Focus on Medical Computer Development

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A study of the Scottish scene by Scientific Control Systems Limited

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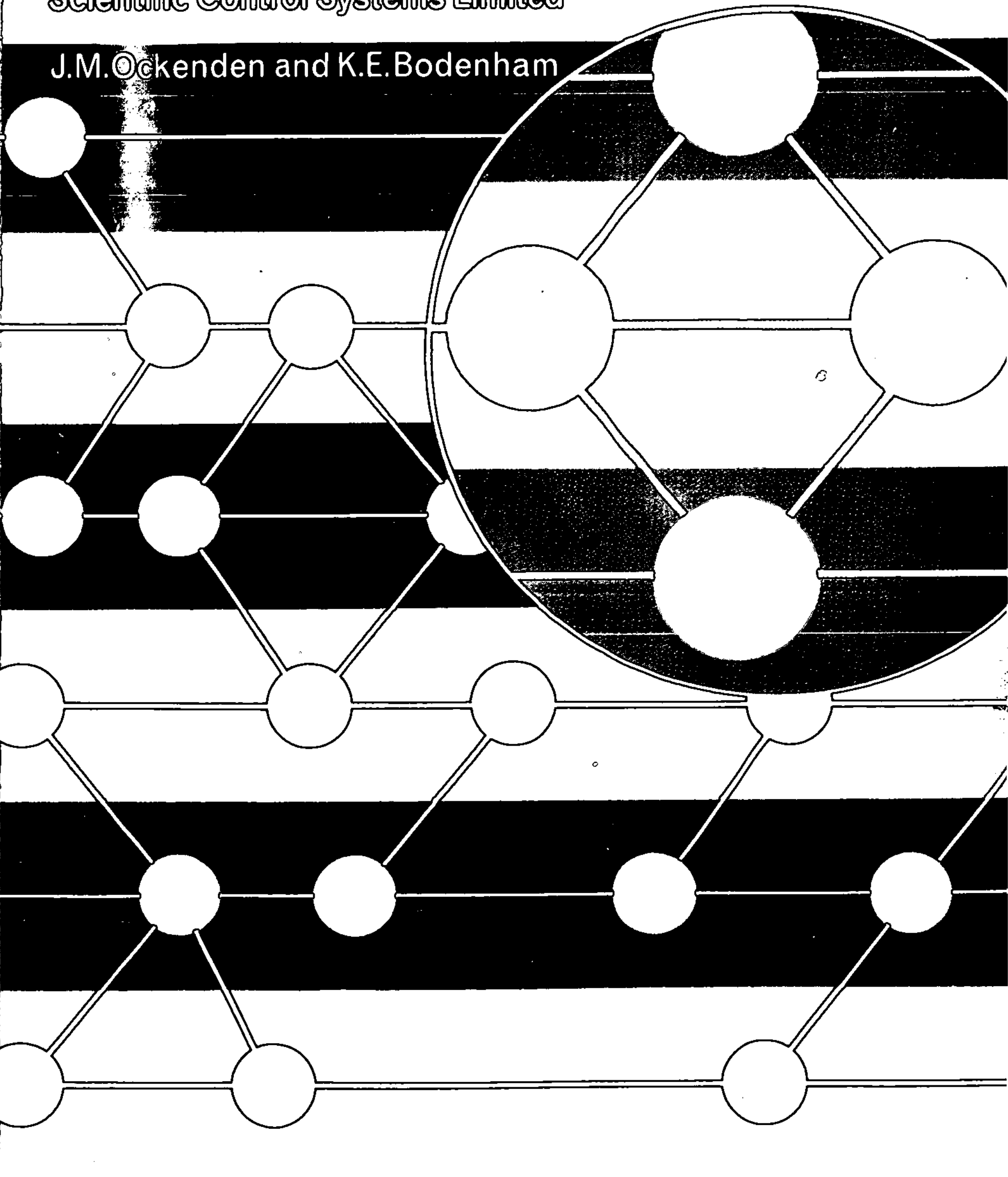

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Foreword

This book is a review by a consultant firm, expert in the computer and systems field, of the present position concerning the application of computers in health services in Scotland, taking into account all the known factors affecting development in the future. It represents a further stage in a long-established Trust policy,[1,2,3] and was commissioned as an assessment exercise. Its scope ensures it has implications for national policies in England too, for the main objective was to look at the whole picture presented by a large, well-defined, health service area, with its own traditions, covering more than five million of the population. The study has been carried out with the full co-operation of the Scottish Home and Health department which fortuitously has been considering its own policy for the future and the report is being made available to the Department to use as they think fit. It was conceived from the beginning to be essentially a practical working document and the brief recognized certain practical constraints on time and finance. As was to be expected during the course of the study other major limiting factors were identified, in the provision of staff of the quality required, the structure of the Health Service, the deployment of key technical resources (such as operating theatres and X-ray machines) and questions of medical and administrative significance.

The flexibility of the recommendations made and the need to reappraise them continually is underlined. Perhaps the most important general proposal is for the adoption of an approach to computer development which hinges on a phased programme, to ensure above all that there are always sufficient trained staff available and that a well-integrated advance is made on as broad a front as possible to make best use of technical resources. Above all, and this is to a large extent why it is hoped the book will get attention outside Scotland, certain hypotheses concerning the use of computing devices in the practice of medicine and the organization of medical care which in the past have tended to receive too scant attention are examined critically.

The understandable eagerness with which many concerned with health services have taken up the general concept that modern methods, some of which have been proved in business, can be applied in medical affairs and that such an outlook is equated with a progressive philosophy of medical care, has tended to cloud judgement about priorities and practicalities. This is not to argue that in all things it is desirable to wait on proof before action, but in an age when the concepts of cost/benefit and cost/effectiveness are being developed as controls against the stampede towards high-cost techniques with all the resultant complex problems they present to management, it is perhaps not too early at least to murmur that some critical appraisals of certain issues would not be inappropriate for health services now.

The key words in these concepts are 'benefit' and 'effectiveness' and surely the appeal in the report for preliminary operational research on some of the issues raised go to the heart of the matter. It is all very well to see how dazzling the prospects are, if it were possible to use high-quality information in many of the problems which concern diagnosis and the consequent therapies; or if the high level of accuracy demanded by some of the scientific approaches to both diagnosis and therapy could be achieved by applying some of the technical achievements which enable men to walk on the moon. It is questionable, however, given the current state of human nature, whether it is possible now, or indeed will ever be possible, to achieve the logistical efficiency necessary in order to gain the benefit from the necessary expensive equipment which is required. Certainly it is a matter for debate whether with the present management educational policies, career structures, and professional differentials the health services can easily train and maintain in the foreseeable future, the highly skilled human resources on the scale necessary for the maintenance, development, and effective day-to-day use of the systems entailed. Yet, without the certainty of an efficient manpower programme covering selection, education, and utilization on both the technical and scientific sides, it is clear that there is no certainty effective computer systems can be implemented.

Foreword

It is perhaps necessary here to hasten to deny that this is in any sense a species of Luddite thinking: rather is it an appeal for prospective and clearer thinking about the present state of the arts and science of medicine in relation to machines and to reinforce the report's special differentiation between computer service operation and computer research and development.

Indeed, one of the most notable features of this report is the identification with considerable precision of the possible applications available for choice at the present time. This concentration upon procedures which can be put to practical use within a limited time period is a refreshing contrast to the usual tendency to extend and modify experiment as an almost continual process, sometimes to the neglect of immediate practical application.

This too has a special bearing on the way the report deals with the question of 'benefit' in relation to its natural enemy—'cost'. There is a 'Fallacy of Premature Economic Assessment'[4] especially when reliance is placed too much on the infant technique of cost/benefit analysis, since in many instances it is difficult to evaluate current computer procedures let alone proposed innovations. To avoid the many pitfalls, the report has sought to set out with clarity a series of limited objectives, in such a way that the progress towards practical objectives and consequently on each can later be evaluated. This is a theme with its insistence on concentrating on the right questions that could well be taken up with advantage by the kind of task force invariably set up by health service authorities to prepare for the introduction of computer systems. Thus, for example, rather than distinguishing which procedures can be computerized with some conceivable benefit, such a task force would be well advised first to satisfy themselves that none of the new procedures could reasonably be introduced more cheaply without computer use and then to prepare for those concerned with both clinical and administrative issues, a series of options and a programme for the implementation of the new procedures.

Three of the main propositions for priority action are worthy of special note: the singling out of the hospital as the main entity to concentrate on, the favouring of batch processing staffing and the need for a special staff policy.

It is hardly necessary to point to the reason for the priority accorded to the policy for procedures inside the hospital. There are, however, those who believe that the computer should be used as an ancillary to some other purpose, for example, to help forge the link between the three parts of the Health Service and who therefore advocate as a *contribution to this end* the compilation of population registers containing in the first instance only very limited data such as name, age, diagnosis, and disposal. This can only cloud the real issues. Structural changes are certainly in the offing for the National Health Service but this will need little of the help which can be provided expensively by computer application. The question of a comprehensive record in which the general practitioner can take a part is one for debate, but there seems little doubt but that operational studies directed towards the *uses* of a community register should precede actual computer experiment.

One of the most uncompromising proposals is that priority should be given at this stage to batch-processing systems, with the exception of a few small computers dedicated to real-time experiments in selected areas of the hospital, or to laboratory systems. While part of the reason for the recommendation may be that there are trials being carried out in England and Wales of the feasibility of real-time procedures, this particular recommendation for Scotland is likely to be criticized by those who believe that a nationalized Health Service must accept its responsibility for pioneering work even when it relates to a field which is inherently very expensive. It is certainly true that if real-time systems are to be developed to meet the situation in the 1980s, intensive experimental work will be required in the coming decade; but surely in any event one should ask whether the advantages of real-time cannot be explored by simulation or by small but intensive studies of medical procedures, based on inexpensive dedicated computers, or using by time-sharing part of a large multipurpose computer.

The proposal for the creation of appointments of senior information processing officer at the highest level in the regional or area health service system raises an issue of great principle, since the repercussions of such a step could be considerable. Can a nationalized service face the challenge of creating a new staff structure of this nature for the quality of service needed? Yet, the alternative would seem to be no development at all or a private contract system with all its drawbacks. This is certainly a problem which merits the highest priority since it would not be exaggeration that all other developments are dependent on it.

There are immediate technological issues which are raised in this document which cannot be ignored much longer and on which important decisions must in fact be taken at the highest level of policy-making. Thus, the creation of a data bank is proposed as a major strategic aim for the future and a case is developed for the allocation of resources inside the hospital for experiments leading towards this objective. Indeed, much of the expense of installing a comprehensive system inside a hospital or hospital group could only be justified by the results which may be got from the establishment of a data bank eventually on a national basis. This is a matter of major general policy which can be easily grasped; but also have we really looked objectively at how in practice most medical practitioners are going to utilize much of the complex and intricate elements of many of the systems being proposed? This is not wholly a matter for the computer technologists, and is something which needs complex educational as well as operational research. It may turn out that the problems are insuperable and the cost of installing major systems with little or no benefit, exorbitant. Certainly there may be a case for a general reconsideration of policy leading to a more intensive study than has been hitherto carried out, of the way in which the doctor and the system itself, accumulates and uses information both for medical and administrative purposes.

Thus, it is that the future may be best served by the cautious but practiced approach suggested in this report for Scotland and a sharper focussing on such issues rather than the ready assumption that the expensive development proposed in many quarters is inevitable. In the event, since in England we seem to move towards policies in a mysterious way which defies analysis, the shortest way to the corridors of the Elephant and Castle may have proved to be via St. Andrew's House.

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The Report

1 Introduction

In January 1969 the Nuffield Provincial Hospitals Trust commissioned Scientific Control Systems Limited to conduct a survey on the use of computers in medicine in Scotland. It was agreed with the Trust that the aim should be to survey the current uses of computers in the Health Service in Scotland, to examine applications meriting priority for development and, where possible, to establish the costs of development. Particular attention was to be given to the period 1972–7, the next period for which capital had yet to be allocated.

Attempts to collect information by questionnaire proved impracticable as there was insufficient quantifiable data and so the more time-consuming but fruitful method of personal interviews was adopted. Those consulted in Scotland included representatives of the Scottish Home and Health Department, regional hospital boards, universities, hospitals, executive councils, local authorities, and general practitioners. In addition much valuable background information was provided by the Department of Health and Social Security, King's College Hospital, the Universities of Birmingham and Exeter, the Department of Clinical Epidemiology at St. Thomas's Hospital, computer manufacturers, and, of course, the Nuffield Provincial Hospitals Trust itself. A list of those consulted appears as Appendix 1 and we should like to record here our grateful appreciation of the helpful manner in which they dealt with our many inquiries.

During the course of this study an increasing amount of publicity has been received by a number of large-scale, real-time computer projects sponsored and encouraged by the Department of Health and Social Security in selected English hospitals. Officers of the Department have, during our discussions with them, been at pains to emphasize the essentially experimental nature of these projects together with the need for careful evaluation of the results. Although the development of real-time, single-processor, computing installations is a perfectly valid approach to the problems of medical computing, it also happens to be one of the most expensive and difficult types of system to implement effectively. The only real-time inquiry systems currently in operation—mainly in the defence and airline-reservation fields—have each taken hundreds of man-years of careful and very detailed preparation, even though they are 'dedicated' systems covering well-defined applications which, by comparison with what is intended for the experimental hospital projects, are almost straightforward. The difficulty of providing the necessary specialized operating systems and application software is in itself bound to inhibit anything like full utilization of the expensive machinery involved in such experiments.

Since we can see little point in Scotland's duplication of the English experiments and bearing in mind particular constraints which soon became apparent in our preliminary investigations, we recommend in the report a much more modest pattern of development, based initially on hospitals and some fairly widely accepted applications. We have placed particular emphasis on the major obstacle to effective implementation, namely, that of ensuring that computer projects are adequately directed by well-qualified and purpose-trained staff. Unless this key issue is quickly solved, investment in other more material resources will be wasted. The provision of intensive training courses for computer staff and appreciation courses for purely medical staff is essential; the Department of Health and Social Security is already in contact with a number of computer manufacturers, computer consultancies, and academic institutions with the object of introducing such courses. However, this tackles only a part of the problem, since staff need not only formal training but also practical experience in developing and using computer systems if they are to utilize sophisticated equipment to the maximum advantage. Such experience can be gained in the short term only by creating a climate of co-operation and ensuring that developments are within the competence and comprehension of all participants.

The Scottish health services should not necessarily reject ideas because they have been found impracticable in the United States. For instance, there is the supposition that application packages cannot be developed for hospitals because procedures differ so widely. The majority of American hospitals are, however, fully independent organizations, whereas in Britain the common content of procedures may well be found to outweigh the differences. The Scottish Home and Health Department has already taken the initiative here, by supporting a National Computing Centre study on application packages.

We have not attempted to lay down a rigid development programme: this would have been unwise at a time when the structure of the Health Service itself is under active review. Rather we have tried to put forward a flexible plan with a given starting-point and a set of ultimate objectives around which the development of computers in medicine can take place. We have tried to pin-point the first stages of that development and to emphasize the need for constant monitoring and review. Particularly to be avoided is the choice of computing machinery at too early a stage in the assessment of requirements: it would be unfortunate and could impose a decided limitation on their effectiveness if applications had to be forced to fit existing and possibly unsuitable or hastily chosen configurations of equipment. The machine must remain the servant.

2 Objectives and constraints of computer usage

Two clear objectives can be distinguished in seeking to apply computer techniques to the health services: (1) improvement of medical care, and (2) improvement in the use of resources. These are objectives which can be achieved in many interdependent ways: by improvements in nursing care, by increases in clinical and administrative efficiency, and by better use of research facilities. However achieved, improvement of medical care and in the use of resources are the two prime objectives adopted for this present study.

Sometimes these objectives may be gained by what has become known as 'computer catalysis', meaning that the promotion of a computer study suggests new methods of work or perhaps uncovers inefficiencies, the removal of which in itself leads to great benefits. In these circumstances the computer study may still proceed or it may be abandoned or reoriented.

2.1 Improvements in medical care

Computation, rapid evaluation of clinical conditions, and information handling are the means by which computers can foster improvements in medical care. Some of the principal applications are discussed here, although, of course, many improvements would rely on a combination of these means.

2.1.1. *Computation*

Calculations of varying complexity are required in biochemical analyses and radiotherapy treatment. Such calculations can be carried out without the aid of computers but the volume of work is placing an increasing burden on technicians and clinicians alike which computers could do much to lighten.

2.1.2. *Evaluation of clinical conditions*

This requires detailed recording of many functions and immediate reaction to certain changes or combinations of changes. Without an efficient monitoring system, hospital staff cannot always be aware of rapid variations in these parameters in time to respond effectively.

2.1.3. *Information handling*

Patient records, whether compiled in hospitals, general practice, or anywhere else constitute a mass of information about individual people. For this information to be of use in caring for the patient it must be easily located and retrieved. At present this is often impossible either because the administrative division of the health services leads to fragmentation of a person's total record between a number of authorities, or because it is difficult to identify a person as the same one who was treated on a previous occasion. Computers can be used to bring together information from different episodes of a person's medical history to form an integrated health record, provided all the branches of the health services with which people make contact have access to computing facilities and provided also that some universally accepted means of patient identification can be introduced.

In this context the computer could improve the medical care of an individual patient simply by being used as an electronic notebook. The extent of the assistance it could provide in this direction depends on developments in both the medical and computing fields, developments which on the one hand concern the presentation of clinical data and on the other entail improvements in storage, communication, and retrieval facilities.

As a minimum contribution the computer could provide identification and routine administrative data with indexes to the location of episodic information about the patient. At the other extreme it is conceivable that full clinical information could be coded and structured so as to be maintainable by computer, even to the point of eliminating handwritten case-notes. The further the development towards this total coverage of information, the more flexible will be the facilities required for its retrieval; this will vary from a simple daily processing of requests for administrative data to a highly complex range of responses, approaching the instantaneous, when clinical data is required.

This progressive computerization of data could at any stage in its development be of lasting value to the health of the community by facilitating epidemiological studies and research in general. Even the simplest collection of data would enable episodic information to be obtained, while increasing sophistication could improve access to an ever-widening range of clinical data.

2.2 Improvements in the use of resources

Improvement in the use of resources usually requires the application of statistical and operational research (OR) techniques, either at a local level or on a national scale.

At a local level these techniques would be applied to tasks such as departmental scheduling, pharmacy stock control, and staff scheduling. They could also be applied to management of the individual patient, by linking data from patient records to details of facilities available and analysing the potential results of allocating such facilities to him. Additionally, the actual as well as the potential results need to be analysed if the doctor is to be able constantly to monitor and improve his own performance.

It is also possible that the development of computer patient records could be considerably cheaper in the long run than continuation of present systems. Estimates of the cost of paperwork need to be treated with some caution but staffing does account for 70 per cent of the total hospital budget and any means of containing rises in expenditure deserve investigation.

At a national level the techniques could best be applied to data collected in integrated health records for long-term planning of health service facilities. Provision of hospitals, health centres, laboratories, equipment, transport, and staff in the right quantities, at the right places and right times is a task which requires all the assistance which modern OR and allied management science techniques can provide: moreover the data to which these techniques are applied needs to be accurate and as broad-based as possible.

2.3 Problems

The thread running through most of these objectives is the compilation of an integrated health record for each member of the community, i.e. what might be termed a 'medical data bank'. (Even applications which might not directly depend on a data bank, such as laboratory analyses and patient monitoring, could contribute to it.) The implication of this is that every person should have a record and that each record should be complete.

Objectives and constraints of computer usage

If such a scheme is to be implemented a number of administrative, political, moral, and legal as well as purely medical problems will have to be overcome.

The major problems are:

1. The current administrative division of the health services into hospitals, local authorities, and executive councils, whose catchment areas vary in size and are rarely coterminous. Adoption of proposals set out in the Green Paper *Administrative Re-organisation of the Scottish Health Services* would obviously remove the problem; failing this, there would at least need to be formal agreements on submission of returns to regional or national centres.

2. Lack of intensive use of facilities, especially in general practice. Development of group practices, and more particularly health centres, could, however, bring about a marked change over the next few years.

3. The volume and variety of data to be collected, coded, and stored.

4. Inadequate communications. Reliable links would be required between each processing unit and such a system could be introduced only gradually.

5. Insufficient finance and technical expertise. Neither money nor skill is likely to be available on the scale required to implement a total system in the near future.

6. Apathy or opposition which would inevitably be met. The difficulty of arousing and sustaining enthusiasm among large numbers of people is well known and initial success is more likely to attend efforts in those areas where the medical profession itself has provided the stimulus.

7. The conflict between privacy and the need for complete information. If people's medical histories are to be made available over a wide area, and this is the implication of a medical data bank, it is essential to demonstrate conclusively first that the wider availability of information is beneficial both to the populace in general and to individuals in particular, and secondly that adequate safeguards can be taken against unauthorized access.

8. The problem of record linkage. This is closely connected with the previous problem. If it could be assumed that public aversion

to enumeration could be overcome, it would be tempting to seek adoption of some form of unique personal number. This could be allocated like the National Health Service number, or derived like the Swedish personal number which consists of 10 digits, namely date of birth (6), place of birth (1), sequence of birth within date and place (2), and a check digit.

The difficulty with an allocated number is that the bearer is unlikely to remember it unless he is convinced of the need to do so and even then may quote it incorrectly. A derived number is less likely to be corrupted, although a surprising number of people give different dates of birth on different occasions, but has the major disadvantage that the same result can be derived by any number of different authorities and linking of information from one data bank to another would be facilitated. In some countries this would be seen as a decided advantage, but in Great Britain it is a sufficient argument to prevent even its consideration.

