Development of a microcomputer-based system for surgical audit and patient administration: a review

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While it is true that clinical audit of varying levels has existed in surgical circles for many years, the concept of the collection of data on all patients passing through a department and its regular review, as distinct from discussion confined to deaths and complications, has been popular for barely more than a decade. Much has now been written on the philosophy and gains to be realized from clinical audit[1-3], although to some it still remains anathema.

However, there can be little doubt that events over the last five years have underlined the need for critical self audit. Changes in the financial fortunes of the National Health Service have led to a closer appraisal of virtually every aspect of spending. Given new approaches to Health Service management resulting from the Griffiths report[4] and requirements from the Department of Health to consider 'performance indicators', there is now a growing feeling amongst surgeons that self audit is preferable to 'external review'. Furthermore, there is ample evidence that data collected by clerical staff for HAA (hospital activity analysis) can be seriously inaccurate[5-7].

In addition to such external influences, we should not overlook the potential benefits that the availability of precise information used for audit can bestow. First, data about the throughput of a unit can alert us to the need to change internal priorities or remedy deficiencies. Second, it is much easier to make rational bids for beds, manpower, equipment and other resources if detailed statistics are available regarding relevant aspects of the workload. Third, it can even be possible to convince colleagues that a particular clinical practice is good or bad, as has recently been done by Gilmore *et al.*[3] Fourth, the gradual but progressive accumulation of large quantities of facts about patients is permissive to clinical research. Fifth, the system of collection and analysis can have grafted on to it better methods of communication both within the hospital and with our general practitioners.

These possible uses have shifted the view of some members of the profession towards the concept that better management systems in clinical care are required to:

(*a*) provide instant access to essential management and clinical information (i.e. patient status and review history – see below);

(*b*) serve the basic management functions of a surgical office, including the holding of the data for, and the production of, booking and cancellation letters to patients, waiting lists, admission lists and operating lists;

(*c*) provide the clinician with a simple means of recording clinical information that may be used in generating an automatic discharge summary and for subsequent analysis;

(*d*) enable the entry of 'prompts' that are displayed as reminders after a given period of time;

(*e*) analyse information either as a routine global 'audit report' or *ad hoc* query analysis.

Data collection

There are two imperatives in data collection. First, it must be simple and limited to the task in hand. Put another way, the temptation to gather in an item because 'it might one day be useful' must be resisted. Second, in our chronic state of shortage of secretarial assistance, it must not impose additional burdens. Indeed, and preferably, it should provide positive benefits for junior clinical and secretarial staff. We had recognized these matters in the mid-1970s when we were running a manual system of audit.

In consequence, our current practice is organized as follows. Patients admitted electively are registered on the system at the time of booking in the outpatient department. Demographic details, including telephone number and GP, are recorded with a reason for admission, priority, and date of admission if given (i.e. sufficient information for scheduling and management purposes; Table 1). All other data are entered shortly before or after patients are discharged from hospital.

The prescribed and limited clinical information is recorded either on a card that will fit into a house-surgeon's pocket (Ashford), or a form that will go into the patient's scratch folder and which is used for his working notes (St Mary's). Once a week a meeting is held either as an item on the agenda of an organizational 'get-together' of the unit (Ashford) or for data entry purposes only (St Mary's), at which the clinical and outcome data of all patients discharged in the previous week are discussed and amended as

Table 1. Information recorded on the booking card

Patient's name		Hospital number
Address	Postcode	Date of birth
Tel: (Home)		GP
Tel: (Daytime)		
Available at short notice?	Y/N	Date of booking
Booked into diary?	Y/N	Date of admission
Priority: Urgent/soon/routine		Date of operation
Reason for admission (60 characters text)		

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Table 2. Estimates of data collection and entry times

	Time per patient record
Consultant/registrar to record details on registration card	30 sec
House surgeon to record clinical details	2 min
Validation of data by whole firm (range 15 sec to 3 min)	1 min
Secretary to enter demographic data	2 min
Registrar to enter clinical details	3 min

required. This exercise alone serves to concentrate the minds of those members of the clinical team who have to present the outcome and plan for each patient.

At first sight the time taken to collect, validate and enter the data may seem daunting (Table 2). However, the ultimate benefits from instant access to information are so rewarding that no member of the team finds the task tedious.

