them completely inaccessible. Any system which uses these devices must retain back-up copies of their data in order to guard against this contingency. With the exception of the cassette drive they are also expensive (for example, a 10 megabyte dual hard disc drive will cost £6,000 while a 100 kilobyte floppy disc drive will cost about £600). They are relatively slow compared with computer memories for the input and output of data.

In the future it is expected that cheap, reliable, solid state electronic memories will be developed which will replace these units. This development could reduce the cost of typical large data storage devices by perhaps a factor of 10. They should have a greatly enhanced reliability due to the elimination of the electro-mechanical element. It is likely that the new type of memory will be far less liable to have catastrophic loss of contents.

Visual display units and printers

The input/output peripherals associated with a computer system are not expected to diminish significantly in cost since they should not change radically in design from existing types. Cost reduction will probably come about owing to an increased volume of production of the devices.

The problem of hardware failure

Always associated with a computer system is a small but finite probability of failure due to hardware malfunction, or an electrical power failure.

The consequences of hardware failure depend upon the device that fails. The failure of an input/output peripheral, although extremely irritating at the time, rarely has long-lasting consequences. The failure of the central processor, random access memory, or operating systems can have more drastic consequences since it can result in the loss of data and the cessation of any computer-based activity within the practice. This type of fault may cause delays of up to 24 hours or more before the fault is rectified and computing can be resumed. The failure of bulk data storage devices such as floppy disc drives or hard disc drives may have catastrophic consequences by corrupting irretrievably the whole data base. A single fault of this kind can wipe out months or even years of work spent in creating a data base and thus render the computer system essentially useless until the data base has been manually recreated.

It is essential when setting up a computer system which is used in a service role to have a maintenance contract which will guarantee that a hardware fault will be rectified within a few hours of the fault being notified to the computer firm. However, such maintenance contracts are expensive and if the role of the computer does not involve severe time constraints a contract which calls for the fault to be rectified within 24 hours is much cheaper.

For the problem of loss of power there already exists a feasible technical solution. A minicomputer company already supplies a battery-powered unit which in the event of a power failure automatically shuts down the computer, preserving the current contents of the system intact. When mains power is restored the computer is automatically restarted and the computing is resumed at the point where it was interrupted.

The problem of loss of data due to central processing unit, memory or operating system faults can also be mitigated by proper program design. The program should regularly write information to the disc files so that in the event of a hardware failure only a small fraction of the data is lost.

A computer-based general practice is vulnerable to a failure of the computer system. When installing such a system, well-defined procedures must be established which will allow the practice to function when the inevitable failure occurs.

Multi-user access and interaction time

The majority of current microcomputer systems are configured for single-user access. Group practices would require multi-user access. The current standard method of permitting multi-user access is by the use of a multiplexed minicomputer. A multiplexer allows the terminals in use to be connected in sequence to the computer. Each user is given a share of the computer resources available according to some prearranged order of priority. This type of system demands a relatively large random access memory and large fast hard disc drives. If the users are competing for the same resources then the system performance may be degraded and the response time to an interactive command may become unacceptably long. Such a situation could arise during surgery hours when all the doctors and receptionists are competing for the use of the same computer resources. A future trend in computer technology, which is now under investigation, is a distributed computer network in which each user has his own computer and data storage facility but can also communicate with, and obtain access to, the resources of all the other computers on the network. Thus, local failures can be compensated for by using the resources in other parts of the network. This is a very attractive solution to the problem of system reliability. The system mimics to a certain extent the organization of biological systems by having a large amount of built-in redundancy of functions.

Communication outside the practice

The development of Prestel now gives the possibility of communication of data and software between practices and local and central government. The equipment for this activity, namely the acoustic coupler or modem, already exists and its design permits access to the general practice computer to be controlled totally by the practice. The practice can thus be certain, by using this equipment, that only that which the practice wishes to be communicated to an outside agency will be communicated.