In the absence of an acceptable numbering system, any all-Scotland scheme of record linkage will have to rely on names backed up by items like date of birth, sex, and place of birth. The maintenance of an alphabetical index would certainly be required in any case (even the highly organized Swedes seem unable to do without one) and this might be used initially to indicate the hospitals, health centres, or other processing units which are known to have treated a person.

Within an individual processing unit, there are considerable advantages in allocated numbers, which cannot be linked to any other data bank, and in most cases such numbers already exist. Even at this level it has been found necessary to maintain an alphabetical index.

Finally, the connection between the health services and the General Register Office needs to be considered. The General Register Office files contain much valuable data, which could be even more valuable with certain minor additions, but we understand that any integration of General Register Office and health service files would probably require legislation, and therefore entail considerable public debate.

9. The problem of data analysis will not directly hinder the establishment of a data bank but could certainly reduce its effectiveness and this is an appropriate place for discussion.

The data stored in a computer must be made accessible to the user, and this is usually achieved by preparing a special report program which converts computer-coded data to a printed report. The disadvantages are clear: if a program does not already exist a long period of preparation is required while the user communicates his requirements to an analyst, the analyst specifies the requirements to a programmer, and the programmer codes and tests the program. The two communication links of user–analyst and analyst–programmer are often causes of misunderstanding and delay. Even if a program already exists to print the information required the data will frequently be presented in a form which is not readily intelligible to the current user, and this aspect of the problem could be accentuated in an environment like the health services where a large number of people are not mathematically trained.

For a data bank to be effectively utilized, authorized access to intelligible data must be made very much easier. For a complex printed report this will necessitate the provision of a sophisticated report generator while for immediate access to a limited quantity of data via a terminal, a medical command language will be required. Both these developments are essential to enable the user to communicate with the machine, without interposing the analyst and the programmer. It must be emphasized again that security against unauthorized access is not a technical problem and should not be allowed to hinder progress on these developments.

The cost of development of either a report generator or a medical command language will vary widely according to the simplicity of the interface required for users, the sophistication of the retrieval routines to be provided and the level of security to be built in. A fairly elementary software development of either type could cost about £50,000 to implement while a comprehensive version would be more likely to cost £200,000. Even this latter figure will not seem excessive if it provides a powerful facility which can be implemented at a number of installations throughout the Health Service.

2.4 Conclusions

While the arguments in favour of integrated health records are convincing enough these problems taken together preclude thought of a national scheme of such records except as a strategic aim.

It is against this background that we have examined the various facets of the health services to determine those areas where the application of computer techniques seems most likely to provide some immediate return within the financial and technical limits certain to be imposed.

A final note of caution. The medical effectiveness of any particular application can be judged only by people with experience in the relevant field. Technological developments and the changing pace of these developments between now and the late 1970s are difficult to forecast. A continuing monitoring of aims, equipment and applications, both medical and non-medical, will therefore be required if computing in the Health Service is to continue to reflect the needs and potentialities of the times.

3 Research

In examining ways in which computer facilities could assist in the carrying out of research projects four main problems arise: the enormous variety of work carried out at any one centre; the constantly changing pattern of that work; the need for different kinds of computing power; and the difficulty of quantifying demand.

3.1 Variety of work

This was apparent in all the centres visited as the following examples show:

1. Medical research carried out at the Edinburgh Regional Computer Centre: speech and communications, social medicine, biochemistry, psychiatry, cytogenetics, geriatrics, human genetics, coronary care, medical physics, applied psychology, preventive dentistry, cardiology, clinical surgery, immunology, radiology, and blood transfusion.

The work includes survey processing, the simulation of physiological systems, the processing of experimental data recorded automatically and manually, and general scientific computations.

The largest amount of KDF 9 computer time used by any medical department in one year was seventy hours and the smallest was half an hour.

2. Some of the research projects currently under way or proposed in Glasgow are: mobilization in recent myocardial infarction, pain relief for long-term ventilation of patients, metabolic balance studies in the severely injured, investigation into anaesthetics, analgesics, and muscle relaxants, the construction

and testing of a sequential model of the diagnostic process, interpretation of ECGs, a number of projects concerning breathing patterns, multivariate analysis of factors causing osteoporosis in rheumatoid arthritis, survey of the infection of surgical wounds, and on-line analysis of foetal cardiac cycle.

3. The results of a survey carried out by the Computer Working Party of the Faculty of Medicine in Edinburgh indicate still more strongly the variety of uses. The number of projects is given in Table 3.1 (two projects described briefly as 'long-term' and one for which no time-scale was given have been excluded while seven departments did not submit a return or submitted 'nil' returns).

	Time scale			
Computing mode	*Already in use*	*Immediate need*	*Needed in 2–5 years*	*Total*
Digital—batch processing	42	28	19	89
Digital—other modes	9	13	5	27
Analogue	4	1	—	5
Hybrid	2	2	1	5
Combinations of computers	2	6	2	10
Total	59	50	27	136

Table 3.1 Number and time-scale of computer-assisted projects identified by the Computer Working Party of the Faculty of Medicine, Edinburgh.

3.2 Changing pattern of work

Three factors contribute to this:

1. Projects start and finish almost at random, often being dependent on funds allocated for the specific investigations over a finite period of time.

2. Academic staff themselves move from one university to another, for example, the Department of Geriatric Research at Edinburgh was using the KDF 9 computer for a particular study but the driving force behind the investigations moved to Essex and the study was transferred to that university. If a high-ranking member of the medical profession transfers to another centre a number of projects can be seriously affected.

3. By its nature research can be a hit-and-miss affair which is often entirely abortive.

3.3 Demands for different kinds of computing power

These are apparent from further examination of the details given in section 3.1 and particularly from the results of the survey given in Table 3.1.

1. Batch processing on a large general-purpose machine, for instance for a number of surveys.

2. Man–machine interaction via terminals (conversational computing), in order to develop models.

3. Analogue or hybrid configurations, to cater for monitoring requirements; for example, in medical physics work.

4. Special-purpose equipment such as might be required for the experiments in chromosome pattern recognition which the Department of Cytogenetics in Edinburgh wishes to undertake.

3.4 Difficulty of quantifying demand

This is a result of the other factors. It is not possible to put forward a series of computer configurations for medical research purposes without the risks that the configurations will be either totally inadequate or substantially under-used. The possibility of under-utilization is underlined by medical usage of the 4/50 computer at Aberdeen University (three or four hours a week) and the KDF 9 at Edinburgh, where the largest user needed only seventy hours in a whole year and most departments required only occasional access. Demands for general-purpose facilities will increase but should still be well within the capacity of most university machines.

3.5 Conclusions

There is, therefore, a reasonably distinct dividing line between research computing as characterized in this chapter and 'service' computing. By service computing we mean the provision of computer facilities which can be used in a systematic manner and which even in the short term can clearly be seen to contribute to improvements in clinical and administrative efficiency, that is to say patient care in the broad sense of the term.

The suggested dividing line was endorsed by the university authorities with whom we had discussions. None of them was prepared to accept any commitment for routine running of service applications although some said they might be able to assist in the development of applications which initially at least had a research content. Of course, the development of service computing could itself facilitate by-product research by way of analysis of routinely collected data and we do not rule out the secondary use of, for instance, a hospital computer for such research purposes. We have not, however, included this in our present definition of research computing.

With regard to research computing in the sense defined we consider that it is not possible to make concrete suggestions on the selection, funding, and control of projects. It seems, in fact, that the informal system of assessment and promotion of such projects is not only inevitable but in many ways ideal.

4 Centralization of processing

The range of available computing equipment is growing rapidly and must present an ever more confusing picture to the non-specialist. The largest computer configurations available costing several million pounds are exceedingly sophisticated and require extensive planning and control while the smallest programmable machines, priced from about £5,000, can provide much more limited facilities, but are capable of fairly rapid implementation.

The Scottish health services are going to be faced with the questions of large or small, central or local, few or many machines, and the questions will have to be examined at national, regional, and local levels to determine not only the objectives but also how to start and how to develop.

Possible hardware configurations are many but there are three main types which sum up the advantages and disadvantages of different degrees of centralization.

4.1 Configuration 1

This is a large central configuration, without satellite facilities.

Advantages

1. It is probably cheaper in pure computing power per pound sterling than any other possibility.

2. Project effort is simple to control and direct since it is all aimed at one installation and not dispersed.

3. Compatibility between applications should be easy to achieve since they are all being developed for the same machine, with no variety of size, facilities, or working hours.

4. The machine is comparatively simple to run, having a known, reasonably predictable, and easily controlled workload.

Disadvantages

1. There is a physical communication problem: the transfer of large volumes of data as documents, cards, or paper tape, over varying distances to meet specified deadlines is not always an easy matter, particularly during the winter months when staff sickness, postal delays, and general transport problems are accentuated.

2. Feelings of remoteness grow up between the supplier of data and the processing centre, and between the processing centre and recipients of disseminated information. The effects of such remoteness are an increase in error rates, a lack of realistic systems design, and failure to provide the information which is really required. Eventually a process of progressive degradation sets in accompanied by processing delays and falling interest.

Processing of the in-patient discharge summary form (SMR 1) by the Scottish Home and Health Department through the Scottish Office Computer Services is one outstanding example of the difficulties of running even an apparently simple application on a centralized system.

Hard-pressed hospital records officers are understandably reluctant to give priority to completion of SMR 1 forms. It is a task of which the benefit is not obvious to them, and in addition to which they sometimes have difficulty persuading a consultant to give a diagnosis because of a feeling in some quarters that the *International Classification of Diseases* is inadequate. The inevitable result is delay in submission of the forms. Further, hospital management are reluctant to have high-grade staff complete the forms and this, plus the delay in completion already mentioned, leads to 12 per cent of the cards punched from SMR 1 forms being rejected by the computer on account of some error or other. This is grossly in excess of normal performance standards in industrial computer installations.

The Scottish Home and Health Department manage to correct most of the errors, but about 2 per cent of the original forms need to be returned to the hospital. By this time several months may have elapsed since the patient was discharged and the task of correction is viewed with even greater reluctance. The last SMR 1 form for 1967 was finally processed at the Scottish Office Computer Services installation early in 1969.

The collection of data via the SMR 1 form is an expensive procedure (estimated cost is £150,000 a year) and in an attempt to make further use of the information at marginal cost SCARS (Scottish Consultant Activity Review Statistics) was developed. The objective is to produce tables enabling each consultant to compare his own performance with the regional and national averages but the response from consultants has been mixed. The adverse criticism has been made partly on account of the delay, partly because the information provided is not what is required, and partly because of lack of understanding; there have also been favourable comments but the Department expects a long process of evolution here.

More frequent processing of SMR 1 forms is proposed in order to reduce delays but there is also a persistent demand for processing to be decentralized to the regional hospital boards, who claim to be in closer contact with the hospitals.

No criticism is implied of this particular application which in technical terms is sound, nor is this the point to appraise the suggestion for devolution to the regional hospital boards, but this example does illustrate the difficulties certain to be encountered in any attempt to centralize data processing on a national scale.

4.2 Configuration 2

In this, satellite facilities are added to the large central configuration.

Advantages

1. The central configuration is still comparatively cheap, at least in terms of hardware.

2. Compatibility between applications is possible given the rigorous enforcement of data-processing standards.

3. There are no physical communication problems for transfer of data, once the network is established.

4. More rapid turn-round should be achieved.

Disadvantages

1. Systems design and applications programming become much more complex, as all local idiosyncracies have to be taken into account.

2. A complex operating system will be required to handle all the

satellites, the central machine, and the communications network. This operating system will inevitably impose a large hardware and software overhead which will be reflected in processing time.

3. To use such a network effectively demands the existence of a number of proven, generally acceptable applications.

It is already apparent that some form of network might ultimately be required, for instance, if the claim for 'immediate' transfer of a person's medical history can be substantiated, or if elimination of physical transfer of documents or cards can be economically justified. What is also apparent, from industrial and commercial experience, is that such a network cannot be set up in haste. There is the question of cost (one bank alone is reported to have spent over £30 million on development of on-line systems) and also the need for thoroughly tested applications (without which the network would be under-utilized). Banks and industrial groups have generally developed their applications over a period of years. Where attempts have been made to go straight to a sophisticated satellite-type operation, fundamental difficulties have been encountered in envisaging the impact of the system on a company's operations and finding the right staff to develop the system.

4.3 Configuration 3

This is a number of local machines of a minimum standard configuration.

Advantages

1. Applications can be developed with the minimum of technical and other complications.

2. Applications can be developed on-site, in the ultimate working environment. This may not be important for much of the programming, but it is vital in systems design and testing stages.

3. Applications can be evaluated at a minimum cost before being adopted for use on a national scale.

4. It will be easier for the user to be directly concerned in the development of the system and real progress is therefore likely to be faster.

Disadvantages

1. Maintenance of compatibility will not be an easy matter.

2. Dispersal of expertise will aggravate the staff shortage.

3. Duplication of effort will be more difficult to avoid.

Large industrial and commercial groups have encountered all these problems. Sometimes there has even been incompatibility of computers, either because each merger or acquisition has brought with it another computer, or simply because the group has deliberately or by default failed to lay down any central policy. Still more frequently applications are incompatible, because of a different parts numbering system, or different file design, for example.

Some organizations, also, have a rather thin spread of expertise and could probably with advantage centralize certain functions on a service basis. There is also no doubt that lack of central control can lead to considerable duplication of effort.

4.4 Conclusions

If the computer developments of some of these large industrial groups have prospered it is despite these factors, not because of them. Some managements have been prepared to accept incompatibilities as the price of varied experience during the early days of a new technology. More and more, however, the tendency is for computer policy to be centrally co-ordinated just as there is central co-ordination of staff policy and production. The location of the computing equipment itself is not important.

If the environment can be kept simple, there could be advantages in experimenting with some satellites linked to regional centres, a possibility which is discussed in more detail in Chapter 9. In general, however, the Scottish health services can hardly hope to overcome all the disadvantages of the first two types of configuration and a number of local machines, installed where there is enthusiasm among potential users, is the method most likely to produce effective results. The fact that these are local machines does not imply any particular size (Chapter 9 indicates that they could be quite substantial, costing up to £200,000 or more). At the same time, all users will have to accept a measure of co-ordination of policy, planning, and staffing if effective use is to be made of resources. A fuller exposition of the organizational problems is given in Chapter 11.

5 Possible sectors of development

The administration of the Scottish health services currently rests with:

1. The Scottish Home and Health Department.

2. Five regional hospital boards and 76 hospital boards of management, covering 400 hospitals.

3. Twenty-five executive councils covering some 2,700 general practitioners, 1,400 dental practitioners, 2,700 pharmacists, and 700 opticians.

4. Fifty-six local (health) authorities.

The services provided, the geographical areas covered, and the information needs of various bodies naturally overlap or are interdependent and proposals are now being discussed which would integrate administration under a number of area health boards. The current grouping of hospitals, executive councils, and local authorities is convenient as the basis for discussion, partly because it is familiar (and the duties of the various bodies therefore need no elaboration) and partly because any reorganization will inevitably take time and could still be incomplete at the end of the five-year period 1972–7.

It is essential first to clarify one point. Under 'hospitals' this discussion excludes such applications as payroll, accounts, and PERT to which regional hospital boards have recently applied their computers. In doing so there is no suggestion that such applications are not worthwhile in themselves; indeed a description provided by the South-eastern Regional Hospital Board and reproduced as Appendix 2 suggests that computerization of payrolls is an economic proposition, while a properly used PERT package can be of undoubted value in any large-scale project. Those applications, however, do not effect any advance in medical computing, and do not assist progress towards a more comprehensive medical information system.

The future development of the computers operated by regional hospital boards is a sensitive subject to discuss at the present time, owing to the uncertainty of future organization. Each current RHB computer could in the medium term provide a service for a group of area health boards. This service would include payroll, accounts and stores application, PERT for control of large projects, and perhaps statistical analyses, for instance if processing of the SMR 1 form is decentralized (see section 4.1). It is also possible that upgrading will permit the servicing of a number of satellites at hospitals. This is an immediately attractive proposition which merits careful evaluation but it will certainly bring to the fore certain problems which the Health Service might otherwise be tempted to disregard in the immediate future.

The integration of RHB computers into the general pattern of health service computing would necessitate a measure of compatibility with any equipment to be obtained, thus to some extent restricting choice of equipment. It would also necessitate the integration of present RHB computer staff into the staff structure which we recommend should be set up for computing in the Health Service in general, a prospect which is likely to meet with opposition in some quarters. It is, however, a process which has its parallel in industry as the impact of computers on an organization's activities has widened.

A full discussion of staffing and organization is postponed to Chapter 11, and it is sufficient here to comment that of the other two possibilities, separate development of RHB computing is hardly likely to be very satisfactory while a total changeover to a different model of computer, with the consequent waste of previous development effort, is not a decision to be taken lightly.

5.1 Hospitals

A hospital is a centre of concentrated medical activity where each individual, or at least each in-patient, experiences one complete discrete episode of his medical history. Each in-patient undergoes some or all of a set of standard events—admission, discharge, diagnosis, laboratory tests, X-rays, various therapies, operations—for which codes either already exist or can be developed. Some of the procedures, e.g.

admissions, are fairly well standardized, at least within a given hospital or group of hospitals, and even if the information collected varies, a certain unvarying minimum could surely be agreed upon at all hospitals, as for instance on the SMR 1 form.

This coherence of structure enables us to isolate the following characteristics:

1. The concentration of activity and standardized nature of some procedures enable data to be economically captured.

2. As each period of hospitalization can be regarded as a complete entity, a diagnostic summary can be compiled and stored for future reference purposes.

3. The departmentalized nature of some procedures (laboratories, X-ray, pharmacy) will allow phasing of computer applications so that each can be independently introduced and firmly established before the next is attempted. The minimization of disturbance to established practice in a hospital could be crucial to the success of any computer developments, just as it is in a commercial or industrial environment.

4. Concentration of activity helps towards efficient utilization of available experience. If full value is to be obtained for expenditure, then it is clear to us that systems and programming staff who will continue to be scarce and expensive must have their attention focused on selected centres of activity and not dissipated over wide areas.

5. Concentration of activity also assists efficient utilization of equipment, the other expensive component of computer systems. Not only the central configuration is involved here, there is also all the ancillary equipment down to the last data-preparation device. Equipment costs are generally on the decrease and the utilization argument may eventually decline in importance. At present, however, it must be regarded as vital.

6. It should not be difficult to obtain the vital medical and administrative knowledge and backing from hospital staff, an argument developed in Chapter 11 of this report.

7. As hospitals account for about 60 per cent of the total health service expenditure an assault on this particular sector is more likely to yield results in the short to medium term than efforts in other sectors.

5.2 Local health authorities

The chief concerns of local authorities are preventive medicine and after-care. Services can be provided in a variety of ways:

1. At clinics; for example, baby care.

2. At other centres; for example, school health and old people's homes.

3. In private homes; for example, home nursing, domestic help, and domiciliary midwifery.

4. Through general practitioners, for example, immunization.

The central problems of this service are twofold, namely, the necessity to identify sections of the population which are 'at risk', and the necessity of ensuring that the services have been provided. When we view these problems in computer terms, we are able to identify the following categories:

1. School health, with a large, locally concentrated, and readily identifiable population which offers relatively easy methods of administration.

2. Pre-school health, with a large but less readily identifiable population which is widely dispersed and often requires painstaking follow-up if provision of services is to be ensured.

3. The aged, who may be either concentrated in residential homes or scattered throughout the community, with corresponding ease or difficulty of identification and administration.

4. Many other categories, all with very much smaller numbers. Each category requires its own specialized method of follow up, depending on the specific cause whether this be mental or physical handicap or previous medical history.

These categories have one factor in common which makes computer development in local authority health services seem worthwhile. It is possible to compile a file for each category, each constituent record indicating past history and future follow-up requirements for an individual patient. Many of the files will be very small but two of them will be substantial and for these computers seem to offer advanced methods of manipulation.

These two are the school population and the pre-school population. All children are constantly in need of surveillance and thus constantly in contact with the Health Service, whether at school or in the pre-school situation. The data available for collection from these two sources, which together account for nearly 1½ million children, is potentially of enormous value for planning, administration, and research.

It is now several years since West Sussex pioneered the use of the computer for administration of child immunization programmes. This is a task for which a fairly modest computer is ideally suited and no doubt other local authorities will wish to implement the application. Midlothian County Council, however, claims immunization rates of over 90 per cent without the use of a computer and it seems possible that the application might be worthwhile in itself only if a large population has to be administered. With smaller populations, immunization can only be viewed as part of a much larger total problem and we consider it needs to be combined with full child health records which may themselves be only the beginning of an individual's total record. Officers of Midlothian County Council suggested that a computer would be invaluable for the development of complete health records for children, starting at birth and continuing to school-leaving age, with links being provided to maternity records and handicap registers.

What can be done when a computer *is* available has been demonstrated by the Social Paediatrics Group of the Department of Child Health, University of Glasgow, and the Health and Welfare Department, Corporation of Glasgow. The administration of immunization programmes when computerized in Glasgow, was treated as an addition to an existing application of child (i.e. pre-school) health records. Data is first captured from birth notification and registration, and subsequently from each contact with social workers, hospitals, and sometimes general practitioners. Since provision has been made to include children who move to the area, it will also be possible to extend the application retrospectively to older children who were not originally included from birth. It is also hoped to enhance the system to incorporate school health records.

Once the initial data is captured, problems of scheduling immunizations and other routine examinations, planning schools, identifying special risk groups, and monitoring standards of community health are very much simplified. Further, the first step towards an integrated health record has been taken.