Conversion of data to information

A filing cabinet full of validated cards is useless unless the data can be combined and analysed. As the collection of cards grows, this becomes increasingly difficult to do by hand and the generation of reports moves from the tedious and demoralizing to the well-nigh impossible. A computer, by contrast, can swiftly manipulate data and, unlike a registrar or medical secretary, does not get bored or frustrated with the tasks of analysis and reporting. In addition, it can print out selected items to form such things as discharge summaries and letters to doctors and patients, so taking over many of the functions presently done manually.

As everyone knows, computers themselves are now relatively cheap though software can still be quite expensive. Yet the deployment of computers for this purpose is not without problems, the two most important of which have been the lack of suitable software and the absolute requirement of individuals with at least primitive computer literacy to solve the problems that arise in the day-to-day running of any machine-based system.

Our first attempt in the early 1980s was to run a system based on a Sirius 1 microcomputer running a commercial database program (Compsoft DMS). Despite the apparent sophistication of the software, it soon became clear that the system was inflexible, restrictive and, above all, difficult to use by any except those with sufficient time to gain familiarity with the program. Each patient 'file' became large because of the need to record much of the detail as text, with the result that only a three-month turnover could be recorded on each 620 kilobyte (kB) floppy disc. Furthermore, by recording diagnosis and operation as text, even in confined categories, searching was unreliable and vulnerable to errors of input. Statistical information still had to be calculated on an item by item basis.

Others have had greater success than this with a different and more complex database[8]. However, in order to compress the information and to allow subsequent searching, information about diseases and operations has to be pre-coded using a modified form of the ICD (International Classification of Diseases) codes[9] and OPCS operation codes[10]; output then has to be 'translated' back from code before use. Though this has provided a usable system it reintroduces tedium and is not free from error. It might well be possible in the near future to take a modern database and adapt it to get rid of this difficulty, and indeed Dunn and Dale have gone some way to achieve this objective and configure a workable system[11]. However, it has been our conviction that to produce the greatest flexibility, the best data compression for efficient storage and fast handling, and have the possibility of enhancing the system as additional needs are identified, a custom-made package is essential.

We therefore formed a liaison with professional programmers in the software industry. Our combined task was to produce a system that would run on any 16-bit 'office' microcomputer and behave in a logical, predictable and 'friendly' manner to those of its users who are not familiar with the ins and outs of computing.

Two aspects of the program design are worthy of mention for they highlight the differences between this program and others that are configurations of general purpose databases. First, all repetitive text (e.g. GP names and addresses, diagnoses, etc.) is held in 'look-up' files. The codes that link the patient record to these files are generated and handled automatically and are quite 'invisible' to the user. This technique allowed us to specify a patient record, the average size of which permits the storage of some 18 000 admissions on a 10 mB (megabyte) hard disc together with program (1.3 mB) and 'look-up' files (0.9 mB).

Second, all the clinical data are selected from menus. The first menu for operations gives 16 options, which are roughly comparable with the titles of the volumes of *Operative Surgery*[12]. Selection of an item leads to the display of a second menu, comparable with chapters within a volume. Further selection reveals a third menu of actual operations. This third-level list is expandable to accommodate specialist or 'personal' procedures. Hidden behind this final selection is the OPCS operation code and a nine-level 'severity index', both of which are used in analysis and output. Approximately 1500 operations and 3200 diagnoses are built into the system. This approach enables automatic coding, and reliable searching and analysis. We have found also that selection is faster than typing an operation by name and virtually immune from input error.

All who have worked with ICD and OPCS appreciate that they were intended to be comprehensive and widely accepted. Despite their shortcomings they do form part of the Körner data set for inpatient activity; thus the relevant codes are linked in the system. Each specialty requires only a limited subset of the codes. However, the precision of description of diagnoses and operations is far greater using the menu structure, because more than one operation or diagnostic entry may have the same ICD code (e.g. ICD does not differentiate between the T stages of bladder cancer). Since it is possible that in the foreseeable future new coding systems will replace ICD and/or OPCS[13], the program allows the linked codes to be changed.