Communication of software between computer systems

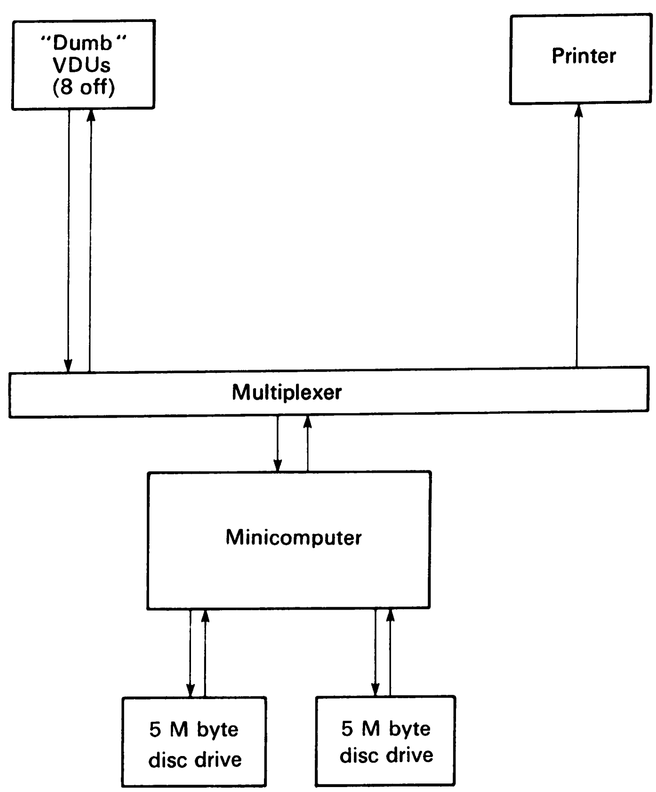
At present, the standard computer languages such as FORTRAN, BASIC, ALGOL, and COBOL have many dialects peculiar to the machines on which they have been implemented. A newer language which is gaining widespread acceptance is PASCAL. This language is designed to give a structure which is independent of the machine on which it is implemented. It is quite possible that this language may replace BASIC as the standard language for microcomputers. If this should happen, the problems of software transfer should be greatly mitigated. An alternative solution would be to have a central agency which could convert programs from one dialect of a language to another dialect of the same language. It is even possible to convert a program written in one language to a program written in a different language. The problems of software and data interchangeability are matters of current concern within the computer profession, and it is reasonable to expect steady progress in these areas.

Possible solutions to the Phase 1 and extended phase general practice system

The model systems described in this report require the following features:

1. They are multi-access systems, typically for a practice of four physicians with 12,000 patients. They would require for clinicians and staff about eight visual display units and one printer.
2. The storage requirements are not envisaged to exceed one megabyte of usable bulk data storage in Phase 1 and 40 megabytes in the extended phase.

Figure 1. A Phase 1 solution based on a minicomputer



3. The system must give a fast response to interactive transactions, particularly during the times when the physicians are conducting surgeries.

A current possible solution—the multiplexed minicomputer

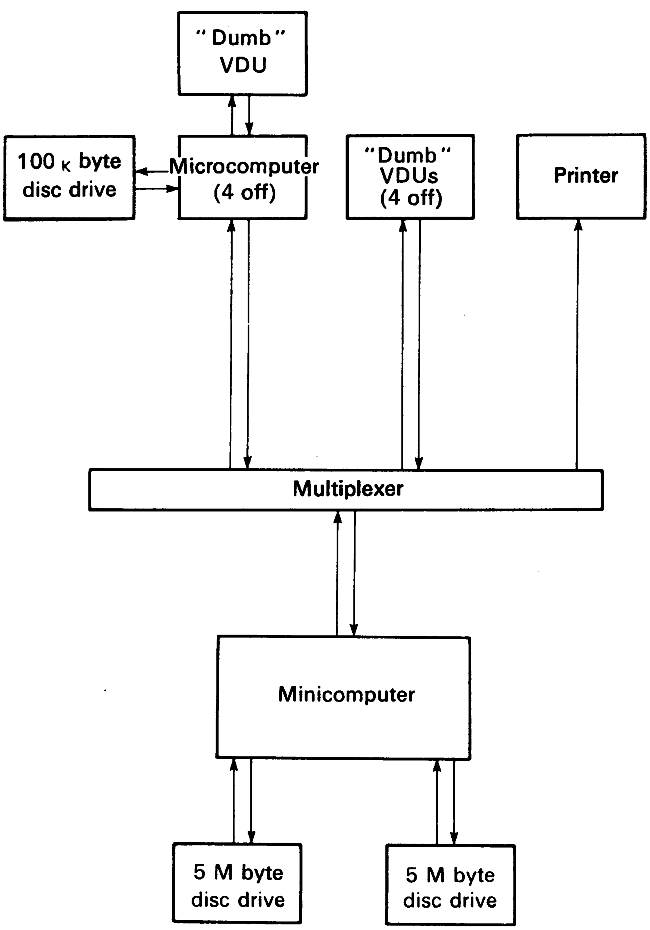
A possible solution which is currently available is a minicomputer which can be multiplexed to a set of 'dumb' VDUs. For a Phase 1 solution, this would require two 5 megabyte disc drives in order to support the multi-access operating system and the one megabyte data base (Figure 1). This solution would give ample data storage and a rapid speed of access to the stored data.