One special difficulty surrounds this whole sphere of development. Local health authorities are dependent on the local authority itself for computer facilities. This can, of course, lead to scheduling problems, but more important it brings into sharp focus the whole question of compatibility both in machines and procedures.

It may well be that Glasgow Corporation was justified in writing its own set of immunization programs because of the unsuitability of the West Sussex system in terms of environment, immunization schedules, and computer. Compatibility between systems and computers of all local authorities cannot be expected, but reprogramming the application several times over could only be a gross waste of public resources.

The proposed reorganization of the Health Service will be the first step towards overcoming this difficulty. In the meantime, progress will probably be restricted but since turn-round requirements are not very demanding, interim provision of services on a bureau basis should be seriously considered.

If it is considered practicable to handle all the smaller files by computer the fairly straightforward routines required could be easily programmed; indeed this is one area where a generalized application package seems worth developing. Under the present administrative structure, however, some of these groups fall wholly or partly within the province of a hospital or even a university department, as, for instance, the thyroid patients at Aberdeen and the various cervical cytology programmes. Close co-operation will clearly be necessary between the different arms of the Health Service.

5.3 General practice

A large percentage of the average person's contact with the Health Service is through his general practitioner. Estimates of this percentage vary from 55 to 80 and are generally based on figures like these (for Scotland, 1967):

Number of prescriptions dispensed	28,257,724
Number of out-patient attendances	8,179,942
Number of in-patient discharges	656,610
Total 'events'	37,094,276

If we assume that one patient/doctor contact (whether at the surgery, in the home, or by telephone) is made for each prescription dispensed, then such contacts account for 76 per cent of the total 'events'. While it is obviously fallacious to assume that the three types of event should be given equal weighting the figures themselves are impressive and make readily tenable the view that the patient/doctor contact is the foundation of the Health Service.

If, indeed, this is the case then proposals for the use of computers must consider it very carefully. We have been able to identify the following possible advantages in the linking of computers with general practice:

1. The total number of persons on the general practitioners' lists is 105 per cent of the population. It should therefore be possible from this source to capture vital information about almost the entire community and to keep that information up to date. Information such as name, address, date of birth, NHS number, family status, social status, area of residence, occupation, employer, and next of kin, which often has to be laboriously collected over and over again could all be held on a series of general practitioner files.

2. The number of patient/doctor contacts is considerable, and forms a substantial part of most people's medical history.

3. The general practitioner is involved in much laborious, repetitive, routine work, for instance in the writing of prescriptions and requests for hospital appointments. Not only is this work tedious but also the output is not at present in a form which lends itself to any type of automatic processing.

The above factors of universality, volume, and routine usually promise a substantial return from investment in computing. It is obviously, therefore, worth considering what existing digital computer techniques have to offer the general practitioner. The following applications in ascending order of complexity seem to be possibilities:

1. Analysis of consultations by patient and by diagnosis. The doctor would need to note a patient and diagnosis code after each consultation and periodically (quarterly might suffice) have these notes punched and processed. (Dr H. P. Dinwoodie of Edinburgh is one of the doctors who have been conducting simple experiments on these lines.) The consumption of computing resources is very modest.

2. Analysis of prescribing habits. The doctor himself needs no computing facilities but somehow the data on each prescription has to be made acceptable to a computer.

3. Storage and retrieval of patient records. This can be done either off-line, as for instance at Livingston and in the stand-by system at Harlow/Thamesmead/University of Essex, or on-line as envisaged for the main experiment at the latter installation.

The envelope on which the general practitioner is supposed to record all events, and in which he is supposed to keep all notes and correspondence relating to a patient has often been criticized and certainly seems inadequate for present-day needs. We gained the impression that many people feel it is necessary for some other means to be found of recording this information.

4. Diagnostic aid. The prospect of enlisting a computer to assist a doctor in his direct dealings with patients is an exciting one. A general practitioner cannot hope to be fully conversant with all diseases and possible symptoms, investigations, and treatments, and an on-line connection to a computer has been likened to having expert opinion available at the touch of a button. Computer-assisted diagnosis is the other aspect of the University of Essex experiment and for this on-line facilities are, of course, essential.

Unfortunately, there are two factors which will tend to inhibit progress in the immediate future:

1. General practitioners are widely dispersed throughout the community and for the most part still practise singly or in small groups although there is a growing trend towards concentration in health centres. Consequently any system will have a large number of out-stations to service and this means either that methods must be cheap and simple or that recognizable benefits of a substantial nature must accrue at an early date to offset high costs.

2. General practice is by its very nature, indeed by definition, ill-defined. A practitioner has 2,000 or so patients most of whom stay reasonably healthy most of the time. Yet any one patient might have symptoms relating to any of the 30,000 or more recognized diseases. In the midst of all the routine there has to be an individual assessment of each case, a constant sifting of comment, and an endeavour to communicate effectively and create a sympathetic atmosphere. These are demands which cannot be met by known computer techniques.

5.4 Executive councils

The 25 executive councils in Scotland are mainly concerned with remuneration of the practitioners who are in contract with them. Although much of their work is of the repetitive, routine, clerical, and arithmetical type for which computers are suitable, the number of staff employed is often fairly small (12–15 employees), and some staff have to be continually on hand to deal with members of the public. Staff economies do not therefore seem very likely except for the very largest councils, at least under the present Health Service structure.

Of the four different types of remuneration, that for dentists is already calculated by the Scottish Office Computer Services computer and that for opticians seems to be too restricted a field to warrant serious consideration. The remuneration of the general practitioner, while now far removed from the straightforward *per capita* basis of 1947 could still hardly be justified as a self-standing computer application but would be an obvious by-product of any general practitioner record processing.

There remains the costing and analysis of NHS prescriptions. There is undoubtedly much valuable data concealed in prescriptions, which could be used for many purposes, from compilation of 'at risk' registers, through analysis of prescribing habits, to the remuneration of pharmacists. The bulk of this analytical work has a slow response requirement, however, and can be done at leisure, probably even in hired time, but results obtained from analysis of prescriptions in Northern Ireland certainly suggest that there is scope for further investigation.

To keypunch or otherwise manually transcribe data on 28 million documents each year is a formidable operation. Sampling has been tried for the purpose of remuneration of pharmacists: it was, however, felt to be an inadequate technique for this purpose. It will also clearly be unsuitable for compilation of 'at risk' registers and psychologically unacceptable for an analysis of prescribing habits. Data from both the general practitioner and the pharmacist will have to be captured at source in machine-processable form, possibly through provision of simple plastic card-type data recorders.

5.5 Conclusions

There is an urgent need to improve the use of resources in hospitals and to relieve staff of as much routine work as possible. We do not believe that all Scotland's 400 hospitals can afford to wait several years for the setting up and evaluation of large-scale real-time computer projects although such studies could influence developments beyond, say 1973–4. Computing facilities are required now for the following reasons:

Possible sectors of development

1. Hospital management must be given an early opportunity to have their information requirements satisfied.

2. An early start is required to the long-term project of building a data bank.

3. Medical and paramedical staff must begin to look on a computer as an integral part of hospital equipment, and the sooner this is possible the better.

4. Hospital data processing must be automated as soon as possible to relieve hard-pressed staff.

Hospital developments should then be accorded the major development effort; most emphatically, however, we do not wish to suggest that other developments should be neglected, rather that in other areas funding will have to be more selective. The particular applications we should like to see developed (other than in hospitals) are child health records and other local authority follow-up registers.

Apart from these there are a number of existing experiments to be monitored, and a number of new experiments and studies which need to be set up. Current projects include:

1. The University of Essex on-line experiment. Apart from using the computer as a diagnostic aid and for information storage, it is hoped to experiment with different line speeds to determine requirements and to be able to estimate the cost of a real-time system for general practice. We hope also that an assessment will be made of the effect of the presence of a terminal on the patient/doctor relationship.

2. The South-western Regional Hospital Board and University of Exeter's plans for an integrated computer-based health service in the Exeter area. Although the early years of this project will concentrate on the new district general hospital and two new health centres it should provide useful experience of integrated operations.

3. The off-line experiment at Livingston. This should provide indications of the usefulness or otherwise of data collected at each patient/doctor contact.

Many small-scale experiments, such as that undertaken by Dr Dinwoodie, will be necessary to define general practice requirements more clearly, but there is an urgent need for a pilot study to determine the feasibility and acceptability of the use of data-recording techniques, to link prescribing, costing, and analysis of prescriptions. Data recorders of the type in common use in credit-card applications are available for as little as £13–15 each, and the plastic cards themselves cost from £10 per thousand. The main expense lies in provision of central scanning and computing equipment which would have to be arranged on a service basis. A pilot study should as far as possible be confined within one enthusiastic executive council, probably to a fairly closely knit community of about 10,000 population, 5–10 doctors, and 5–10 pharmacists.

A general point to be made here is that any scheme for the introduction of computers into general practice will, however modest, be unlikely to be initiated by the practitioners themselves, if only because the cost/benefit of such experiments is almost impossible to determine. There is also the point that any benefits likely to emerge will accrue to the Health Service generally rather than to individual practitioners. If patient care is to be improved in this sector therefore, the burden of initiation and funding of experiments must fall on government.

Finally the blood transfusion service seems to offer scope for computer development, but to demonstrate the viability of computers for the other main centralized service, the provision of ambulances, will require a careful evaluation by the OR study now being undertaken by the Scottish Home and Health Department.

6 Criteria for applications

The following criteria are suggested as being the most important for selection of applications:

1. It should be possible to demonstrate benefits derived specifically from the applications.

2. They should constitute a definable area of work.

3. They should be suitable for development in a batch-processing mode.

4. They should lead to the establishment of a data bank.

6.1 Criterion 1: Demonstrable benefits

Our inquiries into existing applications rarely produced definite statements on the benefits produced. A retrospective inquiry is certain to be difficult to answer, particularly if an application has been developed as an experiment, or even an act of faith, without any clear statement of the benefits to be expected.

Such experimental developments are bound to continue, but where large sums of money are to be spent and the policy of a national service is to be decided, it must be made possible to assess whether an application is likely to prove beneficial and, subsequently, to measure the success. To do this the aims must be clearly stated at the outset and the norms against which fulfilment will be measured must be laid down in advance.

This evaluation of a project can be made only by the users. It is they who must set the criteria by which success can be judged. Computer staff will define and develop the systems to achieve the objectives and will control the technical progress but they cannot be expected to evaluate the benefits obtained. Where there are a number of competing projects, and finance and staff are insufficient, the evaluations can be used to set priorities.

In view of the difficulties experienced in assessing the value of a project it may be helpful to illustrate some of the questions which need to be considered by those responsible:

a. Cost reduction: what is the cost of a procedure now, and what is it expected to be?

b. Error reduction: what is the current level of errors and how serious are they?

c. Production of new reports: who will receive these reports and what use will be made of them?

d. Speed of turn-round: will speed make any real difference to the effectiveness?

e. New development: is it a job which has not previously been possible? If so, why does it need to be done?

For some applications, the simplicity of the above questions will be deceptive. Whereas costs will sometimes be readily assessable, there are other occasions when it may be extremely difficult to gauge current cost levels. For instance, what is the cost of waiting-time in the out-patient department to the patient, to his employer, to the country, and to the hospital? What real reduction in costs would be obtained if waiting-time were halved? A further example is in length of stay in hospital. It is said that if patients' average stay could be reduced by one day, waiting-lists would be eliminated. It seems at least possible that the current length of waiting-lists acts as a barrier to many patients being considered for in-patient treatment and the reduction in average stay would lead to a higher throughput of patients with just as long a waiting-list as ever. (It must be made clear here that a reduction in average stay cannot on that account alone be considered undesirable. The implications of higher throughput, however, are more intensive use, or increased quantities, of operating theatres, X-ray and laboratory equipment, and staff, while the reduction in length of stay could lead to readmission or some other call on the Health Service at a future date. These are factors which need to be evaluated.)

It may be necessary for some projects to enlist the aid of operational research to unravel the complexities of benefits. For others, the evaluation will be straightforward. Whichever category a project falls into, it is imperative that such an evaluation be made.

6.2 Criterion 2: Definition

One problem which is often encountered in systems development is that of defining the optimum limits of a particular application. From the implementation aspect the ideal would be a completely self-contained application. However, this ideal does not exist and indeed from the over-all systems point of view it is essential that an application should be able to interface with others. The problem is therefore one of ensuring that these interfaces are accurately defined. If this is not done, likely consequences are delays in implementation, duplication of effort because of application overlap, or gaps in the system.

Turning to the industrial field for an illustration of this point, the example with which most people would claim some familiarity and in which almost all have an interest is payroll. This could be defined as 'calculating the amount to be paid to each employee' but it would be impossible to begin programming at this point as there are already two interfaces needing definition.

At the beginning there is an interface with general administrative and personnel operations which raises the following questions: Will the computer be supplied with each employee's gross pay? If so who will supply it? If not, who will supply the details from which it will be calculated? Who will supply details of standard deductions and allowances?

At the end there is an interface with actual payments procedures: Will the computer merely print a list of wages payable or will it print a payslip for each employee? For those paid by credit transfer will it also print the credit transfer documents?

Lateral interfaces now start to impose on application development. Should the application include all pension fund processing or should it merely calculate each employee's contribution? Should it accumulate details of holiday pay or not? Most significant is the relationship with cost analysis—the labour component of which should be available as a by-product of payroll—and production control. For certain classes of employee payroll could even become a by-product of production control.

A further example from the commercial field is invoicing. A computer can easily be programmed to produce lists of invoice values if given unit prices, quantities sold, and discounts applicable. More sophisticated is the actual printing of invoices to be sent to customers. In the first case an interface is required to the billing procedures, while in the second the interface has been moved along the line to mailing and sales ledger. In either case the interfaces with the general administrative routines of order processing, stock recording, and warehousing need very careful definition. The lateral interface in this case is with sales analyses—by customer, by product, by area, by salesman, etc. A very careful examination of possibilities here might well lead to a decision to turn the application into one of sales analyses, with invoicing a mere by-product; if sufficient information is collected for a thorough set of analyses it should always be enough for invoicing; the reverse, however, is not true.

An example drawn from hospitals is patient administration. Questions which need to be discussed are:

1. Should both in-patients and out-patients be included?

2. Are waiting-lists to be included?

3. What is the interface between waiting-lists and both in-patient and out-patient routines?

4. What is the interface between casualty department and in-patient and out-patient routines?

5. What effect could these routines have on laboratories, X-ray departments, staff scheduling, and pharmacies?

6. How do in-patient discharge procedures relate to subsequent follow-up routines?

If such questions are not identified and answered, it will be impossible to evaluate a project and estimate implementation dates.

These same principles apply in any systems study regardless of its nature or environment.

6.3 Criterion 3: Batch-processing and real-time techniques

'It is of the utmost importance that all those responsible for large projects involving computers should take care to avoid making demands on software that go far beyond the present state of the technology, unless the very considerable risks involved can be tolerated.'

The above quotation is from a paper presented by Professor S. Gill to the conference 'Software Engineering', sponsored by the NATO Science Committee in October 1968. While the report on the conference presents a slightly more depressing picture than is justified by achievements in the field (this much is stated in the report itself), one of the points which emerges clearly and repeatedly is that applications can be seen to be working in limited areas only, despite large investments of money and staff.

Some indication of the effort involved in the software area can be gathered from the fact that IBM's OS/360 absorbed some 5,000 man-years of skilled effort and TSS/360 is estimated to require some 1,000 man-years.

As a general rule the greater the number of environments with which an item of software has to contend, the greater the complexity and the less the efficiency. Even attempting to mix batch processing and real-time simultaneously brings undoubted penalties which are to some extent quantified by comparative costs of hardware for different modes of processing. An even greater penalty exists in the amount of user effort which will be required for software development.

Many organizations, with well-developed applications and many years of operational experience, have found that the adoption of a real-time approach created unforeseen and costly difficulties on a scale that not even their considerable experience could have prepared them for. Unless it is considered worthwhile to join these costly pioneering efforts, it is better to choose applications which will be satisfactorily executed by batch-processing methods.

We do not think this point can be overstressed, in view of the very much greater burdens imposed on the systems and programming staff, and consequently, much greater costs and time involved in real-time systems. There is so much to be done to develop the applications that to divert at this stage too much of the available effort to this type of computer software, would be a misuse of resources.

We are well aware that these thoughts are unfashionable and that much has been said about hospital computing being dependent on provision of real-time facilities, meaning that replies to inquiries, transmission of messages, and updating of all affected data files must be 'instantaneous'. Most proposals for large-scale medical computing equipment currently being studied in England are based on this concept.

Apart from the costs of developing real-time systems, and the unknown effect that computing will have on environment, both of which suggest the necessity for a cautious approach in application development, we believe that the vast majority of applications do not need real-time facilities once response requirements have been closely determined and it is pertinent here to examine some of the applications for which real-time is being claimed as essential.

1. Communication of requests and results between laboratory,

ward and computer. The demand for instantaneous communication ignores the facts that the sample must be physically transported to the laboratory, that in all probability the laboratory will batch the test with many others and that any results which really are required urgently can be telephoned. One professor of clinical chemistry estimated that 5 per cent of all tests might have this level of urgency and that twice-daily reporting would be adequate for the remainder. The question to be decided is whether the costs of a real-time application can be justified by the convenience provided for the urgent 5 per cent.

2. Transmission of a test request from an out-patient clinic to a laboratory. This will be worthwhile if the result is required during the same clinic, the laboratory can undertake the test immediately and communicate the result, and the patient or the sample can be quickly routed to the laboratory. Even if all these requirements are met, the value of real-time transmission of the request itself remains doubtful. If even one of the requirements cannot be met the patient will in any case need to book a return appointment to have the test done.

There is also the danger that provision of real-time facilities would mask the need for investigation of current procedures. It is permissible to speculate at this juncture how many instant test requirements would remain if all initial out-patient appointments were subject to scrutiny to determine whether a test might be required.

The demand for real-time connection with laboratories therefore ignores the interface necessary with laboratory procedures and possible shortcomings in existing procedures.

3. Ward terminals are said to be required to facilitate clinician-computer communications. This view ignores the frequency with which such terminals would be required before complete codification and computerization of the patient's clinical record is possible. The lack of complete computerization means that 'traditional' case-notes must continue to be kept in the ward, which in turn means the need for real-time inquiry has virtually disappeared. If progress is made towards computerization of case-notes, it will still be necessary to produce printed summaries, if only for standby use. The number of terminals even then might consequently be much smaller than most people imagine.

4. Another real-time use of ward terminals is said to be in connection with drug prescribing, with immediate transmission

of prescription details, firstly to the patient's record to check on allergies and incompatibilities with previously prescribed drugs, and secondly to the pharmacy who can forthwith proceed with dispensing and packaging. The reference to patient records overlooks the possibility of printed records, while direct communication with the pharmacy ignores current requirements for verification of the doctor's signature. The whole concept, however, shows a *naïveté* of approach to procedures and we must draw attention to the experiments with the concept of ward pharmacists conducted by Crooks, Calder, Barnett, and others which could alter the nature of prescribing procedures.

5. Aspects of patient administration concerned with the admission of in-patients, booking of out-patients' appointments, and inquiries about such appointments are also said to require real-time. Yet the first two can be done very easily and in fact faster by provision of listings and retrospective data acquisition, while an inquiry can be answered either by reference to a list if the inquiry concerns only a short period ahead or on an overnight response basis for longer-term requirements, as tentatively envisaged for the standby system in the hospital project at Stoke.

There are, of course, some applications which do seem to merit real-time facilities. Patient monitoring, for instance, might well be a waste of effort and expense unless an immediate response is obtained to a change in condition. Such applications may well be served by a free-standing computer, however, possibly quite small and perhaps purpose-built.

The only other point on which we currently agree with the real-time protagonists is that on-line terminals would enable immediate verification of format and content of input to be undertaken. These problems can largely be overcome with good form design and advanced methods of data capture. A very searching analysis of the extent and effects of remaining errors in content would be required before real-time could be justified for this reason alone.

It is possible that future developments will shift the balance towards real-time, but the evidence now available is strongly in favour of batch-processing methods, dull and unglamorous though they may be. Further evidence will probably only be available when the effect of such computer techniques becomes quantifiable as a result of operational trials. As already stated in the Introduction, we regard the English hospital projects as just such experiments and we hope to see them brought to a satisfactory conclusion. For the present, if the Scottish health services must choose real-time, the real-time elements must be separated from normal processing by provision of dedicated machines, or at least ameliorated by provision of front-end computers.

6.4 Criterion 4: Data bank

In Chapter 2 we have outlined the long-term aims and uses of a system of integrated patient records. If such a data bank is accepted as a strategic aim, every potential application should be examined to see whether it contributes to the integrated record. If it does, there could be a powerful argument for eventual implementation, and the greater the contribution it can make the more powerful the argument. The contribution can be great either in terms of the amount of information supplied about each person experiencing a particular sequence of events, or in terms of a large percentage of the population experiencing one event. An example of the former is a patient's normal stay in an acute hospital, where in the course of a few days a considerable number of events occur. Examples of the latter are birth and death records, vaccinations, school health examinations, and mass radiography.

It should always be the objective to capture data once, for all purposes in the Health Service, first to avoid duplication of effort and secondly to eliminate transcription errors. Only by storing data permanently, or at least for the duration of its probable usefulness, can one be certain of achieving this objective.