Working with the system

Access to the program is protected by an identification code and password. Users are ascribed one of three levels of access. Up to nine surgical firms can be specified with an indefinite number of junior staff. At startup each day, the program compares the day's date against a diary of messages and prompts (for outstanding discharge details, overdue diagnoses and special follow-ups); those due are offered for inspection. The main menu (Table 3) is then displayed. Throughout the system, selection of a patient may be from hospital number or name. If more than one name or part name is found, all matches are displayed for selection. The menu allows the following selections:

Table 3. The main menu

Patient status
Register/amend patient details
Book patient
Waiting list management
Operation and discharge details
Outstanding diagnosis update
Follow-up reports
Amend previous admission details
Review patient history
Overdues diary
Analysis
Maintenance

Patient status provides a quick check of a patient's full name, address and telephone number; GP's name, address and number; date and reason for the last admission and waiting list status.

Register/amend patient details allows input of a patient's demographic data and GP name.

Book patient enables a patient to be placed on a waiting list or given a date; in the latter case a letter is automatically generated to the patient.

Waiting list management permits the user to print the waiting list by priority and/or by patients given an admission date or not. Entries can be deleted or cancelled, priorities changed, and patients selected from lists for given operation/admission days. Admission and operation lists are generated through this module. If all admissions have to be cancelled for a given time period, then a letter is sent automatically to all patients affected.

Operation and discharge details enables the input of clinical discharge data (see below).

Outstanding diagnosis update, follow-up reports and amend previous admission details: updated clinical information is entered in these modules.

Review patient history allows a search through all details of a patient's record; if multiple admissions or operations exist, then options are present to 'page' through from one to another.

Overdues diary holds lists of outstanding prompts which are displayed when the system is started up each day.

Analysis provides audit reports and searching facilities (see below).

Maintenance allows the system to be adapted for local use.

Input to the system

The information called for on the data cards we use (booking, inpatient detail; Tables 1 & 4, and follow-up) is deliberately limited to information that is both easily collected and necessary to achieve useful output. No attempt is made to replace the written clinical record. Additional information, if required, can be entered.

Elective admissions are registered on the system by the secretary from the booking card (Table 1). Patients can be entered on a waiting list or given a date and held on a diary. Inpatient data are entered from the audit card (Table 4).

To cater for special requirements, a set of 10 user-definable, single-character fields are available in each admission record. Possible uses include coding the patient's occupation, graft types used in vascular surgery, feedback data from patients for assessment of treatment, etc.

After the entry of clinical data, the clinician is given the option of making value judgments by entering one or more 'points for review', which cover delay, diagnosis, management, complications and death. These data can only be accessed from the highest level of security and are only output in the confidential audit report. However, herein lies the opportunity for the surgeon to flag patients to be reviewed at 'outcome and audit' meetings.

At the conclusion of data entry for an admission, additional text information can be entered which will appear on the discharge summaries; it is not permanently stored. Prompts for this additional information include: drugs on discharge, follow-up interval, information given to patient and relative and a paragraph for further details. Three summary documents can be produced: a tabulated version, which contains all the information for the patient's clinical notes; a word-processed letter for the general practitioner, which can be designed by the user and may contain as much or as little of the data as is deemed appropriate for local use; and a special document, for HAA use, which is added to a batch file for intermittent transmission to the medical records department. The latter two documents, although printed through the word-processor, require no amending by the user apart from initial installation.

Prompts can be set to remind the clinician to enter follow-up data or take specific action on selected patients after any given time interval. They are also

Table 4. Information recorded on the 'audit card'

Patient's name	Consultant firm
Address	Hospital number
Tel: (Home)	Date of birth
Tel: (Daytime)	GP
Origin (A/E, OPD, referral, etc.)	Date of admission
Diagnoses (up to 6)	Any outstanding diagnosis
Main operation	Other operations
Procedures within operations	Antibiotic and DVT prophylaxis
Date, surgeon and anaesthetist for each operation	
Complications	Points for review
Date of discharge	Discharge destination

DVT = deep vein thrombosis

automatically set to ask for data a selected period after the entry of a 'pending' diagnosis.

Output from the system

All patient-related information can be viewed on the screen or printed. The system-generated letters (booking letters, discharge summaries, etc.) are held on file and printed in batches once or twice a day. Up to 20 standard forms and letters are held on the system, their text being created and modified to suit local requirement. The program downloads the relevant information to the word processor where it is merged into the appropriate standard letter.