This system could be readily extended by the addition of further disc drives to give a data storage capacity of 40 megabytes necessary for an extended phase solution.

The possible disadvantages of the minicomputer solution are:

1. The cost (hardware and operating system): Phase 1 £20,000, extended phase £38,000.
2. The vulnerability of the system to equipment failure. Failure of the multiplexer, minicomputer or disc drive would make the system completely or partially unusable.
3. The possibility of unacceptably large response times due to the competition for resources at times of high activity such as surgery times.

Figure 2. A Phase 1 solution based on a multiplexed minicomputer with peripheral microcomputers



A limited redundancy solution—the multiplexed minicomputer with peripheral microcomputers

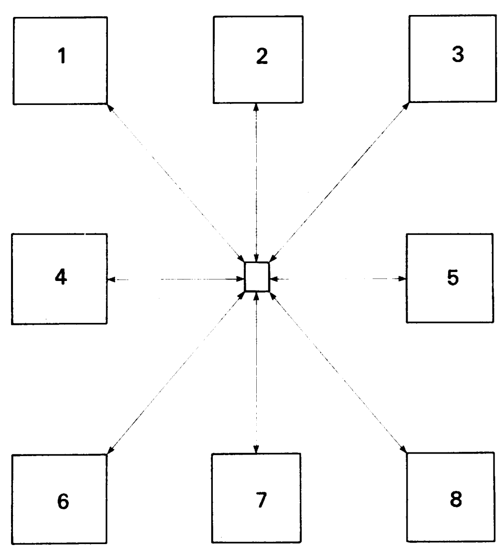
One of the major advantages of a record system based on an appointment system is that by surgery time the majority of patients attending have been identified and thus their records may be transmitted, as convenient, to peripheral microcomputer data storage (Figure 2). During a surgery session the local data stores can be updated probably within one minute of the doctor requiring the record. The provision of local data storage will also lessen the competition for central resources at times of peak activity since the clinicians' peripherals will enter into competition only when modifications to the local data bases are required, for example when additional patients are added to the doctor's consultation list.

The use of peripheral microcomputers would also give a limited redundancy of function in that a central computer failure would still permit the peripheral units to function with a 95 per cent efficiency. Peripheral microcomputer failure, if restricted to the most likely cause, i.e. the disc drive, would still permit the peripheral to function in the 'dumb' mode, competing only with secretarial staff for computer resources. The doctor's terminal could also automatically be given a higher priority for computer resources if the central computer had a suitably flexible operating system. The cost of using peripheral microcomputers instead of 'dumb' VDUs would add about £4,000 to the cost of the system described in the previous section.

A future system with full redundancy of function

Computer system design is now moving towards computer networks in which all the resources of the network are available to every computer at the nodes of the network (Figure 3). The system is dynamically adaptive in that the total resources of the network are optimized to cover the individual needs of the nodes. If, for example, a node needed more computing power, it would

Figure 3. An extended phase solution based on a computer network (after 1985?). Non hierarchical mode



Each computer in the network has peripherals suitable for its local function.

use the central processor and fast memory resources of the nodes which have this resource available. If a computer at a node broke down, the other nodes would automatically share their resources with that node's input/output peripherals. Such a system would have a very high standard of reliability owing to the dynamic redundancy of function built into it.

Assuming that such systems will be generally available within the next five to 10 years, with large fast cheap solid state memories for bulk data storage, then such networks would be optimal technological solutions to the general practice problem.

Conclusion

Technological solutions to the general practice computer system problems already exist but they are relatively expensive and unreliable.

It is quite possible that progress will bring the cost of technology down to acceptable levels. The problem which still exists, and which will continue to exist for the foreseeable future, is the provision of suitable software which will enable this technology to play a useful role in general practice. What this role is to be has yet to be agreed. It may be surmised that in this area there is a long hard road ahead, with many blind alleys, which will need to be explored before the ultimate system emerges.

CHAPTER 5

Political and economic problems

ALTHOUGH in other parts of this report it is assumed that computers will be used increasingly by general practitioners, the speed at which they will become a normal item of practice equipment depends on a number of factors.

General practitioners in the National Health Service are independent contractors. The majority are unlikely to use computers unless they believe that a computer will help them to run their practice, increase business efficiency and increase income, and/or help them with their clinical work and increase clinical efficiency.

The more effectively computers can be shown to do these tasks, the faster and more widespread will be their adoption—provided that using the computer does not involve the general practitioner or his staff in too much extra time, cost, or effort.