6.5 Summary

Not many applications are likely to be found which clearly fulfil all the conditions outlined, and it will sometimes be necessary to accept the absence of one or more criteria if other compensating factors are present. One such factor is enthusiasm among the eventual users and another is the possibility of using a simple application as a lever to stimulate more widespread enthusiasm. Enthusiasm is most likely to be generated by successful implementation of an application.

7 Applications

This chapter will deal only with applications in hospitals. We have already discussed applications in other spheres of activity which could bring tangible benefits and are therefore worth pursuing, but the main concern here is to channel the main flow of immediate development.

At this level of choice as in all others the selection of one application and the exclusion of another is likely to lead to controversy. However, the criteria set out in Chapter 6 can be applied in order to determine the first moves. Taking the selection criteria outlined in Chapter 6 we now propose to discuss in turn those applications which are most often suggested.

7.1 Patient administration

The accurate recording of admissions, discharges, transfers, operations, diagnoses, therapies, and tests, is central to the efficient management of a hospital. Without it, there would be no information on which to base waiting-list, theatre, staff, and laboratory scheduling, nor would it be possible at a regional or national level to examine the figures for trends and deviations in order to determine possible improvements, plan new buildings, initiate new or terminate old services.

The data to be recorded is likely to vary from time to time, and there may be good reason for local variation. The data currently collected on Scottish Home and Health Department form SMR 1 is suggested as a starting point. Hospitals are already used to providing this data and notification of discharge via the SMR 1 form can be avoided.

This application has the following advantages, when considered against the criteria discussed in Chapter 6:

7.1.1. *Benefit*

The estimated cost of SMR 1 form collection is £150,000 a year, so that a small saving of direct costs is immediately possible to offset computer programming and running costs.

A reduction in the number of errors is likely once a patient's basic data has been recorded. While the actual importance of the errors is difficult to assess in the case of an individual patient, the improvement in reliability of returns such as the daily bed-state will assist in day-to-day administration.

Improvement of turn-round for reports will become possible. Hospital activity analysis can be made available as an immediate by-product, and the addition of relatively small amounts of data such as projected date of discharge will ease problems of, for instance, waiting-list management.

7.1.2. *Definition*

This discussion has so far limited the application to in-patient administration and a clear boundary can be marked off between this and waiting-lists, out-patients, laboratory procedures, X-ray and operating theatre scheduling, casualty department and clinical records. Whether the application should in fact be confined to in-patient administration or should be extended to cover waiting-lists and possibly still further to include out-patients will depend on a number of factors such as hospital attitudes, staff availability, and implementation time-scale. Whatever decision is taken, the application area can still be clearly defined.

7.1.3. *Processing mode*

The application can function adequately in batch-processing mode. The benefits to be gained from immediate on-line availability of reports and statistics seem marginal and would need to be measured very carefully against increased costs. There could, however, be scope for experiments with a small dedicated machine on a real-time basis.

7.1.4. *Data bank*

The capture of basic information about the patient is the first stage of the contributions to a national data bank which can be expected from hospitals.

7.1.5. *General*

Other factors favouring this application are its relative simplicity, and the likelihood of finding sufficient enthusiasm among the administration at a particular hospital to contribute to early and successful implementation.

7.2 Clinical records

Computer storage of clinical records is the dream of many people, but at least an equal number are extremely sceptical of the possibility of the realization of that hope. The application is, however, an interesting and apparently logical extension to patient administration and measures up to the criteria in the following ways:

7.2.1. *Benefits*

These are undoubted but difficult to measure. Cost of computer storage is constantly being reduced for instance, but the level at which it becomes economic for the very large quantities of data required is hard to pin-point. A computer report or display would be free from obscurity of handwriting or lack of structure, but quantification of the seriousness of errors arising from these two faults would be extremely difficult. The value to research would be considerable but may be limited by our inability to predict what information could usefully be stored.

7.2.2. *Definition*

This is certainly not a definable area. Every speciality requires different data to be recorded, possibly even a different approach, but even within one speciality precise needs are very difficult to determine. This is illustrated by the facility for free text provided at both King's College Hospital and the Western Infirmary, Glasgow (see Chapter 8).

7.2.3. *Processing mode*

The Western Infirmary claim that on-line processing is not necessary at their current stage of development. If printed reports are available for inclusion in the patient's case-notes, merely as a convenient summary, this is obviously true, but for complete replacement of hand-compiled case-notes, on-line retrieval of data will be essential unless a very fast turn-round of printed reports is found possible. Considering the difficulties which will be encountered in data preparation and physical communication, such a turn-round seems unlikely.

7.2.4. *Data bank*

The contribution to a data bank is not in question, but the extent of the contribution to be allowed from any one episode is very difficult to decide, as already discussed under sections 7.2.1 and 7.2.2.

7.2.5. *General*

This application, however desirable ultimately, could well hold back development of hospital computing for many years unless its relative importance is kept in perspective. It is ideal for experimentation in selected specialities and in hospitals where enthusiasm is high: the problems are therefore discussed in more detail in Chapter 8.

7.3 Service departments

Biochemistry, radiotherapy, ECG, EEG, and intensive care units provide specific services in hospitals and have been tending towards automation at various levels in recent years. Some of these techniques have given rise to sharp controversy in the medical world as to their ultimate value. This controversy will have to be settled within the confines of the medical profession and the present evaluation, meanwhile, assumes a medical benefit of one kind or another.

7.3.1. *Benefits*

Cost reduction is certainly apparent in biochemistry where the number of tests per technician has increased. Error reduction is claimed in biochemistry because the computer does not get 'tired'; in radiotherapy because more detailed plans can be prepared, and alternatives can be more easily compared; and in ECG, EEG, and intensive care units because of the constant monitoring that can take place. Biochemistry can also claim that a shorter turn-round leads to improved quality control while ECG, EEG, and intensive care can expect new developments in large-scale analysis of data collected.

7.3.2. *Definition*

All these areas are clearly definable.

7.3.3. *Batch processing*

Possibly only radiotherapy is entirely suited to batch processing but the others can easily be divided into on-line monitoring of output from auto-analysers or patients, for which a small dedicated computer is ideal, and data processing, i.e. analysis of data collected which can be done in a batch mode.

7.3.4. *Data bank*

All could contribute to a data bank although the nature and extent of that contribution still needs to be determined, for example, would every biochemistry result be required for all time?

7.3.5. *General*

There will be no lack of enthusiasm for these applications. It is important to recognize that requirements could differ from one hospital to another and a 'best' approach could be more difficult to arrive at than for a more straightforward data-processing application. We consider the value of computers to have been demonstrated in biochemistry and radiotherapy, and their use to be justifiable in the other three services. The number and size of computers required for these last three is not beyond the current resources of the Health Service and if the case is still considered unproved such installations could continue to be regarded as largely experimental.

Certain other services, for instance haematology, bacteriology, and morbid anatomy, have been excluded only because their development does not generally seem to have reached the stage where computers can be applied extensively.

7.4 Patient scheduling

There are many aspects of patient scheduling, some relatively simple and others very complex. As a starting-point we have considered a simple waiting-list application for the following reasons:

7.4.1. *Benefits*

A reduction in 'error-rate' is possible because a computer will always give the stipulated weight to all factors, and a reduction in 'cost' can be claimed because less medical staff time will be required for reconciliation of the needs of different patients.

7.4.2. *Definition*

The application area is very strictly defined since it can be confined to the specialities where a special need has been identified.

7.4.3. *Processing mode*

Batch processing is adequate.

7.4.4. *Data bank*

There is little contribution to a national data bank.

7.4.5. *General*

The absence of contribution to a data bank can be discounted in this case because of the very powerful influence this fairly straightforward application could have in stimulating enthusiasm in successive areas of application.

Other aspects of patient scheduling are much more complex, or at least require on-line facilities. These start with out-patient scheduling, X-ray and other departmental scheduling, operating theatre scheduling, and finally progress to optimization of a patient's progress through a hospital, taking into account all the different services he will require. These aspects of scheduling cannot be suggested as initial applications as insufficient experience has yet been gained.

7.5 Patient follow-up

No particular distinction is made here between follow-up procedures in the hospital and those operated by local authorities or general practitioners. In fact, co-operation between the three arms will frequently be necessary and it may be convenient to keep the records, and evaluate the consultation, at a hospital or university medical faculty while the actual consultation is with the patient's own general practitioner, at a local authority clinic or health centre. (This is how the Aberdeen thyroid follow-up programme is organized.)

7.5.1. *Benefits*

The benefits are perhaps less tangible than in some cases, but the repeated follow-up of patients is essential and would be very difficult to achieve by manual means. This follow-up not only improves patient care but is also of value to the medical profession in assessing long-term effects of different forms of treatment.

7.5.2. *Definition*

The application can be introduced for any readily identifiable group of patients.

7.5.3. *Processing mode*

Batch processing is adequate.

7.5.4. *Data bank*

There is an undoubted contribution to a data bank since each patient is having new data added at regular intervals.

7.5.5. *General*

As developed at Aberdeen, the application is sufficiently generalized to be adaptable to other specialities. Although much of the programming was done in Cobol, it is not machine-independent but it ought not to be too difficult either to find a suitable machine in a given area, to develop special programs for a particular installation or even to run the application remotely.

7.6 Drug administration

This term covers the prescribing, dispensing, and stock control of drugs in hospitals. It is another application which meets all the criteria.

7.6.1. *Benefits*

Some reductions in cost from improved stock control and in error from recording of allergies and incompatibilities can be expected, although the extent of these reductions is difficult to forecast at this stage. They could be achieved by computer catalysis rather than by actual application of computer techniques, i.e. by focusing attention on problem areas. Costs at any rate are measurable, and it will be possible to set objectives.

The other advantage is that automatic logging of prescriptions enables future recall crises to be dealt with expeditiously, for instance, when a drug is found at a later date to have unwanted side-effects, and could even facilitate recognition of the causes of the side-effects by isolating common features of the patient's therapeutic history, as, for instance, in the thalidomide cases.

7.6.2. *Definition*

The extent of the application could vary considerably but is nevertheless definable, whether it be confined to stock control, extended to include records of drugs prescribed and dispensed, enhanced still further to monitor allergies, incompatibilities, and overdoses, or finally extended to monitor the actual administering of the drug to the patient. Not only is each area definable, but also progressive implementation of a total system is also possible.

7.6.3. *Processing mode*

All procedures except monitoring the actual administering of the drug to the patient are certainly suitable for batch processing. The administering of the drug might require on-line facilities, but the need will have to be substantiated by experimentation, possibly in conjunction with some patient administration experiments on a small dedicated machine, as tentatively suggested in section 7.1.

7.6.4. *Data bank*

The contributions to a data bank could be considerable. Records of drugs administered form an important part of each person's record, and facilities could be provided for analysis of prescribing patterns and interrelationships of drugs, diagnoses, operations, and side-effects.

7.6.5. *General*

There are a number of people in the medical profession keenly interested in problems connected with prescribing and monitoring an ever-growing number of drugs. This will provide added impetus to the successful implementation of such a system.

7.7 Nurse scheduling

This application is probably suggested more often than any other but even a fairly rudimentary examination reveals substantial difficulties. Taking the criteria in turn again:

7.7.1. *Benefits*

The benefits could be considerable, but in terms of efficiency rather than cost. Although the primary aim would be to maximize the utilization of scarce nursing staff, any cost-constituent which consumes as much as one-sixth of a hospital's budget is well worth examination on that account alone, despite the difficulties of applying cost/benefit analyses.

7.7.2. *Definition*

It is at present difficult to quantify workloads, e.g. number of medications, bed-baths, and drips at different times of day, in order to substantiate or dispute claims for additional staff. It is equally difficult to establish the limits of the application, since in practice ward and theatre requirements can be spread over several hospitals in a group and must be reconciled with training requirements.

7.7.3. *Processing mode*

This application could probably be started in batch mode but its dynamic nature is such that batch processing might soon be found inadequate.

7.7.4. *Data bank*

The application would make no contribution to the data bank as defined but would have to be based on computerized personnel records of nursing staff on which useful analyses could be carried out.

7.7.5. *General*

The most telling argument against this application is its lack of definition. Some of the more fundamental difficulties might be overcome if the more limited area of maternity nurse scheduling were tackled first. The application would then not be complicated by problems of the nurses' training programme since all such nurses are by definition already qualified and if this more limited application proved successful, the larger task could be studied in more detail.

7.8 Menu planning

This again is a frequently suggested application, although not necessarily by the medical profession. Its potential can be evaluated as follows:

7.8.1. *Benefit*

The only possible benefit seems to be in cost reduction. Yet the differences between a patient-by-patient analysis of diet status and estimates based on statistical averages of the hospital population are marginal. The average cost of food per patient is only £1. 12*s*. per week in Scottish hospitals, and it hardly seems worth developing computer programs on grounds of economy.

7.8.2. *Definition*

The application does have a definable area of work, whether it stops at menu planning itself or is extended to cover purchasing.

7.8.3. *Processing mode*

On-line facilities would be ideal for keeping the patient records up-to-date but generally the application could function in batch mode.

7.8.4. *Data bank*

There would be no contribution to the data bank.

7.8.5. *General*

The sum of the above factors is not very impressive and it seems unlikely that this application would fire medical personnel with enthusiasm for the use of computers.

7.9 Diagnosis

This is the application which has the most obvious appeal, the one whose glamour attracts writers in the popular and serious press alike. It is also an area in which very strenuous and concerted experiments are being carried out.

7.9.1. *Benefits*

The potential benefits are enormous, chiefly in the saving of experienced clinicians' time. The proposition that the best medical ability and experience could be condensed into a set of programs is extremely attractive.

7.9.2. *Definition*

Unfortunately the process of diagnosis is seldom well defined. Although it is possible to codify a large number of decisions taken by a clinician, diagnosis is often claimed to be intuitive in nature. This may be partly true but we suspect that the real issue here is a comparison between the sophisticated accessing methods of the human brain and the grossly inferior and inordinately complicated logical branching systems necessary in a computer program designed for the same task.

7.9.3. *Processing mode*

Batch processing will not suffice. A fast response and conversational mode are required.

7.9.4. *Data bank*

The contribution this application might make to the data bank is rather obscure. Some at least of the data collected during the diagnostic process would presumably find its way into the integrated record just as it does in the King's College Hospital and Glasgow applications (see Chapter 8). This, however, is history-taking and examination which would proceed whether the computer or a clinician was actually attempting the diagnosis.

7.9.5. *General*

While it is doubtful whether it will ever be possible to provide totally acceptable diagnosis by computer, the computer could well become a very powerful diagnostic aid and could also prove very useful in the teaching of diagnosis. It is therefore an application to be persevered with in an exploratory fashion but hardly one on which to base hospital computing over the next few years.

7.10 Summary

Patient administration, service departments, waiting-list scheduling, patient follow-up, and drug administration are the applications on which early development should be concentrated.

More investigation, possibly in some cases experimentation, is required into other applications before they can be accepted as ready for wide-ranging implementation.

8 The integrated health record

8.1 Importance of file design

In any computer application, file design and adequate but economical coding of data is important. This importance is increased if several applications access a file. Where a file serves an entire company system, with many applications and many users able to update it and read it (i.e. if we are considering a so-called management information system), file design and coding are crucial.

In discussing integrated health records which form part of a data bank we are indeed discussing part of a management information system. All classes of medical personnel will need access to various parts of the file, from various locations, using various application programs. They will require to retrieve a piece of information if it is there, to enter a piece of information they consider relevant, and to delete a piece of information which they consider no longer relevant.

8.2 Classification of data

The actual contents of files, *vis-à-vis* the storage capacity and media available, will have a profound influence on file design. Two factors contribute to the actual contents: the data it is considered necessary to hold and the computer representation of that data (i.e. the coding structure). Whether a particular item of information will be stored in a computer record depends on both ease of coding and assessment of usefulness.

8.2.1. *Ease of coding*

All organizations deal with information which may be numeric, coded, easily codable, possibly codable, or complex and unlikely to be codable.

	Application		
Class	*Order processing*	*Payroll*	*Hospital*
Numeric	Price Quantity	Rates of pay Hours worked Quantity produced	Results of laboratory tests Date of admission Date of discharge Date of birth
Coded	Part number Account number	Employee number Tax code NI number	Hospital case number NHS number
Easily codable	Product group Transaction type	Department Method of payment Family status NI class	Consultant General practitioner Diagnoses Operations
Possibly codable	Names and addresses Special instructions	Name and address Training history Levels of competence Terms of service	Name Address Next of kin Symptoms X-ray request Discharge letter
Complex	Correspondence	Correspondence	Opinion Correspondence Any other narrative

Table 8.1 Classification of information by ease of coding

Table 8.1 attempts to classify information from three application areas (two industrial and one medical) according to the five categories listed above. It should be remembered, however, that information may be easily codable in one organization and already coded in another (e.g. product group) or possibly codable in one and easily codable in another (for instance, names and addresses would normally be in the 'possible' class but the problems diminish as the number of names and addresses decrease).

The category to which information belongs will affect the ease of development of an application and the relative success of attempted coding will affect the amount of storage required.

8.2.2. *Usefulness of information*

When information is to be classified according to its usefulness much greater problems are encountered. Even for a specific purpose it is possible only to say that information may be essential, probably useful, possibly useful, or probably useless.

Table 8.2 illustrates this different classification but there are items in the probably useful and possibly useful categories which might easily become essential, depending on the scope of the application. The essential hospital information as shown in Table 8.2 could be used to analyse events by diagnosis and

	Application		
Class	*Order Processing*	*Payroll*	*Hospital Event-based analysis*
Essential	Quantity Part number Account number	Rate of pay Hours worked Quantity produced Employee number Tax code	Diagnoses Operations Date of birth Consultant General practitioner
Probably useful	Price Product group Transaction type Names and addresses Special instructions	Name NI number Department NI class	Name Hospital case number NHS number Date of admission Date of discharge
Possibly useful	Correspondence	Address	Results of laboratory tests Family status Symptoms Address X-ray requests
Probably useless		Family status Training history Levels of competence Terms of service Correspondence	Next of kin Discharge letter Opinion Any other narrative

Table 8.2 Possible classifications of information by usefulness (these are not the only classifications by usefulness).

operation, with breakdowns by consultant, general practitioner, and age. If an analysis by area of residence were required, address would become essential (and a determined effort would be made to code it). If it were decided to make the analysis person-based rather than event-based then at least one of the items, NHS number, hospital case number, or name would become essential.

The probably useful and possibly useful categories are those which can cause the most serious problems in computer applications. To include too little information will mean that a simple extension to the application can only be made at great cost: to include too much will cause the programs to operate at reduced efficiency.

8.3 Patient record developments

Various attempts are being made at codification of clinical data, the two which are probably best known in the United Kingdom are those at King's College Hospital, London, and the Western Infirmary, Glasgow (SWITCH).

The former is attempting to capture information through Visual Display Units (VDUs) on-line to an ICL 1905E, and demands the ability to branch through a series of displays, each display being called to the screen by the choice made at the previous display. Obviously facilities have to be provided for reverting to earlier displays, for re-sequencing displays in the light of experience, and for bypassing unwanted displays when one known item is to be input or when information is to be retrieved.

The latter, designed primarily for research purposes, captures information off-line on preprinted forms from which paper tape is punched and input to a KDF 9. The computer prepares a case-summary in a standard format which is filed with the case-notes.

Although the approaches in terms of computer techniques are quite different, these two developments have much in common:

1. Both have initially set definite limits to the area of development. King's is concentrating on the speciality of general medicine and Glasgow started work in the Department of Surgery's peptic ulcer clinic. Both, however, hope to extend their application and Glasgow already claim some success in the hypertension and thyroid fields.

2. The aim of both systems has been to provide a generalized structure to minimize program maintenance problems. King's has built in the facility to add, alter, or resequence displays while Glasgow requires that any new data input be adapted to one of twenty-four general standard formats.

3. Both allow free text, but neither can attempt to analyse it.

4. Both acknowledge difficulties in quantifying much of the information, but claim some success initially and expect to extend quantification steadily.

5. Both developments are keenly supported by clinicians, to professorial level.

6. Both seem to have overcome the problem of patient identification, King's because the clinician visually checks that the screen refers to the right person, Glasgow because previous case-notes bearing a system number are available.

The conclusions to be drawn from the first four points above are clear. They are, first, that any attempt to quantify and codify clinical data must start modestly, allowing free comment where necessary and second, that much more data is likely to be quantifiable and codable than might initially be apparent.

The conclusion we draw from point 5 is that there must be enthusiasm within the medical profession to initiate and encourage developments, and that the chances of success will be improved if the enthusiasm can be generated at a senior level. Computer specialists will be able to advise on feasibility only from a computer point of view: the onus for medical practicality must remain with the medical specialist.

The assessment of usefulness is therefore likely to be the more important of the two factors mentioned earlier, since a user who is convinced of the usefulness of an item will exert all the influence he can to have it included, whether coded or not. The greater influence he can exert the more attention will be given to evolving a suitable framework for its codification.

8.4 Future problems

The Glasgow experiment already caters for both in- and out-patients but the King's project has concentrated on in-patients so that the possibility of unforeseen problems if it is extended to out-patient departments cannot be ruled out.

Further problems could arise with attempts to extend data capture to health centres and general practice. This is because in-patients, out-patients, and general practice patients tend to differ in severity of illness, intensity of care, and quantity of data to be recorded. These factors will impose differing demands on response times, transaction volumes, storage requirements, and the telecommunications network required.

There are also possible problems in organization. There is, for example, the question of whether each speciality should maintain its own computer files, the parts of one patient's total record being linked by common keys, or whether the present trend of physical records, whereby one record containing all episodes is held for each patient, should be continued with the advent of more computerized systems. There is no ready answer to this question, and the considerations which have prompted the present trend in physical records do not necessarily apply to computer records.