Analysis

Information on individual patients is instantly available throughout the system. Comprehensive search routines are available to select populations of patients for retrospective review. Any stored information can be searched on. Thus it is possible to retrieve patients who have had a specific operation and live in a given post code area and to analyse this population for length of stay, types of complication, etc. Multiple analyses can be performed on a selected group and that group can be progressively refined.

Reports are available to provide standard lists by predefined criteria, for example all operations by a given surgeon. Groups of patients and GPs may also be selected so that their names can be used by the word processor for 'mailmerging'.

The most complex report is the 'audit' (Table 5), a document of some 20 pages that analyses the work of the unit in a considerable variety of ways. It contains all the relevant statistics on turnover and performance that a surgeon could want, so as to provide his own quality control and to be seen to be assessing his own effectiveness.

Table 5. Some of the information produced by the audit report

Time period under review	Total discharges
Estimated discharges/year/ week	
No. booked patients by priority	No. on waiting list by priority
Range and mean time on waiting list	
No. of operations	Estimated operations/year
No. procedures within operations	
No. nonoperative discharges	
Use of special analysis codes	
Use of antibiotic prophylaxis	Use of DVT prophylaxis
Monthly and totals analysis of:	
—Male/female numbers	—Source of admission
—Priority	—Delay to admission
—Length of stay	—Age by decade
—Discharge destination	—Points for review
Inpatient transfers by firm	Hospital transfers by hospital
Incidence of complications	
Operations by surgeon/severity	Operations by surgeon/category
Subcategory analysis by operative group	Numbers performed
—Mean and range of age	—Mean and range of stay
—% with complications	—Number of deaths

Discussion

The system was installed and set up in the summer of 1985 following six months of trials and 'debugging'. Within the first six months of use we managed to enter all current 'live' and one year's retrospective data at one centre and to run the system prospectively at the other.

As noted above, it is our belief that information systems in a medical environment will only succeed if they fulfil two fundamental criteria: first, that they are very easy to use and behave in a logical, predictable and 'friendly' manner; and, second, that those involved in data collection and input perceive a tangible benefit to themselves and to patients.

Experience with the system so far suggests that it satisfies these criteria. Experience at Ashford has shown that this system is considerably easier to work with than our mainframe-based Patient Administration System running ICL software. Our secretaries had, prior to the installation of the program, no computer experience at all; they were apprehensive of the hardware, fearful that they would disrupt the software and anxious about the time required to spend entering information. Now, they would not be without the system. Overall, little time has been saved. However, the tasks that used to be most tedious are now dealt with automatically: production of the weekly admission list takes 16 seconds. Of more importance is that they have instant access to information and can respond efficiently to the many enquiries from patients, GPs, clinicians and managers.

Before the systems were installed we thought that we had a secure method of ensuring that appropriate follow-up action was instituted for all discharges. However, during the entry of retrospective data we discovered at Ashford 8 patients for whom no such action had been taken. In every case clinical care would have been seriously affected. Four of the 8 were patients who should have had a cystoscopy for follow-up of bladder cancer; despite careful explanation to these patients, none had come forward voluntarily.

The program was originally specified with general surgery 'menus'. Recently the menus have been written for systems to cater for orthopaedics and paediatric surgery. Further systems are at present being specified for urology, gynaecology, ENT and ophthalmic surgery.

Prout and Blood[8] noted that many of their problems would have been overcome by combined hardware and software purchase and support from the same source. They also underlined the necessity to maintain archive copies of the data and to update them regularly. This is normally achieved by copying on to a series of floppy discs. However, it is now possible to archive to an external hard disc system with exchangable cartridges, or to a tape streamer.

There are many other applications of a microcomputer in a surgical office. Our hardware is extensively used for the word-processing of papers, documents, the firm's procedures manual, reports, curricula vitae and duty rotas. Other uses include graphics, bibliography records, nutritional assessment and a typing tutor. More recently an autodialling modem has been installed to access the Medline database direct for literature searches.

We believe that this system will allow surgeons to tackle clinical audit in a structured and meaningful

way which is likely to benefit not only the members of the clinical and secretarial staff but also patients.

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