The major factors which will hinder the speedy introduction of computers can be grouped under four headings:

1. Technical

Manufacturers have only recently begun to look at the particular requirements of information systems in general practice. It would be true to say that at present although cheap computers with a few programs are available, they cannot provide many of the functions a general practititioner requires from his record system (see Introduction and Chapter 1). It is true that computers are available which *can* do what is needed, but they are expensive and in an early development stage. Moreover, the techniques used to put information into the computer system are still relatively primitive and may be unacceptable to many general practitioners. There is no doubt that the situation is changing fast, but there is still some way to go before the easy-to-manage fool-proof off-the-shelf system suitable for normal practice use is available.

2. Political

Being independent contractors, general practitioners are responsible for their own premises, equipment, and staff. The advantages for both patients and doctors have been spelt out by the College (1977) and the British Medical Association (1977) in their evidence to the Royal Commission; the direct provision by government of hardware and software to each practice might be viewed with suspicion in view of the effect this could have in diminishing general practitioners' standing as independent contractors.

These political constraints suggest that we should consider whether general practitioners might choose to buy or lease.

3. Financial

General practitioners are unlikely to buy or lease their own systems, or part of a system, on a large scale, if by doing so they lose money, i.e. if the cost is not covered by increased income.

It is possible to postulate that increased efficiency within the practice will result in increased income (through better stock control, prompt and accurate claims for items of service, and so on) but no studies comparing the cost and benefits of manual and computer systems have yet been published. Moreover, with present calculations of target net income, one practitioner's gain of income from items of service results in loss of income by those practitioners who do not perform them.

It is likely that to supplement a hypothetical increase of income due to increased efficiency, general practitioners will look for fresh sources of income which may be generated by the use of a computer, e.g. payment for morbidity data which could be used for local planning purposes, or reimbursement of part of the cost as a 'mechanical secretary'. Such considerations and negotiations are the remit of the General Medical Services Committee, who are responsible to the profession for negotiation of terms and conditions of service with the DHSS. But whichever way negotiations go, it is unlikely that the DHSS would agree to pay what is potentially a considerable amount of money to a large number of practices unless they get something in return—for example, reduced health care costs, demonstrably improved services, reduced prescribing costs, or fewer demands for expensive hospital services.

At present, the cost would deter most general practitioners from introducing a computer into their practice.

4. Attitudinal

Some general practitioners are interested in machines and gadgets. Many are not. An increasing number are interested in preventive medicine, and in regular follow-up of patients with chronic disease, but many are not. Only a small minority have a clear idea of the revolution in office procedures which is looming, and very few have so far seen or used a computer in practice.

One of the factors which will influence the speed of introduction of computers into general practice is the speed with which the profession as a whole accepts these new ideas.

Future possibilities

There are contrasting views of future developments. If no co-operative action is taken by the College, the British Medical Association, or the Department of Health and Social Security, the likely outcome would be that manufacturers would see a useful but limited market in general practice. Relatively cheap systems would be produced. The facilities provided would depend on what the practitioner could afford, which, in turn, would depend on the increased income he could obtain. There would almost certainly be a plethora of machines. Programs produced by the company which manufactured the machine would be specific for its own machines. Each practice would purchase or rent its own machine. There would be no ability to share programs between practices, to transmit information directly from one practice to another, or from a practice to a hospital. The practice would have gained a useful tool, but its use would inevitably be limited and many important advantages would have been lost.

The alternative view is that, by one means or another, when computers are acquired by general practitioners they should be able to expand the system to take in new facilities and programs without jettisoning the hardware. They should be able to link their computer to a data base which could provide them with management and clinical information. They should be able to accept programs from various sources and not just from one manufacturer. They should be able to transmit information directly from one system/practice to another system (practice or hospital).

In our view, as expressed earlier in this report, it is probable that development will take place in stages. In the first stage an increasing number of enthusiasts will buy their own machines—the first generation of practice computers—which they will mainly use for practical office procedures.

The second stage will involve the majority of general practitioners who will need robust equipment. Some of them will be prepared to use their system in a sophisticated way, but if the full potential of computers is to be exploited this equipment should be able to communicate with machines outside the practice. The ability to do this will not arise by chance.

There are various technical ways in which it might be brought about (e.g. through Prestel and closed user groups, through family practitioner committee machines, or through compatibility of individual microcomputers). Each technical solution has political and financial implications. It is our hope that in the near future the College and the General Medical Services Committee will be able to agree a common view. The situation is changing fast. The earlier a united profession begins discussions and negotiations with the Department of Health and Social Security, the less likely are we to be overtaken by events.

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