A final problem is the necessity of providing for free comment which will impose unpredictable demands on computer storage. It is not possible to assess whether future reductions in storage costs will ever entirely offset the demand for unlimited storage facilities.

8.5 Suggested line of development

Suggestions that everyone's record can be computerized in the foreseeable future should be firmly rejected. On the other hand the view that there is no point in attempting to convert certain kinds of records to computer form seems unnecessarily pessimistic.

What is required is a framework within which any enthusiastic department can develop its own clinical record. This framework will probably require three levels:

1. A base, which is constructed for every patient. This base will include most of the details collected on the Scottish SMR 1 form, although some difficulties might be encountered if such items as 'social class' have to be coded locally. There might also be problems over the number of diagnoses and operations to be allowed, the difficulty of actually giving or coding a diagnosis, and the desirability of including additional information. The contents of the SMR 1 form will, however, at least provide a basis for development and there is not likely to be too much dissension while dealing with what is essentially administrative data.

Further, there seems to be sufficient common ground among current procedures at various hospitals to warrant investigation of an applications package to handle the basic files.

This is without doubt the essential beginning. Although there may be a variety of reasons behind their choice, others seem to have reached the same conclusion, as the following instances show:

a. In-patient registration was one of the first applications to be tackled at the Queen Elizabeth Hospital, Birmingham.

b. At King's, admission and discharge routines are to be handled for the whole hospital from the first phase of development.

c. The Glasgow Western Infirmary staff who have developed SWITCH are convinced that basic information about each patient making contact with the hospital must be captured. They would still proceed with this application even if there were no immediate return in the way of hospital statistics.

d. The North-east Region in Scotland is attempting to standardize recording practices, so that all users can eventually have access to a common data bank.

e. The London Hospital is satisfied that its patient administration system, based on an Elliott 803, originally designed to supply statistics for government returns and subsequently extended to provide hospital management information, will form a suitable basis for large-scale developments.

2. Superimposed on the base, a general section or sections within which each speciality can specify and develop its own information requirements.

Although both the King's and Glasgow projects aim to provide this general structure, none of the staff is under any illusion about the amount of preliminary work which will be required on the part of each speciality to define the information to be collected.

Probably they are also aware of the large amounts of backing store required in support of the system. The original estimate at King's was that 10,000 display patterns would be required; a figure which is now regarded as an over-estimate. At Glasgow a separate set of dictionaries would need to be built up for each speciality and this would again demand a large amount of storage additional to the actual patient data.

Another question to be decided is that of editing of data. Different levels of detail will assuredly be required for episodes of different age although there can be no easy definition of the criteria on which to base decisions about the continuing usefulness of data.

These are all problems of procedure, codification, and storage capacity, which can be handled independently of generalized program design.

3. A third level is a special section or sections to enable data for a particular purpose, for example, a research project, to be collected.

While it should often be possible to collect information specific to an individual research project within the established framework, it may be advisable to leave sufficient 'holes and handles' for specialized routines to be added, particularly since neither the King's nor the Glasgow project has yet really proved its usefulness in this respect. The King's application is not yet live and it is still too early to predict the outcome. At Glasgow standard case-summaries have been provided to replace the often illegible traditional case-notes but the principle original objective was to gather data which would be useful to future research, and so far the value of the data collected is not proven.

8.6 Summary

1. The importance of file design in any computer system cannot be over-emphasized.

2. Ease of coding and usefulness of information are key factors affecting file design.

3. Current patient record experiments emphasize the importance of gradual development and top-level involvement by clinicians.

4. A framework should be established consisting of a base of essentially administrative data, general sections within which each speciality will be able to develop its own clinical record, and special sections for specific projects.

9 Manufacturers' proposals

9.1 The approach to manufacturers

Once the field had been narrowed to a number of applications it was possible to consider what type of hardware might be suitable. Before we could seek the views of computer manufacturers, however, we had to define the applications as clearly as possible by establishing the following parameters for a model hospital:

1. File sizes.

2. Transaction rates.

3. Actual processing routines.

4. Response and turn-round times.

Details for items 1 and 2 were obtained by special request from major hospitals in Aberdeen, Dundee, and Edinburgh; general statistics already given by the Western Regional Hospital Board were then used as a check to ensure the reasonableness of our hypothetical hospital. For items 3 and 4 we relied on our own previous experience in data processing, coupled with detailed work descriptions given at various hospitals in the course of the study. Our thanks are due to many officers of regional hospital boards and hospitals for the patient assistance provided.

A copy of the outline specification drawn up on the basis of the information received is provided as Appendix 3. Briefly, we asked for costs of four different types of processing—mode 1 is entirely batch processing; mode 2 is on-line data entry but with all verified data being written to a file which is subsequently used for batch processing; mode 3 is on-line data entry with real-time updating of patient records, other processing again being deferred for subsequent batch operations; and mode 4 is an extension of mode 3 to allow real-time updating of all files. It was also specified that the capacity of the system should not be more than 50 per cent utilized, in order to allow both addition of further applications and provision of facilities for research work if required, on the basis suggested in section 3.5.

To secure the co-operation of manufacturers, for whom these investigations entailed a substantial amount of work, it had to be made clear that the proposals would be used as a guide only, could not be regarded as binding, and that manufacturers would be free to revise them completely if they were invited to tender for an actual hospital installation in Scotland.

The main objectives of the approach to manufacturers were threefold: to ascertain the capital costs of hardware, to isolate the costs of real-time, and to elicit alternative approaches.

9.2 Capital costs

The three major manufacturers who responded to the invitation were Honeywell, IBM, and ICL. Detailed proposals were confidential and would in any case be too bulky to be included in this report but a summary of the quotations is given in Table 9.1. The basic configurations suggested for batch processing

	Central processing unit/main store/cost			
Manufacturer	*Mode 1*	*Mode 2*	*Mode 3*	*Mode 4*
Honeywell	1250 80K characters £280,000	1250 and 516 (96K) (16K × 16 bits) £540,000	3200 and 516 (128K) (16K × 16 bits) £635,000	3200 and 516 (128K) (16K × 16 bits) £660,000
IBM (Growth system)	360/40 64K bytes £263,447	360/40 128K bytes £370,512	360/40 128K bytes £370,512	360/40 256K bytes £566,811
IBM (Minimum batch) system)	360/25 49K bytes £209,595	—	—	—
ICL	4/40 65K bytes £188,500	4/40 131K bytes £406,000	4/50 196K bytes £505,050	4/70 393K bytes £904,050

Table 9.1 Summary of manufacturers' proposals.

are reasonably similar in price, differences being largely accounted for by choice of medium for main file residence. The discrepancies which arise in the various real-time modes are

much more substantial, but are for the most part related to differences in interpretation of requirements, such as the kind of VDUs required, the response time which can be demanded, the degree of security against machine failure which may be required, and the extra capacity which might be built in for other work, for instance, research work. Only Honeywell have recommended a separate front-end processor for modes 2, 3, and 4, an approach which could have many advantages; but ICL also report that they seriously considered the possibilities of both front-end and twin processors, particularly for mode 4. These differences are inevitable in this kind of inquiry and would, of course, be resolved in any formal invitation to tender.
The main conclusion to be drawn is that it will cost about £180,000 to £200,000 for a fairly large hospital to have its own batch-processing computer installation, which would deal adequately with the initial workload and leave plenty of scope for expansion.

9.3 Costs of real-time

Three different levels of real-time working (modes 2, 3, and 4 in the specification) were specified. It is immediately obvious that mode 2 (on-line input only) is not worth doing. In ICL's and Honeywell's scales of costs it is much nearer mode 3 than mode 1, and IBM's costs do not distinguish between modes 2 and 3 at all.

Mode 4 is more difficult to comment on, because of the wide variation in estimates, but even taking the mean at about £750,000 (which could be achieved, for instance, by front-ending a system 4/50) it seems unlikely that the Scottish health services would be inclined to invest such an amount in one installation. ICL were careful to point out that the 4/70 configuration would have plenty of spare capacity for additional applications, especially research work, that a large hospital would wish to implement. Our view is that such an installation might eventually be justified in a very large teaching hospital but only after the basic applications were fully tested to the point where they were giving a reliable, trouble-free service. Only then in fact is it likely to be known just how much spare capacity there would be after all the real-time requirements had been met.

Any self-standing, single-hospital installation will therefore require a choice to be made between mode 1 and mode 3, that is, between 100 per cent batch processing and real-time updating and inquiry facilities for at least the current patient files. The difference in hardware costs between the two modes again varies substantially but in two of the three quotations is in the region of £300,000. This, however, is only part of the cost. The cost of development has been growing steadily in relation to hardware as complexity of applications increases and is now usually estimated as being at least equal to the cost of hardware.

Real-time certainly causes a substantial increase in complexity, although few people are willing to hazard an estimate of the consequent increase in development costs. In early real-time applications the security and recovery procedures alone, which hardly exist in batch processing, were estimated to have consumed 65 per cent of development effort and while this percentage may have been reduced in later applications, it still seems reasonable to assume that the £300,000 difference in hardware costs between modes 1 and 3 would be matched by a further £300,000 difference in development costs.

By the time the additional costs of air-conditioning and building have been added, the total difference between modes 1 and 3 is likely to be approaching £750,000, which seems a very high price to pay for advantages which have yet to be established.

Finally the possible effects of any further unbundling (separate marketing of hardware and software by computer manufacturers) should not be overlooked. If unbundling is extended to the United Kingdom from 1970, as seems possible, the net effect is certain to be an increase in prices, and probably a further addition to the difference in costs between mode 1 and mode 3.

9.4 Alternative approaches

The specification was deliberately framed in as flexible a manner as possible to give manufacturers of smaller equipment the chance to make useful contributions and to free the major manufacturers to suggest any special equipment or techniques or alternative lines of development. Three interesting suggestions have been made, one each by Computer Technology Ltd., ICL, and Honeywell.

As might be expected, Computer Technology Ltd., makers of Modular One, favour an approach via small dedicated machines, which could possibly in due course be linked together or to a regional centre. They doubt the value of the large amounts of data processing, particularly of clinical data, contained in our specification, at least in the foreseeable future. Instead CTL suggest a dedicated configuration for a real-time 'logistics' application. The main hardware would consist of a processor with 16K store (16 bit words), control console, paper tape input and output, line printer, replaceable disc, and communications multiplexer. Terminals would be located in out-patients, admissions office, and records office. The installation would be able to provide out-patient appointment control, waiting-list analysis, hospital activity analysis, disease index, and patient index including in-patient register.

The cost of the hardware would be £58,600. There is very little commercial software available with Modular One, but the price of the hardware adequately compensates for the lack of a large number of utilities many of which may in any case never be used. This type of configuration looks cheap enough to justify experimentation, both in the context suggested (hospital logistics) and for on-line patient-history taking.

ICL, recognizing that a stand-alone configuration costing £200,000 would be too expensive for the majority of hospitals, suggested satellite processors at hospitals linked to existing RHB equipment via telephone lines. The hardware at the hospital would be a communications terminal costing £3,250 to which various peripherals could be attached. Typically, a line-printer at £9,500, a card reader at £4,350 and a teletype at £700 could be used initially to provide off-line services in simple in-patient administration, out-patient control, and laboratory management.

The total hardware cost at the hospital approaches £18,000, but at least a 1902A, 1903A, or 4/40 would be required centrally. Also, if more than about five satellites were to be connected or if remote batch processing were not adequate (for instance, if a hospital required constant on-line transmission and response within minutes) it would probably be necessary to provide a front-end to the central machine. The over-all capital cost is more likely therefore to work out at £25,000 to £30,000 per satellite or even more where the present central installation is a 1901 which would require upgrading. The equivalent rental for even £30,000 capital cost would be no more than about £7,500 a year. After adding maintenance and GPO datel charges, which are together estimated at £1,350 on a line distance of 50 miles, a total within £9,000 a year is obtained as the cost of providing facilities to a hospital.

Honeywell suggested that 316s and 516s could be installed to develop many self-standing, real-time applications in hospitals, especially in laboratories, and also put forward the idea that admission and discharge routines could be developed on such a machine before being accepted for implementation on a larger installation. Costs would have to be obtained separately for a specific installation, but given the dual processor configuration set out in their main suggestions, this is a perfectly valid and in many ways attractive approach.

9.5 Summary

The scales of costs quoted should enable the Scottish health services to determine for themselves how best to allocate available funds. Considering the likely availability of funds, however, it seems clear that the major investment will have to be in development of batch-processing applications, with some encouragement of limited remote-processing and special-purpose equipment.

10 Phasing of developments

10.1 The necessity for planning

All enterprises try to plan developments several years in advance. The objectives of such planning are to ascertain what finance and other resources will be required and to set a standard against which progress can be measured.

It is frequently necessary to modify plans either because the assessment of resources required was itself inaccurate and the expected progress had not been achieved, or because the resources available do not match those required. As those responsible for planning gain experience, the inaccuracies of assessment should diminish, but actual availability of resources is often quite outside the planners' control, particularly if, as is the case in most enterprises, the availability is constantly changing. In these circumstances it is usual to evolve a two-tier system of planning which might typically consist of a five-year over-all strategy, couched in fairly general terms and full of assumptions about economic conditions, government policies, and human relationships, and a one-year plan of specific development aims, closely related to the present position and covering some of the ground towards fulfilment of the five-year strategy. Annual or more frequent reviews are necessary to determine how much more or less a new five-year strategy should embrace and what the next one-year plan should be. The periods covered by the two tiers can be varied but periods longer than five years and one year begin to verge on the unrealistic, and the principle of periodic review must be adhered to otherwise plans will, in the course of time, come to bear little relationship to the actual position.

10.2 The outlook for the Scottish health services

In the case of the Scottish health services, some idea of what the initial five- and one-year plans should embrace can be gained from Figs. 10.1 and 10.2. Fig. 10.1 is a simple network diagram of the activities to be accomplished between now and the time the first system(s) can be expected to be installed, accepted, and operational, i.e. a period of about 2½ years. Even this is a fairly optimistic view as we have assumed that some early solution will be found for staffing problems. During that time admittedly we hope that several parallel developments in each region will have been undertaken, in addition to some exploratory work outside hospitals. Possibly in conjunction with the Department of Health and Social Security in England, work on such software items as a report generator, a medical command language, and a real-time operating system will also be under way. For such developments to succeed, however, they will need to be established as projects, with a professional, full-time staff, clearly defined objectives, and a properly organized schedule of work.

Fig. 10.2 shows how these parallel developments could progress under reasonably favourable circumstances. It will be seen that while development of different aspects of computing will inevitably proceed at different speeds, evaluation of all the immediate developments could be complete by the end of 1974/5, the last year of a five-year period starting in April 1970. This would leave two years of the next financial five-year period for a full-scale review of all developments and agreement of wide-ranging implementation plans. As already emphasized, however, at least annual reviews of the position should be made, and at each review the five-year chart should be redrawn, if a realistic outlook is to be maintained. Only by this type of intelligence exercise can the Scottish health services expect to minimize the effects of any delays or take advantage of any developments which are ahead of forecast.

The cost of hardware for hospital computing during the early stages is estimated at £1¼ million, made up as follows:

Three batch-processing data-processing installations	£600,000
Three dedicated self-standing laboratory installations, with 'industry-compatible' output	£200,000
Three to four small real-time experimental machines	£200,000
Ten small-hospital satellite connections to larger machines	£250,000
	£1,250,000

We are not including the possibility of experiments with a large-scale, real-time installation, which would cost upwards of

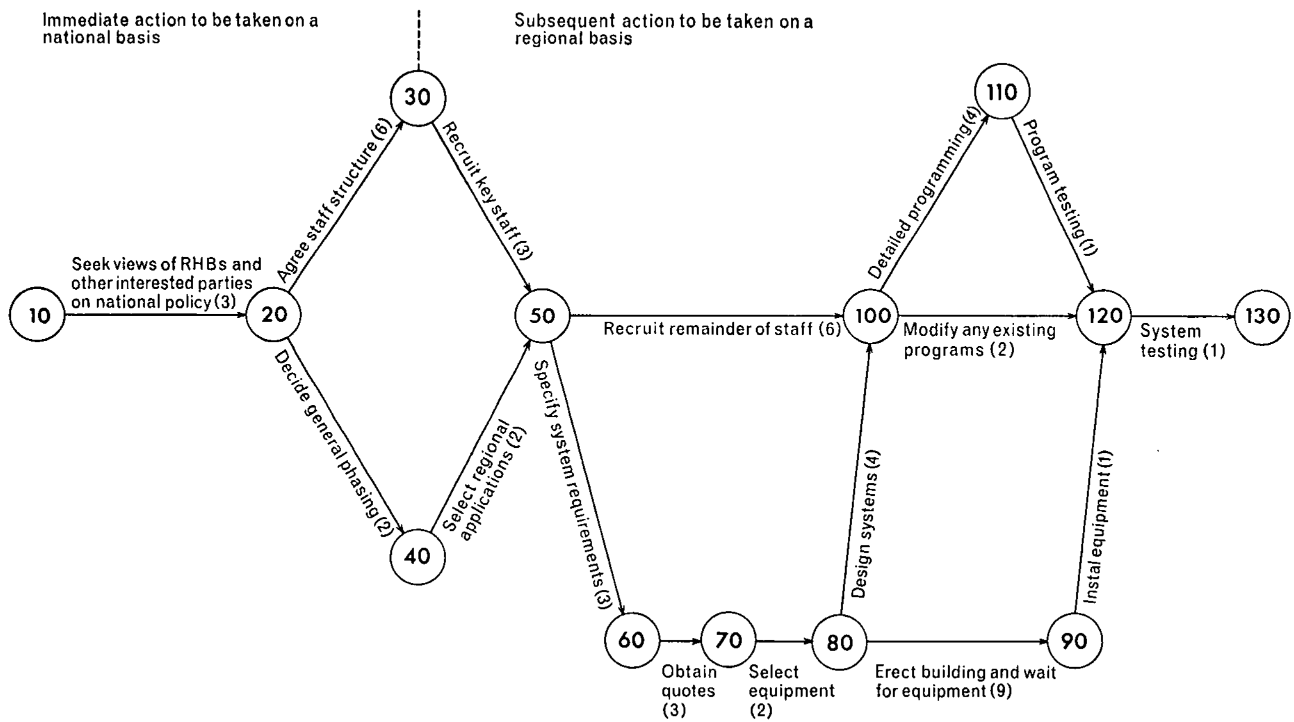

Fig. 10.1. Activities to be accomplished before first systems are operational. (Figures in parentheses ( ) indicate duration of activity in months. Figures in circles are an aid to identification of events and activities.)

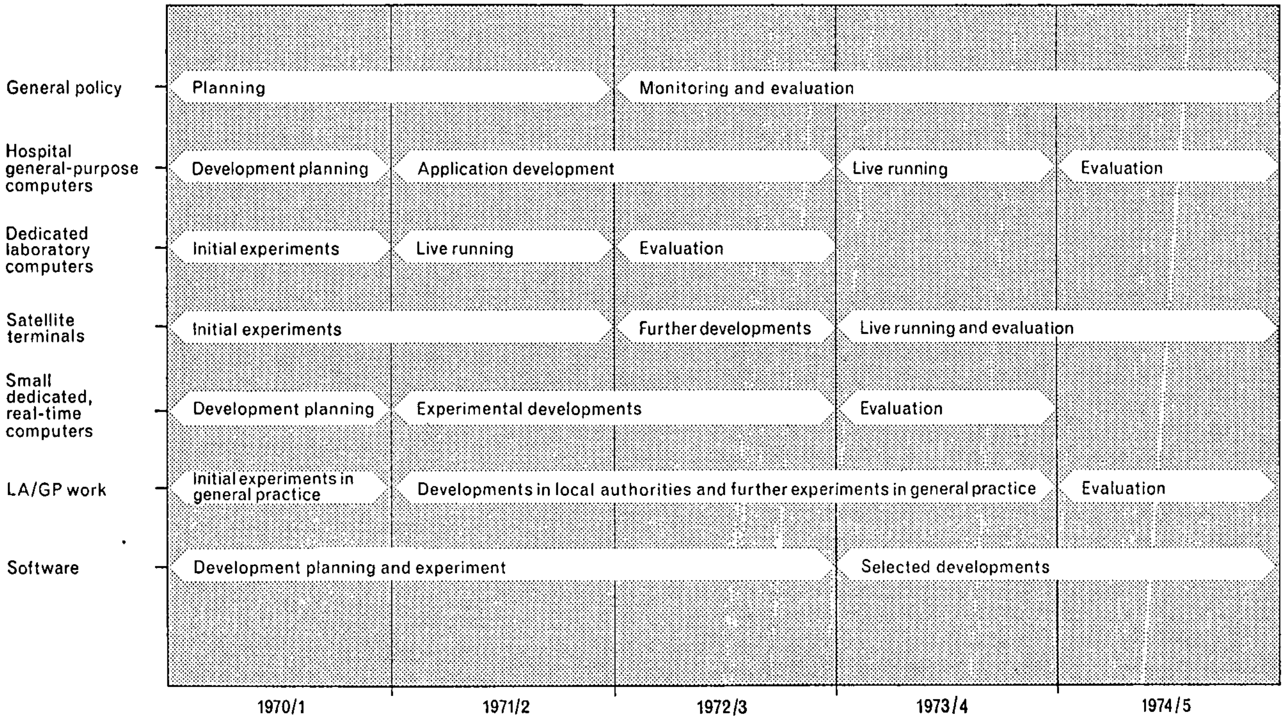

Fig. 10.2. Phasing of developments.

£500,000, as we do not recommend such a development at the moment.

Any heavy demand for services by local authorities, together with the outcome of experiments in general practice, could easily bring the total figure to well over £1½ million. This total could well account for the bulk of capital funds approved for the entire period 1972–7 but we recommend that if applications fulfil the criteria and are found to be feasible, and if there is enthusiasm among the users the money should be spent during this initial period rather than held back for future developments. It is our belief that the power of computing must be demonstrated forcefully as soon as possible, and that once this has been done the demand for computing facilities will be irresistible.

10.3 Rental of computers

With the limited funds likely to be available in the next five-year period, it is essential to examine every possible means of improving return on expenditure. Arguments about rental, leasing, and outright purchase appear in the press from time to time. Leasing does not appear to have any benefit to offer a government department, but the advantage of rental over purchase may be summarized as follows:

1. Developments during this early period will have to be regarded as experiments which need to be evaluated. The evaluations could show that different equipment is required.

2. Computers are inevitably obsolescent by the time they are installed. This could be particularly true of any equipment which may be acquired in the short term by the Scottish health services (see section 10.4).

3. The development programme suggests that a large portion of the money available for the five-year period will need to be spent during the early stages. Rental would offer a means of spreading expenditure more evenly if required.

4. Purchase offers no benefit by way of investment grants to government departments. This alters the basis of discounted cash flow calculations normally applied to determine the amortization period of purchased equipment.

5. There is a psychological advantage in being able to withhold payment, if service from the supplier should in some way be found unsatisfactory.

10.4 **Beyond 1974/5**

We would not wish to be drawn into longer-range forecasts than this in any field, and least of all in any developments connected with computing, which has a dynamic history. The difficulties encountered in any attempt to forecast beyond 1974/5 are:

10.4.1. *Hardware development*

As already indicated we would not expect the initial evaluation to be complete before the end of 1974/5, i.e. five years from the time of writing. Five years can be a very long time in terms of hardware development and in fact 1974/5 is the period currently favoured by predictions about deliveries of fourth-generation machines. Attempts to phase developments beyond this date seem futile on this account alone.

10.4.2. *Environment*

Even the very basic applications recommended as a starting-point are likely to have a profound effect on hospital organization. Precise effects cannot unfortunately be forecast but the change in environment in its turn will affect the evaluation of applications and the demand and scope for new applications.

10.4.3. *Health service reorganization*

It is not possible to predict how far any reorganization of the Scottish health services will have proceeded by 1974/5. The setting up of area health boards will not only increase the possibilities of integrated health records, but also, depending on the geographical area covered by an AHB, will affect the feasibility of central processing for an area, with all hospitals, health centres, etc., connected to the central processing unit.

10.4.4. *Finance*

It is not possible for us to predict what finance will be available beyond the immediate development period. Even if a definite sum is set aside now, it will only require another period of severe economic pressure for that sum to be brought under review. Success in the interim period is likely to be the only effective counter to economic pressures.

The long-term aim of a data bank of health seems to be outside the time-scale at which this report is aimed, and is certainly beyond the five-year period 1970/1 to 1974/5. We would tentatively place it about ten years away, but this will depend on the resources available and the use which is made of them.

11 Staffing

11.1 General

We have devoted a substantial amount of effort during this study to an examination of staffing requirements. Both the Department of Health and Social Security and the Scottish Home and Health Department, who must by now have developed some feel for the scope of the difficulty, agree with our views that staffing could well be one of the greatest problems in health service computing. The problem will not be made any easier if it is necessary to conform to established grades and salary scales. In addition the existing system whereby each post has to be applied for and staff are not transferable makes it very difficult to offer any clearly defined career structure to applicants and robs the Health Service itself of much-needed flexibility.

We are convinced that the requirements for advancement of any undertaking are interdependent with the needs of the staff of that undertaking, and there is abundant evidence from the behavioural sciences to support this conviction. If staff of the necessary quality can be attracted into health service computing and can be given the opportunity to develop themselves within the organization, rapid progress is more likely to be made towards achievement of objectives.

11.2 External recruitment

Finding good-quality staff, of any profession, is a problem which has steadily grown more difficult over the past twenty years. Nowhere is the difficulty more pressing than in the computer field, which each week provides the quality papers and technical publications with many advertisements for managers, consultants, analysts, programmers, operators, punch girls, and control staff. Competition has tended to create a situation where it is easy for an installation to pay a high salary and substantial recruitment costs for a programmer with little useful experience and little intention of staying long enough to make a worthwhile contribution.

11.3 Internal recruitment

For an industrial or commercial organization prepared to take some trouble and a longer-term view, there is always the possibility of finding suitable programmer potential among its existing staff, who can be trained both formally and on the job. Such staff tend to have more loyalty to the company than those recruited outside, and in addition are able to apply some of their previous knowledge of the business and perhaps provide a quicker return than might be expected. We suspect that there could be less likelihood of inducing health service staff to enter the computing field because of the more dedicated and professional nature of their present work. We do not subscribe to the opinion held in some academic circles that programming requirements can be met by part-time deployment of research scholars. They will probably be valuable in specific isolated projects closely related to their line of work, but are likely to have little interest in the general data-processing field.

There is then a potential shortfall of suitable internal programming recruits, and this could make the staff problem in health service computing even more difficult than in industry and commerce.

11.4 Requirements

The results of a recent company survey carried out by our Behavioural Sciences Division showed that the elements contributing to an individual's satisfaction with his current job are:

1. The interest of the work.

2. Development of knowledge and skills.

3. Making full use of abilities and experience.

4. Salary.

5. Recognition of abilities by manager/supervisor.

When asked about future prospects the respondents ranked the following as major requirements:

6. Greater variety of work.
7. More responsibility for projects.
8. More responsibility for managing people.
9. Opportunities to develop new techniques.

The above elements largely fall into three main categories; namely job interest (1, 2, 3, 6, 9), rewards (4, 5), and career development (7, 8, 9). We shall now examine these three categories before considering the organizational framework within which all requirements—applications and staffing—might be fulfilled.

11.4.1. *Job interest*

Each task undertaken needs to be interesting in itself. Interest can be generated by a number of factors including the utilitarian or aesthetic nature of the end-product, the demands made on a person's abilities, the requirements for creative thinking, and the variety of the work. If a task can be shown to be part of a much larger, worthwhile, over-all plan, its interest will be considerably enhanced and even the most junior participant may respond to what is in effect job enrichment

The position itself needs to be both one which will allow a succession of tasks with the above features to be undertaken and one in which those tasks can be brought to a successful conclusion, on schedule.

The morale in many computer installations is adversely affected as much because jobs are delayed or not completed at all as because they are uninteresting in themselves. Projects need to be very carefully administered, and compromises between perfection, speed of implementation, and user satisfaction will frequently be necessary if an installation is to avoid this dilemma.

11.4.2. *Rewards*

Major industrial organizations go to considerable lengths to ensure that the salaries they offer to people with particular skills are generally in line with those available nationally, with perhaps some adjustment for locality. Smaller concerns are often willing to offer slightly more in order to tempt people away from the major organizations, rather than attempt to carry too much in the way of training overheads.

It will be argued by some, no doubt, that financial reward should be a secondary motivation to anyone really dedicated to a job. Against this, it must be stated that any computer team is likely to be made up jointly of those who are dedicated to the particular—in this instance medical—field, and those who are computer professionals.

Many of the latter will have to be attracted from current employment if the Health Service is to be able to handle complex systems and a heavy programming workload; a competitive salary is thus one of the prerequisites. Demand for staff exceeds supply and unless salaries are fully competitive, understaffing with inferior-quality staff is inevitable. For salaries to be competitive, there will need to be a regular review of scales and a flexibility of attitude towards annual fixed increments and merit increments. Fixed increments can be a means of ensuring that seniority and the increased competence which is presumed to be acquired with seniority do not go unrewarded, but their relevance in a young profession and dynamic environment is doubtful. There may be a case for extending the system of merit awards now to be found in some hospitals to this particular type of staff.

In view of the volatility of computer staff the implementation of a formal staff appraisal procedure is also to be recommended.

11.4.3. *Career development*

The problem of adequate career development is also one which engages a great deal of attention in industrial concerns. Some are known to have planning boards covered with coloured markers indicating skills, achievements, and requirements and to record the names of the next two, or even three potential incumbents of each managerial position. Others prefer to create a climate in which there is always a selection of staff of varying talents from whom a choice can be made when there is a vacancy to fill. Whatever the merits of any individual scheme, the lesson is that career development is recognized as a problem that has to be actively tackled, rather than one which will solve itself.

There are several possible avenues along which a systems analyst or programmer in an industrial environment might expect to progress. These are:

a. Promotion away from the computer department to management of a line department.

This type of movement has, however, to be handled with special care. Many computer staff, being of an intellectual nature, may not be suited to and may not relish the prospect of line management. In addition their salary structure sometimes makes it difficult to 'promote' them to a managerial position. Nevertheless the competent systems analyst will gain an overview of a company which it is very difficult to gain from any other position of comparable seniority, and in consequence 'management potential' is often one of the qualities sought when interviewing candidates for computer vacancies.

b. Management within the computer department itself, or within the broader concept of a management services function.

Although this seems a more logical line of development it is obviously a more limited possibility as there are fewer managerial positions in management services than in the rest of an organization.

c. Consultant status within management services.

Some analysts and programmers will develop their expertise to a point when it will be profitable to place it formally at the disposal of others, whether in terms of design or programming strategy or in terms of evaluation of new hardware and software.

d. Changing jobs.

It must be realized that there are a large number of people, particularly those in the early stages of their development, who are looking for a career in computing rather than a career with any one organization. Such people, provided they stay for a reasonable period of time, can do a most useful job for the organization concerned, while at the same time furthering their own career prospects.

We consider that these factors are equally applicable to the Health Service and we have tried to meet these criteria when framing the proposals which follow.

11.5 Proposals for staffing

Two factors must be present if the needs of staff as outlined above are to be met. They are professional leadership and a suitable organizational framework. The same two factors play a central part in over-all developments.

11.5.1. *Professional leadership*

The concept of 'selling' computers in the Health Service is frequently urged. This can, however, be a slightly dangerous exercise. At one end of the spectrum there is the situation where the computer system is oversold at too early a stage in its development, and at the other the situation where a system is imposed in too authoritarian a manner. The former produces a state of euphoria which quickly leads to disillusionment when the promised results fail to appear and the latter can provoke reactions ranging from lack of interest to resentment or even outright opposition. It is clear, therefore, that if computers are to become an accepted part of the medical environment, senior clinicians and officers of regional hospital boards, hospital boards of management, and local authorities will have to be able to discuss their problems with a person whose judgement they can respect and whose competence is beyond question. Such a person will, therefore, we suggest need to be of equal status with the SAMO, secretary and treasurer of a RHB, senior consultants in hospitals, heads of departments in the medical faculty of a university, and the local MOH.

His broad objectives will be:

a. The provision of a comprehensive information service to all recognized medical and administrative personnel of a geographical area.

b. The constant improvement of the methods by which the service is provided.

c. Extension of the scope of the service.

To achieve these objectives he will need to have at his disposal human resources, such as systems analysts, programmers, operators, and distribution and control staff, machinery such as computer hardware, ancillary equipment, and mailing and transport facilities, and a range of services including accurate information from medical sources and advice from medical, administrative, and laboratory personnel.

The emphasis must be placed firmly on the provision of an information service of the highest quality, comparable with the services provided, for instance, by laboratories and X-ray departments. It is only in this manner that we can create a climate which will stimulate the development of applications and help to provide analysts and programmers with the essential elements of job interest.

11.5.2. *Organizational framework*

The major problem to be resolved under this heading is the question of centralization. We have already, in considering the centralization of equipment, alluded to the necessity for central co-ordination of developments and it is now necessary to consider how far co-ordination should be hardened into control.

The Scottish health services resemble in some respects a large, loosely knit industrial group with many more or less autonomous divisions, carrying out a diversity of operations. It may, therefore, be of interest to summarize the results of a survey of the organization of computer services in eight large multi-divisional companies in the United States.

All eight started with completely decentralized computer programming and operations. In the course of four years, three had become completely centralized, three others were partly centralized and becoming increasingly so, and the two that remained decentralized had established centralized 'consulting' groups whose influence was increasing.

The trend towards centralization is clear, but it is also apparent from the survey that the hardware itself remains decentralized and that there is not yet any agreement on how much centralization is beneficial. Nor is it certain that the trend will not at some future date be reversed. What is certain is that the amount of centralization reflects the current needs of the organizations. It is on this basis that we must consider computing in the Scottish health services, at the four levels of over-all direction, application development, application implementation, and specialist services.

Over-all direction. The first point to be considered is the position of the professional leader referred to above. It is obvious from the objectives of the post that his main contacts will be with those senior personnel mentioned, but particularly the RHB and hospital personnel in the initial stages when development effort is likely to be concentrated in hospitals. He must therefore be looked upon as a member of a regional team, if a feeling of mutual trust and confidence is to be created, and for this reason we recommend that the position should be a RHB appointment rather than a central one or one with joint responsibility to the RHB, the Scottish Home and Health Department, executive councils, local authorities, and the university medical faculty. We do, however, envisage the need for an increasing amount of interaction between the various sectors of the Health Service as progress in both health service computing and health service reorganization is made and some means of defining relationships with these other authorities may have to be devised.

Not only must he be a member of a regional team, he must be a leading member of it, in other words he must be the equal of the SAMO, the secretary, and the treasurer and not subordinate to any of them, otherwise he is unlikely to command the respect of hospital personnel.

The question of job title needs to be settled. The first suggestion was director of medical computing. We dislike the term 'medical computing', partly because it has research-based connotations and partly because 'computing' is far too narrow a word.

The essential feature of the job is information in the widest sense and we should like to see that word in the title. We considered 'information scientist' but again this might conjure up the wrong impression, and information processing officer seems a more accurate description. With the example of SAMO before us we finally decided to recommend senior information processing officer (SIPO). A more detailed job description than the outline already given is provided as Appendix 4.

Applications development. The second consideration is the progressing of a number of applications within a region. Each application will require a team leader, OR staff, analysts, and programmers. The number of each type of staff will vary not only with the complexity of the application but also with the stage of development. Flexibility of assignment is required so that the applications team can be augmented when necessary, either because of the stage reached, or because a special skill is temporarily needed or to retrieve slippage on estimated progress. Such flexibility will be difficult to provide in a single-application or even a single-hospital environment: the area of activity needs to be larger and will sensibly be equated with the area under a SIPO who will thus be able to deploy his total staff to the best advantage.

We have every sympathy for the view expressed in one quarter that a hospital project team must be totally dedicated to the hospital in which it is working, but find no basic contradiction of this view in our suggestions. The application team leader will be appointed to see development through from start to finish and will be totally identified with the hospital or other location in which he is working.

The application team leader, moreover, will be responsible for the technical implementation and must have the constant guidance of the user to ensure that the objectives of the application are being met.

It is here that the doctor, the pathologist, the administrator, or whoever is the user must play his part. Scattered throughout the industrial and commercial world are applications which are ineffective because the user has not been totally involved in their development. The lesson is being learnt: computer applications cannot be imposed and even where the user seeks help the applications cannot be developed without his active and continuing participation.

The surest way of achieving this is by having the application development led from the inside. This simple device is becoming more and more frequent in industry. For example, the leader for a production control application might well be the production manager or the assistant factory manager, while the equivalent in the hospital sphere would be a clinician, administrator, or laboratory worker of some standing. Such a person naturally cannot be assigned full-time to the application, but he is expected to take charge of all progress meetings, to ensure that the application does not deviate from its original objectives without good cause, to give formal approval to any report layouts and finally to accept the application on the evidence of test results and parallel running. Where an application affects several users it may be necessary to set up a small steering committee, like the 'pentagon' at the London Hospital to which medical, nursing, administrative, data-processing, and OR staff each contribute a senior member.

Application implementation. Once an application has been developed it must be run on a computer which may be sited in a hospital, a health centre, RHB premises, or in a completely independent building. The total amount of computing equipment in a region must be capable of providing the required information service, and if this criterion is met the actual location of equipment is unimportant. In practice it will usually be convenient to have a computer in, for example, a hospital, but this is merely because communication problems are thereby reduced.

The SIPO will be expected to advise on siting of computers. Because he is responsible for provision of information he will also need to undertake general supervision of computer operations, by advising on the appointment of operations managers and reviewing operational performance.

Specialist services. There are some services which could be too specialized to be provided even on a regional basis and those would require to be centralized under the guidance of the Scottish Home and Health Department. Specialist hardware expertise, software development, and OR staff come to mind immediately as possibilities but the composition of an all-Scotland advisory group would necessarily vary from time to time as requirements change. All we can say here is that the existence of such groups has been found useful in industry and might be found equally useful in the Health Service.

One class of personnel which presents a difficult problem is that of programmers. We are unable to resolve the conflict between provision of an economic service with a minimum of wasted time, which is best achieved by organizing programming as a specialized, centralized activity, and the desirability of the SIPO having complete control over his own programming workload. Industrial organizations have tried both methods, neither has been fully satisfactory and neither has been disastrous.

There is also a conflict from the behavioural point of view. Programmers are often quite junior in relation to the complexity of some of the problems they have to tackle and it seems reasonable to try to shield them to some extent from exposure to additional problems in the user environment. We ourselves have tended to regard systems analysis as work which must be done on site and programming as work which can best be done at base. This could, however, be too simplistic a view as it ignores the implications of treating programming as a rigidly defined task with no possibility of job enrichment, and we recognize that opportunities of improving on the practice must constantly be sought.

11.5.3. *Summary of organizational framework*

a. Leadership should be on a regional basis, to provide the environment for application development.

b. Computers themselves can theoretically be sited anywhere, but questions of turn-round and communication will probably dictate their location at particular hospitals.

c. Some specialist services will need to be provided on an all-Scotland basis.

Tentative organization charts are shown in Figs. 11.1, 11.2, and 11.3. Fig. 11.1 depicts the simple organization which might be suitable in the very early stages when preliminary investigations are being made. User involvement is not excluded from this stage but is likely to be on an informal basis.

The organization could have developed the structure shown in Figs. 11.2 and 11.3 in, say, three years. Fig. 11.2 shows the structure for development work, where the emphasis is placed on application teams, led by the users and staffed from groups of experts. Two such groups have been shown—the most likely ones of analysts and programmers—but O and M, software, OR, and behavioural science are other possibilities. These have not been formally indicated because they seem less likely to be provided as separate regional groups. They might be provided either from within the main analyst and programmer groups or from a national centre, but this may vary from time to time as the needs of the Health Service develop. Our earlier discussion of the national or regional deployment of programmers underlines the necessity for a flexible attitude towards organization and Figs. 11.1 and 11.2 must on no account be regarded as definitive.

Fig. 11.3—the structure for computer operations—is comparatively straightforward and needs no elaboration.

We have already indicated that job interest will in part be provided through professional leadership. The framework proposed will provide the remaining requirements for staffing. Salaries will be adequate because the position of SIPO is senior in itself and consequently the scope for a progressive salary

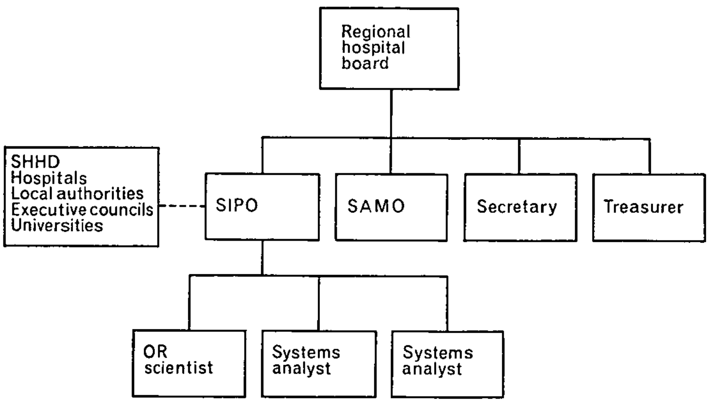

Fig. 11.1 Scottish health services: possible organization in the early stages of computer investigations.

structure for his staff is established. Most of the avenues of career development are made available, namely management services, management in the form of SIPOs and application team leaders, consultant status through central specialist groups, and, of course, changing jobs. The most difficult line of career development to provide in the Health Service could be that of line management but openings at a managerial level could be made available in the hospital service for suitable systems analysts.

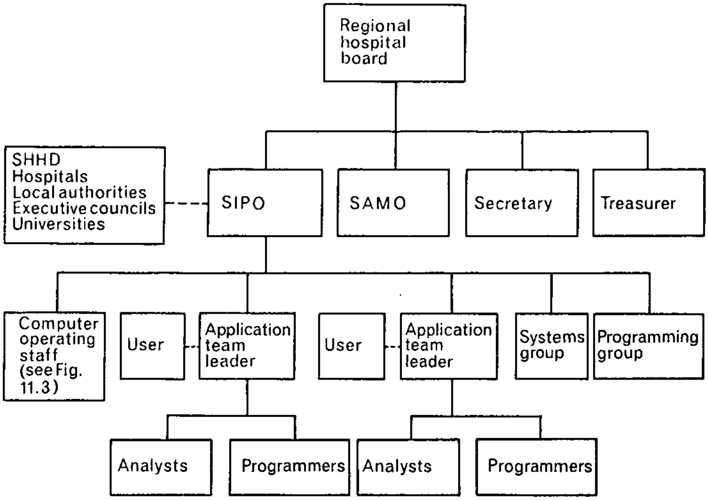

Fig. 11.2 Scottish health services: possible future organization for computer application development.

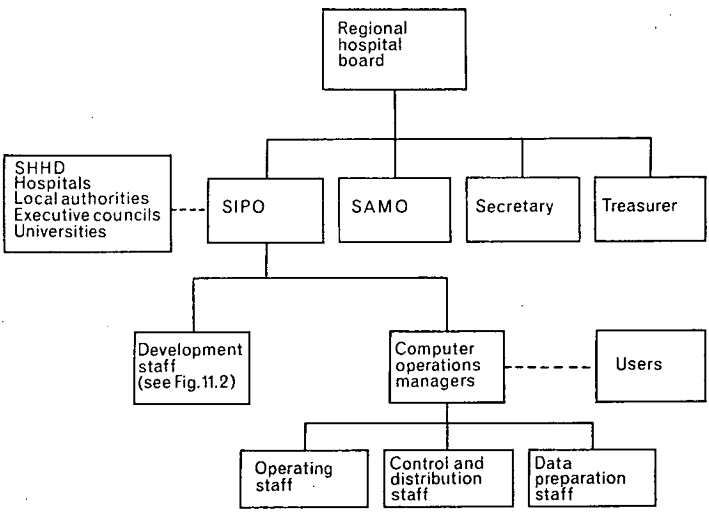

Fig. 11.3 Scottish health services: possible future organization for computer operations.

11.6 Remaining problems

There are four problems to be resolved, for which we can offer tentative solutions.

1. The necessity to secure national compatibility must not be overlooked. This problem will probably disappear if the right calibre of person can be found for the post of SIPO. Such persons will be conscious of issues wider than those in their own regions and will readily collaborate with each other. The Scottish Home and Health Department will nevertheless require computer expertise of at least an equal calibre partly to provide a focal point for such collaboration and advise RHBs on the appointment of SIPOs, partly to keep abreast of developments, and partly to co-ordinate the work of specialist groups. We offer chief information processing officer or chief information scientist as a title for this post. His precise position and responsibilities in the SHHD organization need to be determined, but he will need to be of at least equal status with SIPOs.

2. Any reorganization of the Health Service into area health boards, of which there might be fifteen or more in Scotland, could present difficulties. It would be totally impracticalable not to say uneconomic to establish a SIPO in each AHB and some zoning of activity would need to be evolved.

3. The number of SIPOs needed under the present organization has to be decided. The simple solution is one per RHB but it might be better to look ahead to the possible distribution of AHBs and ensure that the reorganization will cause as little disruption of a SIPO's duties as possible.

4. The major problem is undoubtedly the reorganization which will be necessary if the new post of SIPO is to be established. Detailed discussions will be required between the Scottish Home and Health Department, regional hospital boards, the Whitley Council and, because of the wider implications, the Department of Health and Social Security and the Civil Service Department. Even if all parties accept the general principle the time required to conduct such intricate negotiations could be as much as two years. We firmly believe that the post of SIPO is crucial to the success of computer developments in the Health Service in Scotland: nevertheless we consider a delay in development work of up to two years would be intolerable and we are therefore obliged to recommend temporary arrangements.

The first possibility is to make an experimental SIPO appointment. Such an appointment might be approved in a very much shorter time, say nine months, which is approaching the time-span allowed in Fig. 10.1. The disadvantage of this suggestion is that as an experiment it could probably not be applied to all regions and a selection would therefore be necessary, but it has the decided advantage that it comes quite near to the original recommendation.

The second possibility is to rely on a panel of informed university and RHB personnel to provide the leadership in the interim period and to make appointments at application team leader level and below where necessary.

The arguments for such a solution are that the panel would be staffed by people of the same standing as a SIPO and that future vacancies at SIPO level would be a decided inducement to potential recruits. On the other hand, management by committee is often unwieldy and time-consuming, the panel might be weakened by lack of general commercial computing experience, and ideally a SIPO should be free to nominate his own staff. However, where an experimental appointment is impossible such a solution should provide a workable *interim* arrangement.

The engagement of outside assistance has also been suggested. Such assistance should be sought in order to support the activities of any regional panels which may be set up rather than to replace them, but should neither of the first two possibilities be realizable this one would obviously have to be given serious consideration.

It is conceivable that attempts to carry out developments with existing staff under the wing of the RHB treasurer's department may be made. We reject this idea as firmly as we earlier rejected the possibility of a SIPO being subordinate to the SAMO, secretary, or treasurer, mainly because it is unlikely to have a significant enough impact on computer development. When computers were first introduced into industrial and commercial organizations they were often placed under the care of the chief accountant or company secretary, partly because the initial applications were usually of an accounting nature and partly because it simply was not realized that computers differed significantly from accounting machines and punched-card equipment. In recent years there has been an accelerating trend in industry to transfer computer responsibility to a separate function, reporting at top level, as the computer's potential impact on total company operations has been realized.

In order that the Health Service should not be obliged to under-go the same difficulties in organizational structure at a later date, we recommend that current RHB computing facilities at this stage be clearly subordinated to the more general computing requirements of the Scottish health services of the future.

The case we have presented does not imply that present RHB computer staff are necessarily unsuitable or incapable of contributing to future developments. It should be the responsibility of SIPOs to assess the capabilities of such staff as are currently available within the Health Service.

12 Conclusion

Scotland is in many ways ideally poised for the next step in the application of computers to medicine. A great deal of successful experimentation has been carried out and a considerable body of knowledge accumulated by those organizations—and more particularly enthusiastic individuals—whose efforts have produced workable systems with often modest resources.

At an early stage in our inquiry we found it necessary to distinguish between the types of computing facilities demanded or in use whether for administrative data processing, conversational computing, or the monitoring of special equipment with analogue or hybrid configurations. We also found it useful to preserve the distinction between 'research' and 'service' computing—discussed in detail in Chapter 3—when attempting to formulate plans for the future. Although the informal system of assessment and promotion of research projects is probably inevitable and perhaps even ideal, we consider that service computing—that is, the provision of facilities contributing to clinical and administrative efficiency in the short run—must be judged by quite different and preferably quantifiable criteria. Unless this slightly artificial but nevertheless realistic dichotomy is made, then there is a great danger that scarce public resources will be squandered on large-scale research projects masquerading as service developments.

An issue which we quickly discovered to be a highly emotive one, that of centralization, is discussed in Chapter 4. Here we draw industrial parallels to demonstrate that central co-ordination of computer policy is fast being recognized as essential once the initial trial period has been passed. Some nationalized industries with wide geographical coverage make a point of allocating the development of specific applications to their regions before implementation on a national scale: we would like to see the same process of rationalization carried into the Health Service so as to avoid the duplication of effort which we suspect is likely to arise from some projected experimental installations in England. Clear objectives must therefore be established and the work suitably apportioned between centres so as to maximize the return of the national investment. The achievement of a particular target—be it a system of drug administration or a workable medical command language—is a reasonable price for a hospital to pay for the day-to-day use of a powerful computer system: real solutions cannot be attained in isolation by design committees—they can be achieved only by hard practical work.

Notwithstanding the impending reorganization of health services in Scotland we have made an assessment in Chapter 5 of the possible areas of computer development within the current grouping of hospitals, executive councils, and local authorities, mainly because the likely changes will probably not be complete by the end of the five-year period specified in our terms of reference. The risk of dissipation of effort has led us to conclude that the selection of applications in hospitals is preferable to a more widespread plan not only because staff and funds can be more effectively deployed, but also because hospitals account for some 60 per cent of total health service expenditure and are thus the sector most likely to yield early results.

One slightly alarming but not entirely unexpected feature of our inquiries into existing computer applications was the apparent lack of any clear statement of the benefits to be expected. With this very much in mind we have set out in Chapter 6 a series of criteria which we suggest should be considered before an application is selected for development. In the following chapter we go on to assess a number of well-defined applications by these same standards. Whilst we do not decry the value of research we feel that it is now time for the development of those areas of application where the expertise already accumulated—either nationally or internationally—should be fully exploited. Only in this way can the profession prepare itself for the coming revolution in data handling which is, perhaps, presaged by the real-time computing systems now being sponsored by the Department of Health.

Chapter 9 deals, in a very tentative way, with the proposals of computer manufacturers who were kind enough to assist in the costing for a model hospital computing system. For the purposes of the exercise we specified four stages of development ranging from simple batch processing to real-time updating of files by remote entry. The scale of costs shown should assist the Scottish Home and Health Department to determine the optimum allocation of funds, but we would judge that the major investment is likely to be in the unglamorous but effective batch-processing area with some encouragement of remote processing on a limited scale.

We have deliberately refrained from the formulation of over-ambitious, sophisticated development projects, not solely because of the obvious financial constraints which obtain in Scotland, but also mainly because we consider that the essential ingredients to success for such schemes do not at present exist: we refer to the necessity for complex specialized operating systems together with the associated application software and the imperative need for specialized staff trained in both medical and computing skills. In the latter case we have offered in Chapter 11 some constructive suggestions for the establishment of a realistic staff structure within the existing governmental framework and have put forward certain interim arrangements which, given the normal lead time in establishment changes, may be necessary in the short run.

What does seem important is that health service staff at all levels should become involved in the planning, design, and implementation of computing systems in medicine so as to provide a sound foundation of knowledge and experience upon which more efficient methods of management and control can be constructed. Improvement of patient care is clearly a laudable aim but one which we have not at any stage in our study been able to quantify: we do consider, however, that any approach which holds a promise of increased utilization of scarce resources, be they human or material, is a step in the right direction.

Appendices

1 *List of those consulted during the course of the study*

In Scotland

Scottish Home and Health Department.
Scottish Office Computer Services.
South-eastern Regional Hospital Board.
South-eastern Region Computer Co-ordinating Committee.
Western Regional Hospital Board.
Eastern Regional Hospital Board.
Eastern Regional Joint Consultative Committee on Computer Developments.
North-eastern Regional Hospital Board.
Northern Regional Hospital Board (by correspondence).
Royal Infirmary, Edinburgh.
Western Infirmary, Edinburgh.
Royal Infirmary, Dundee.
Psychiatric Services Group, North-eastern Region.
Special Hospitals Group, North-eastern Region.
Maternity Hospital, Aberdeen.
Royal Infirmary, Aberdeen.
Aberdeen University departments: Computing Centre, Mental Health, Social Medicine, Cervical Cytology, Physiology, Medical Physics, and Chemical Pathology.
Edinburgh Regional Computer Centre.
Edinburgh University departments: Social Medicine, Medical Physics, Clinical Chemistry, Human Genetics, and Surgical Neurology.
Dundee University departments: Computing Centre and Clinical Chemistry.
Glasgow University: Department of Computing, Department of Epidemiology and Preventive Medicine, Staff of the Royal Infirmary, and Staff of the Western Infirmary.

Strathclyde University Bio-Engineering Unit.
Aberdeen City Health Department.
Midlothian County Council.
Corporation of Glasgow Health and Welfare Department.
Dundee Executive Council.
Lothians and Peebles Executive Council.
General Register Office.
Dr. H. P. Dinwoodie.
Scottish Hospital Administrative Staffs Committee.

In England

Department of Health and Social Security.
King's College Hospital, London.
Birmingham University Department of Social Medicine.
Exeter University Department of Biometry.
Department of Clinical Epidemiology, St. Thomas's Hospital.
Nuffield Provincial Hospitals Trust.

Computer manufacturers

Computer Technology Ltd.
Honeywell Ltd.
IBM (United Kingdom) Ltd.
ICL.

2 The economies of computer payroll

A review by the South-eastern Regional Hospital Board, Edinburgh

1. Under the manual system of payroll in the 1950s the average pay clerk was able to cope with about 130 employees per week. This was before Graduated Pensions, Earnings Related Sickness Benefit, more complex Superannuation Regulations, and Conditions of Service were introduced. In addition the pay clerks had to prepare manually the quarterly National Insurance stamps return and the year end superannuation and income tax P60s which necessitated considerable overtime working at these periods. Each Board employed a full-time comptometer operator who spent about half to three-quarters of their time on payroll.

2. With the introduction of accounting keyboard machines, the number of employees each pay clerk could deal with rose to 175 a week, a figure agreed by the Scottish Home and Health Department O and M Division as late as 1960. Again this was before the introduction of the Graduated Pension Scheme. At the largest board—the Royal Infirmary—two operators were employed.

3. Under the present computer system each pay clerk can deal with at least 250 employees, and comptometer operators and accounting machine operators have been reduced. Overtime is also substantially reduced because National Insurance, income tax, and superannuation returns are produced by the computer. (Note: this figure of efficiency has not yet been obtained in the smaller groups but a new joint pay department is being set up to achieve this target figure.)

4. The cost of pay clerks on the *a*, manual; *b*, accounting machines; and *c*, computer method is calculated as follows:

10,000 weekly payroll plus 10,000 monthly say equivalent 13,333 weekly.

a. Manual 13,333 ÷ 130 = 100 approximately at an average of £1,000 pa. £100,000

b. Accounting keyboard machine 13,333 ÷ 175 = 75 approx. ∴ £75,000

c. Computer 13,333 ÷ 250 = 54 approx. ∴ £54,000

5. The gross saving between manual and computer methods is £46,000 per annum excluding overtime, cost of premises, desks, heat, and lighting for the additional pay clerks.

6. The saving in pay clerk salaries between accounting machines and computer methods is £21,000. In addition there is the saving of staff operating the keyboard machines and the rental of these machines which would bring the total gross saving to over £40,000.

Computer costs

7. The present computer installation including rental, heat, light, and operating staff totals £40,000 per annum. To this figure has to be added the cost of magnetic tapes, programming staff, etc., but not stationery as this would also be required for a manual system. A total cost figure of £50,000 could be agreed as reasonable.

8. It is estimated that payroll work, including supporting management information which was not produced manually and including the analysis of expenditure over subheads, is occupying approximately 55 per cent of the present machine loading. The cost therefore of preparing payroll on the computer is £27,500 per annum, i.e. 10*d.* a payslip.

Conclusion

9. Computer payroll is not only cheaper than manual or accounting keyboard machine methods but also produces a by-product, cheques, bank Giro credits, statistical and expenditure analysis which otherwise had to be produced by manual methods in the accounts section of the Board's department.

10. The balance of the computer costs £22,500 (£50,000 – £27,500) covers stores, creditors, nominal ledgers for the fourteen boards of management and the regional board, equipment scheduling for capital schemes, and a measure of survey and statistical work in the medical field.

It is the view of the Regional Board that the benefits of better accounting information and standardization more than compensate for the remaining costs.

3 Specification sent to manufacturers

Outline of information for determining possible configurations and costs of computers for use in hospitals

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A3.1 INTRODUCTION

A3.1.1 The information required is divided into two main headings:

a. Suggested configurations, with costs, for batch processing, with or without on-line input facilities.

b. Suggested configurations, with costs, for real-time processing, partial or total.

A3.1.2 Brief descriptions of the various functions to be performed, together with data and transaction volumes, are given in section A3.2. Manufacturers are at liberty to suggest one configuration to do all the processing, or compatible configurations to do different parts of the processing, or indeed to quote only for part of the total system.

A3.1.3 It is requested that information should be supplied in the sequence suggested.

A3.2 FUNCTIONS

A3.2.1 **Data bank**

A3.2.1.1. *Maintenance of data bank*

In addition to updating of particular modules and files as a result of the patient administration and treatment outlined in section A3.2.2, it will be necessary to allow for other, more general, updating, caused by such factors as change of address, change of general practitioner, new drugs stocked, new consultants, and daily discarding of old appointments lists. Most of the changes are, however, likely to affect patient administrative data and an allowance should be made for 20 per cent of all patients to need some change in such data in the course of a year. Other files are much smaller and the effects of such general updating are likely to be less drastic, so that if a 'safety' estimate of 20 per cent is also made for them, this should be adequate.

A3.2.1.2. *Characteristics of data bank*

It is desirable to allow manufacturers maximum flexibility for construction of proposals and the term data bank, covering the whole of the information recorded, is preferred to the term files which could predetermine the division of the information and be prejudicial to the operation of particular equipment.

It is still necessary to indicate which information is required for specific purposes:

a. The data concerning patients has therefore been broken down into modules as shown in A3.2.1.3. The various classes of patient 'record' to which reference will be required are described in A3.2.1.4 in terms of the minimum number of modules necessary for their usefulness to the system.

b. A3.2.1.5 describes other data groupings some of which need information contained in patient data modules.

A3.2.1.3. *Patient data modules*

Module	*Brief description*	*Examples of contents*	*Size in bytes*
A	Identification	Name, date of birth, sex, patient status, hospital number	50
B	Administrative constants	NHS number, surname at birth, address, occupation, employer, GP number, blood group, allergies	200
C	Diagnostic summary	Admission and discharge dates (or first and last attendance dates if out-patient), consultant, speciality, diagnoses, operations	120
D	Administrative variable for in-patients and waiting-lists	Next of kin, current therapies, date put on waiting-list	600
E	Current in-patient	Details of admission, operations, diagnoses, tentative discharge date	450
F	Current out-patient	Diagnoses	200
G	Laboratory and other examination results	Date, reference number, numerical value, comment	45
H	Drug therapy	Drug code, dosage, frequency, date	12

A3.2.1.4. *Modules of patient data required to be available for particular purposes*

Purpose and number of patients	*Modules*	*Constant number*	*Minimum number*	*Average number*	*Minimum bytes*	*Average bytes*
Patient index	A	1	—	—	50	50
200,000	Total				50	50
Master patient	A	1	—	—	50	50
	B	1	—	—	200	200
	C	—	1	3	120	360
200,000	Total				370	610
In-patient	A	1	—	—	50	50
	B	1	—	—	200	200
	C	—	0	3	0	360
	D	1	—	—	600	600
	E	1	—	—	450	450
	G	—	0	50	0	2,250
	H	—	0	10	0	120
600	Total				1,300	4,030
Out-patient	A	1	—	—	50	50
	B	1	—	—	200	200
	C	—	0	3	0	360
	F	1	—	—	200	200
	G	—	0	10	0	500
	H	—	0	10	0	120
15,000	Total				450	1,430
Waiting-list	A	1	—	—	50	50
	B	1	—	—	200	200
	D	1	—	—	600	600
2,000	Total				850	850

A3.2.1.5. *Other data groupings*

a. 'Files' of constant size.

	Examples of contents	*Size of data groupings in bytes*	*Average number of data groupings*
X-ray and clinic appointment lists	Clinician (or unit), speciality, frequency, constraints, dates, times, patient names and numbers	25,000	50
Daily biochemistry laboratory work list	Sample type, ward, patient, tests required	50	350

Pharmacy stocks	Drug number and name, unit of supply, cost, stock levels	120	500
Pharmacy movement	Drug number, 24 movement figures, EOQ, supplier	120	500
Patient follow-up	Patient modules A, B, C (×0–3) and follow-up details	500–900	2,400
General practitioners	Number, name, address, telephone number	100	250
Numerical patient index	Patient number, name, initials	30	200,000

b. 'Files' which will constantly grow.

	Examples of contents	*Size of data groupings in bytes*	*Rate of growth per day*
Discharge summary	Hospital code, patient's name and number, dates, occupation, diagnosis, operations	200	60–100
Biochemistry laboratory log	Patient number, patient module G	50	1,800
Pharmacy log	Patient number, patient module H	16	300
Drug index	Patient module H, in drug code sequence	12	300
Diagnostic index	Patient number, in diagnostic code sequence	4	250
Operations index	Patient number, in operation code sequence	4	50

A3.2.2 Routines

A3.2.2.1. *Patient registration*

Because of the need to allow manufacturers maximum flexibility in methods of handling patient data it is not possible to indicate precisely what action will be taken in response to each particular type of transaction. At one extreme it is conceivable that a single file containing one large record for each patient will be used, in which case each transaction will affect one record on the file. At the other extreme a large number of very small records for each patient linked by a common key is possible, in which case one transaction could affect many records.

The following descriptions of transactions should be read in conjunction with Table A3.1 and sections A3.2.1.1 to A3.2.1.5.

In-patients: administrative

Admission. After module A, set up module E framework, print general practitioner notification.

Transfer. Alter module E.

Discharge. Alter modules A, D, and E, set up new module C, write discharge summary record, print general practitioner notification.

Put on waiting-list. Alter module A, set up module D framework.

Select from waiting-list. Alter modules A and D.

Out-patients: administrative

New out-patient appointment. Alter module A, set up module F framework, update clinic lists.

Old out-patient appointment. Update clinic lists.

Out-patient attendance. Alter module F, update clinic lists.

Out-patient discharge. Alter modules A and F, set up new module C, notify general practitioner.

Treatment

Operation. Alter module E, update operations index.

Confirm diagnosis. Alter modules E or F, update diagnostic index.

Prescribe drug. Set up module H framework.

Dispense drug. Alter module H, update pharmacy stocks, pharmacy index, and pharmacy movements.

Request laboratory test. Set up module G framework, update laboratory work list.

Receive laboratory result. Alter module G, update laboratory log.

Request X-ray. Set up module G framework, update X-ray department work list.

Receive X-ray results. Alter module G.

Follow-up patients

New follow-up patient. Alter module A, update follow-up files, notify general practitioner.

Follow-up attendance. Update follow-up file, notify general practitioner (for full details see A3.2.2.2).

A3.2.2.2. *Patient follow-up*

Each follow-up file is scanned monthly for patients who are due for a check-up. A notification will be sent to those selected from the file, and to their general practitioner or a special out-patients' clinic. The results of the consultation will be submitted to the computer for evaluation and summation of the various factors, according to predetermined weightings. Results falling outside a specified range are to be highlighted for further investigation.

Six follow-up files should be allowed for, each with 400 patients, spread over 150 general practitioners; the number of factors to be evaluated should be taken as 50.

A3.2.2.3. *Pharmacy stock control*

To print recommended order quantities when either stock of a drug falls below a re-order level or usage shows a marked increase, and to recommend revised re-order levels where appropriate. This is not necessarily the method to be used for every drug but will suffice for the present level of investigations.

Frequency—monthly. Number of drugs in stock—500.

A3.2.2.4. *Waiting-list management*

For each speciality, to examine priorities of patients currently on the waiting-list and produce a recommended admittance sequence. Factors affecting priority are likely to include length of time on waiting-list, clinical urgency, social urgency, expected length of stay, and whether an operation is required.

The number of specialities will be about 20. The average number of patients on a waiting-list should be taken as 100, with a maximum of 400. Frequency of operation will be weekly for each speciality.

A3.2.2.5. *Laboratory calculations*

a. To calculate test results from laboratory readings and produce the report described in A3.2.3.7.

b. To compare values with previous values for the same patient and highlight any trends which could be significant. Also any absolute values outside a given range. This information will be included in the reports described in A3.2.3.3 and A3.2.3.4.

c. To perform quality control functions in the laboratory itself.

Number of samples daily—350. Number of tests daily—1,800.

A3.2.2.6. *Radiotherapy treatment planning*

There are different views held on the value of radiotherapy and on the method to be adopted for treatment planning. It should be assumed that rotational field therapy will be required. The description given in paper 9 of *Computers in the Service of*

Medicine, vol. i, published for the Nuffield Provincial Hospitals Trust by the Oxford University Press, may be found useful.

Number of treatments to be planned—750 p.a.

A3.2.3 Reports

The reports required are outlined in terms of general content and frequency only. No attempt can be made at this stage to determine detailed layouts.

A3.2.3.1. *Bed-state control form*

Print basic details of each patient in each ward. Basic details include: name, number, consultant, length of stay so far, and expected discharge date.

Allow for 30 wards, up to 30 patients in each ward, say 2,000 lines of printing spread over 60 pages.

Frequency—daily, as soon as practicable after admissions, transfers, and discharges are 'completed'.

A3.2.3.2. *Out-patient clinic lists*

Print, for each out-patient clinic for which there has been a change in bookings, a list of the current booking state. Allow 240 clinics (8 specialities at 30 clinics each), each accommodating up to 30 patients, say 240 pages at 50 lines per page.

Frequency—daily, as soon as possible after out-patient clinics finish.

A3.2.3.3. *Out-patient summary*

For each current out-patient whose record has been changed, print a new summary.

Allow 350 current out-patients with changed records, each requiring one full 66-line page.

Frequency—daily, as soon as possible after out-patient clinics finish.

A3.2.3.4. *In-patient summary*

For each current in-patient whose record has been changed, print a new summary.

Allow 500 current in-patients with changed records, each requiring two full 66-line pages.

Frequency—daily, as soon as possible after doctors' rounds are finished.

A3.2.3.5. *X-ray department bookings*

Print for each X-ray session for which there has been a change

Type of transaction	*Data groupings affected* *Module* A	B	C	D	E	F	G	H	*Pharmacy stocks*	*Pharmacy index*	*Pharmacy movements*	*Laboratory work-list*	*Laboratory log*	*X-ray work-list*
Admission	x				x									
Select from waiting-list	x			x										
Discharge	x		x	x	x									
Transfer					x									
Put on waiting-list	x			x										
New out-patient	x					x								
Out-patient appointment														
Out-patient attendance						x								
Out-patient discharge	x		x			x								
New follow-up patient	x													
Follow-up attendance														
Operation					x									
Confirm diagnosis					x									
Prescription								x						
Drug dispensed								x	x	x	x			
Confirm diagnosis (out-patient)						x								
Laboratory request							x					x		
Laboratory result							x						x	
X-ray request							x							x
X-ray result							x							
General update	x	x	x	x	x	x	x	x	x	x	x			

Table A3.1

Type of Transaction	Diagnostic index	Operations index	Clinic lists	Follow-up files	Discharge summary	GP file	Minimum frequency	Number of transactions
Admission						x	D	60–100
Select from waiting list							W	300–500
Discharge					x	x	D	60–100
Transfer							D	10
Put on waiting-list						x	D	60–100
New out-patient			x				D	60–100
Out-patient appointment			x				D	250
Out-patient attendance			x				D	250
Out-patient discharge						x	D	60–100
New follow-up patient				x		x	W	20
Follow-up attendance				x		x	W	100
Operation		x					D	50
Confirm diagnosis	x						D	250
Prescription							D	150
Drug dispensed							D	300
Confirm diagnosis (out patient)	x						D	150
Laboratory request							D	350
Laboratory result							D	1,800
X-ray request							D	100
X-ray result							D	100
General update	x	x	x	x		x	W	20%

Table A3.1 *(cont.)*

in bookings, a list of the current booking state.

Allow 30 sessions, each accommodating up to 25 patients, say 30 pages at 50 lines per page.

A3.2.3.6. *Diagnostic, operation, or drug analysis*

From diagnostic, operation, or drug index list all patients, by number, who have suffered from a particular disease, undergone a particular operation, or been treated with a particular drug between specified dates.

More sophisticated possibilities are:

a. The listing of patients to whom different combinations of the above parameters apply.

b. The actual retrieval of the computer patient records.

Frequency—on demand. Length of print out—variable.

A3.2.3.7 *Laboratory reports*

From the laboratory tests conducted reports will be printed showing, in ward order, the results for each patient tested.

Frequency will be twice daily, say 12.30 and 4.30 p.m.

Allow one page, with 30 lines per page, per ward for 30 wards.

A3.3 PROCESSING MODES

A3.3.1 Off-line batch processing

A3.3.1.1. *Description*

The basic quotation required is for batch processing in the normally accepted sense of the term. Input in this mode can be by card or paper tape (either key-punched or pre-punched) or turn-round documents, or any manageable combination of these. As an example, for patients admitted from the waiting-list there are the following possibilities:

a. Computer punches a card for each patient—this is returned as input when the patient has been admitted.

b. Computer prints a list of expected admissions: admissions office mark each arrival and the list is returned to the computer as input.

c. As *b* but the list is used as a punching document.

A3.3.1.2. *System requirements*

a. The system should be capable of meeting the peak loadings within the time-scales stated with the capacity not more than 50 per cent utilized.

b. The system should be available for operation over 1½ shifts.

c. It is desirable that the configuration should be expandable on-site to accommodate modes 2, 3, and 4.

A3.3.2 On-line input, with batch processing

A3.3.2.1. *Description*

All input can be by terminal, and as much of the format and content as possible will be vetted by resident program modules, notice of errors being displayed on the terminal immediately for correction.

Other than this vetting, the only action to take place on-line will be the writing of a transaction file which will be used to update the other files at least as frequently as required by the reports and routines in section A2.

The aims of these techniques are:

Immediate validation of data, in the presence of the originator.

Elimination of transcription and its attendant errors.

Elimination of specially trained key-punch staff: input operations to be carried out by the users—doctors, nurses, pharmacists, technicians, admissions clerks, etc.

These aims imply:

All parts of the hospital must have a terminal within easy reach.

Considerable ingenuity will be needed to develop branching and command techniques, so that hospital staff do not need to learn esoteric numeric codes, nor input lengthy typed messages.

VDUs, not teletypes are required, on account of speed and noise factors.

The number of terminals is estimated as follows:

Wards (1 in each)	30
Out-patients	8
Appointments	2
Admissions	2
X-ray, laboratories, pharmacy	8
Administrative	10
	60

A3.3.2.2. *System requirements*

a. The system should be capable of meeting the batch-processing loadings within the time-scales stated with the capacity not more than 50 per cent utilized.

b. Response to a request to input information, and acceptance or rejection of data entered should be within a maximum of one second. This response time should be met 95 per cent of the time even if the system was working at 100 per cent capacity.

c. The system should be available for operation over two shifts. Peak loading for line traffic should be allowed for at a rate of ten times the average load. Such peaks may last for ten minutes.

d. It is desirable that the configuration should be expandable on-site to accommodate modes 3 and 4.

A3.3.3 On-line input, mixed processing

A3.3.3.1. *Description*

Basic functions are the same as section A3.3.2, with the following additions.

a. The relevant patient modules will be updated on-line.

b. Any VDU in the hospital will be able to call up an up-to-date patient record. (This must be subject to confidentiality.)

c. An immediate picture of the bed-state will be available.

The same number of VDUs will be required as in section A3.3.2, but line traffic is likely to be very much higher, and random access devices are now inevitable for current patients. To assess line traffic, assume each in-patient's record will be looked at ten times per day, 250 out-patient records will be looked at per day, and that 'looking at' a record will necessitate calling up five displays by branching techniques.

A3.3.3.2. *Systems requirements*

a. The system should be capable of meeting batch processing within the time-scales stated with the capacity not more than 50 per cent utilized.

b. (i) As in A3.3.2.2*b.*

(ii) The response to confirm patient record updating should be within two seconds. This response time should be met 95 per cent of the time even if the system was working at 100 per cent capacity.

c. The system should be available for operation over two shifts. Peak loading for line traffic should be allowed for at a rate of twenty times the average load. Such peaks may last for ten minutes.

d. It is desirable that the configuration should be expandable on-site to accommodate mode 4.

A3.3.4 Real-time processing

A3.3.4.1. *Description*

Basic functions are as in section A3.3.3, but all 'files' will be updated on-line and the following additional facilities will be required:

a. Interactive techniques for fixing appointments, laboratory tests, X-ray bookings, possibly even development of a radiotherapy treatment plan.

b. Message switching for communicating prescriptions to the pharmacy, urgent test results to the wards.

c. Immediate recall from other files, such as waiting-lists, diagnostic and operations indexes.

d. Miscellaneous on-line use, for example, assistance with composition of a discharge letter by presenting the consultant with a series of phrases, selected on the basis of diagnostic and discharge details, probably using branching techniques.

c. Interface with auto-analysers to accept the laboratory readings.

All files now need random access devices, except the purely historical ones.

In addition to the VDUs, thirty slow teletypes will be required. It should be assumed that the loading on the teletypes will be 40 per cent of that of the VDUs. Allow a 50-character output message average.

It is worth repeating here that provision of these additional facilities still does not demand that the work should all be done on one central computer system.

A3.3.4.2. *System requirements*

a. As in A3.3.3.2*a*.

(i) As in A3.3.3.2*b*(i).

(ii) As in A3.3.3.2*b*(ii).

(iii) The response time to confirm all other file updating should be within two seconds. This response time should be met 95 per cent of the time even if the system was working at 100 per cent capacity.

c. The system should be available for operation over three shifts. Peak loading for line traffic should be allowed for at a rate of twenty times the average load. Such peaks may last for ten minutes.

A3.4 INFORMATION REQUESTED

A3.4.1 General

As explained in the Introduction, the processing of the applications has been considered under the following modes:

1. Off-line batch processing.
2. On-line input with batch processing.
3. On-line input with mixed processing.
4. Real-time processing.

It will be much appreciated if the information requested on configuration details in section A3.4.2 is given separately for each of the above modes. Although this will entail some repetition it will avoid ambiguity.

Suggestions based on past experience, or new equipment, or software will be welcomed.

A3.4.2 Configuration details

A3.4.2.1. *Introduction*

General comments on the system submitted and the reasons governing the selection of particular hardware and software.

A3.4.2.2. *Specification of equipment and software*

The objective of this section is to outline the hardware and software of the proposed system.

a. A complete list of the hardware proposed, detailing for each item: model number, brief specification, quantity required, and price per item.

(i) Purchase price of configuration.

(ii) Rental or leasing facilities.

c. Maintenance charges.

d. Any delivery and installation costs not included in the purchase price specified above.

e. A list of software essential to the operation of the system, and all further software which will be provided.

A3.4.2.3. *Questionnaire*

Answers should give cross-references to the printed material in A3.4.2.5.

a. Hardware

(i) Give details for each processor proposed: speed—cycle time, add, multiply, divide times, Gibson mix, and data-processing unit; capacity—core size and organization; channels—number, speed, and organization.

(ii) *Serial access storage.* Give details for each type of device proposed including: speed-transfer rates, recording density, number of tracks, rewind times; capacity and control units.

(iii) *Direct access storage.* Give details for each type of device proposed including: speed—access times (minimum, maximum, and average); quote formulae if appropriate; transfer rate; capacity—per unit and total on-line; organization and addressable record sizes.

(iv) *VDU terminals* (applies only to modes 2, 3, and 4). Characteristics—size of display, number of lines and characters per line, physical security arrangements; keyboard—character set and flexibility of keyboard design; speed—effective line speed and time to display full screen.

(v) *Teletypes* (applies only to mode 4). Characteristics—keyboard, character set, speed.

b. Software

(i) *Operating system.* Core and backing storage requirements, core handling and organization, job scheduling, peripheral handling, program monitoring features, suitability for real-time operation, security and recovery procedures, system log, interrupt handling.

(ii) *File handling.* Core and backing storage requirements, file organizations supported, set up and housekeeping routines, packing functions, core requirements for buffer areas, security and recovery procedures.

(iii) *VDU handling* (applies only to modes 2, 3, and 4). Editing and format handling, roll up and scrolling, software polling, number of displays that can be supported, time for complete poll of terminals.

(iv) *Compilers and assemblers.* Compilers available for this range of equipment, minimum and recommended core areas, method of testing.

c. Environment

(i) Air-conditioning requirements.

(ii) Floor area.

d. Support

(i) Staff participation.

(ii) Training facilities.

e. System enhancement

Describe how the system, including software, can be expanded to meet future needs, and what limits there are to on-site enhancement. Particular reference should be made to:

(i) Processing power.

(ii) Core store.

(iii) Direct access storage.

(iv) Terminals.

(v) Additional satellite processors.

(vi) I-O operations.

Please state which enhancements require that the operating system should be changed from that proposed.

A3.4.2.4. *Supplementary information*

Give under this heading the full specification of proposed items not covered above, with their performance, software support, and physical requirements. Special software packages and general company background may also be described under this heading.

A3.4.2.5. *Supporting literature*

Manufacturers' manuals and other printed matter should be presented under this heading. Cross-references from other sections of the document should be made where appropriate.

4 *Scottish health services Proposed job description*

Job title: Senior information processing officer.
Responsible to: RHB and SHHD Steering Committee.
Location: Regional centre.

Objectives

1. To provide the following information services to the following recipients.

a. Patients' basic records to any authorized medical staff.

b. Written test reports to any authorized medical staff.

c. Quality control reports to laboratories.

d. Schedule of hospital admissions to consultants.

e. Scheduling of in-patient progress to hospital departments.

f. Patient follow-up schedules to patients, medical staff, and social workers.

g. Prescriptions analysis to hospitals.

2. To improve the methods by which this service is provided.

3. To extend the scope of the service within the region.

Duties

1. Maintain regular program suites for:

a. Patients' basic records.

b. Test reports.

c. Quality control reports.

d. Schedule of hospital admissions.

e. Patient follow-up schedules.

f. Prescription analyses.

2. Devise and constantly review program suites for scheduling of in-patient progress.

3. Recruit, assign, and review staff, including salaries.

4. Appoint application team leaders, define their terms of reference, and review their progress.

5. Advise on appointment of operations manager at each location in the region.

6. Co-ordinate the work of application team leaders and operations managers.

7. Assist with monitoring of operational performance.

8. Assess cost/benefits of applications.

9. Keep SHHD fully informed of proposals and progress.

10. Co-ordinate developments and priorities with SHHD.

11. Evaluate hardware.

12. Evaluate operating systems.

13. Contribute to unified coding standards.

14. Adopt applications packages, where appropriate.

15. Seek new applications, consult interested parties, and advise SHHD.

Resources

1. *Human*

a. Systems analysts.

b. Programmers.

c. Input preparation staff.

d. Operators and maintenance staff.

e. Distribution staff.

2. *Machinery*

a. Hardware for batch processing.

b. Hardware for on-line processing.

c. Equipment for input.

d. Equipment for output.

e. Mailing and transport facilities.

3. *Services*

a. Accurate information from hospitals.

b. Medical, administrative, and laboratory advice.

c. Support from computer manufacturers.

d. Office and building services.

e. Purchasing and accounting services.

f. Personnel services.

Glossary

The definitions given are those relevant to computer usage. Some terms can also be used in a non-computer sense, as for instance 'interaction' and 'dedicated' in Chapter 11.

Analogue computer	A computer dealing with physical quantities (such as electrical voltages) which are continuously variable (compare *digital* and *hybrid computer*).
Backing store	Any computer store other than *main store.* Definite action usually has to be taken to make backing store accessible.
Batch processing	A method of computer organization in which work is collected into batches *off-line* and processed at intervals.
Bit	Anything which may take just one of two possible states.
Byte	A string of (typically 8) *bits*, handled as a single unit by the computer. A byte may contain one alphanumeric character, a binary value in the range of 0–255 or two decimal digits.
Character	A string of (typically 6) *bits.*
Check digit	An otherwise redundant digit calculated from the remaining digits on a coded number and added to the coded number to guard against transcription errors.
Command language	A language approaching normal English enabling non-specialists to interrogate and update computer files in *real-time.*
Configuration	The set of equipment provided at one installation.
Conversational mode	A form of *interactive* working in which a human being at a *terminal* communicates with the computer.
Data bank	The total amount of information available in any system.
Data recorder	Any device or technique for recording data; a simple example is the credit-card kind which captures information from embossed plastic cards.
Dedicated	A computer system which is entirely concerned with a single application.

Digital computer	A computer dealing with digital quantities, i.e. those which can be varied only in discrete steps. Compare *analogue* and *hybrid.*
Direct access	Access provided directly to a particular record in a file, whether by index or because the physical position is known or can be computed. Also *random access.* Contrasts with *serial access.*
Display (pattern)	Arrangement of characters on a *VDU.*
Front-end	A computer provided specifically to handle certain functions, for instance communication lines, editing of messages, and validation, and coupled with another machine which carries out the main processing.
Hardware	Electronic circuitry, mechanical devices, etc. Contrasts with *software.*
Hybrid computer	One employing both *analogue* and *digital* techniques.
Interactive mode	A form of operation in which the computer automatically responds to input from, and generates output for, the rest of the system.
Light pen	A device which when pointed at a cathode ray tube can sense whether the spot pointed at is illuminated or not. Used as an input/output device with a *VDU.*
Line speed	The speed at which data can be transmitted along telegraph, telephone, or private wires.
Main store	That part of a computer storage which is immediately accessible, once the computer is switched on.
Mode	The type of processing—see *on-line, real-time, batch, conversational, interactive.*
Off-line	A situation in which a device produces information in machine readable form (such as punched paper tape) for subsequent processing by a computer. Contrasts with *on-line.*
On-line	Acting under direct computer control, for instance, any *backing-store* or *VDU* which is connected to the computer. (The clear distinction between on-line and *real-time* is not always observed.) Contrasts with *off-line.*
Operating system	A set of *programs* which controls the running of other programs in an attempt to maximize machine utilization. It will include file handling, job scheduling, input/output handling, communications, program compilation, error-recovery, etc.
OS/360	An *operating system* devised by IBM for the larger machines in the system/360 range.
Package	A set of programs which may be application-oriented (e.g. payroll) or function-oriented (e.g. engineering design) and which

is intended to be generalized enough to be run in any installation with a given minimum *configuration.*

Parallel running Operation of both the new computer system and the old system in parallel, and comparing results, until the user is satisfied that the new system is operating correctly.

Peripheral A *hardware* item (input/output, *backing storage* devices, etc.) which can be connected to the computer.

PERT An acronym for Program Evaluation and Review Technique, a method of project control based on identification of the interaction between individual steps and the estimates of time required to complete each step.

Random access See *direct access.*

Real-time 1 (Originally). The actual elapsed time of the real-life procedure, e.g. a real-time simulation is one which takes the same amount of time as the process simulated. Simulations can therefore also be faster than real-time or slower than real-time.
2 (By extension). Responding in time to affect the real-life situation (e.g. process control, patient-monitoring). This has become the most frequent meaning.
3 (Loosely). *On-line.*

Report generator A language enabling non-specialists to retrieve and analyse large quantities of data from a *data bank,* probably in *batch-processing* mode, but possibly also in *conversational* mode.

Response-time The time between input and the corresponding output of an *interactive* computer system.

Satellite A device providing input/output facilities to and from a computer, often at some distance, probably incorporating at least some elementary card-reading and line-printing facilities and perhaps even being a small computer in its own right. Compare *terminal.*

Security and recovery procedures Action to be taken in the event of breakdown of the computer, in order to preserve the results of processing which has already taken place and to be able to re-start from a convenient point, rather than at the very beginning.

Serial access Access to records in the sequence in which they are stored. Contrasts with *direct access, random access.*

Software Sometimes confined to *operating systems* and utilities such as sorting routines, sometimes including application *packages* and sometimes extended to the entire programming effort of an installation. Contrasts with *hardware.*

Teletype — Trade-name of a device resembling a typewriter with which a paper tape reader and punch can be combined and which is capable of serving as a computer *terminal.*

Terminal — A device for providing input/output facilities to and from a computer, often at some distance and probably not including any computational facilities of its own. Examples are *teletypes* and *VDUs*. Compare *satellite.*

TSS/360 — An *operating system* with particular emphasis on communications, developed for the IBM 360 series.

Twin processors — Two identical processors, capable of being linked in various ways. Usually arranged so that one machine can carry on with the important work if the other one breaks down.

Visual display unit (VDU) — A *terminal* whose output device is a cathode ray tube on which text and possibly diagrams can be displayed. The input device may be a complete typewriter-like keyboard, a more limited keyboard or a *light pen.*

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