Implications of Computerised Prescribing in Hospitals in the UK

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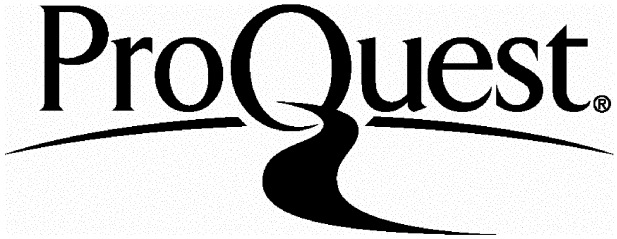

Abstract

In a computerised prescribing system (CPS), doctors would prescribe on computer terminals on wards and outpatient departments. The prescribing information would be transmitted electronically to the pharmacy department. The introduction of CPS to hospitals in the UK will change the current practices of prescribing, dispensing, drug administration and the pharmacy profession significantly.

This thesis looks at the potential advantages and disadvantages of CPS and how CPS may fit into the current health services information requirement. It describes observations made at four hospital pharmacy departments in the USA. It was found that prescribers' support was vital for the success of CPS.

Structured face to face interviews were conducted with 39 doctors at two London hospitals to examine doctors' attitudes towards CPS. Most of the interviewees had not heard about CPS. Their main concerns were system reliability and the time that might take to prescribe on computer terminals.

Computers are used in hospital pharmacies for labelling individual patient medication. Since the labelling process requires similar information to that of a

prescribing system, the time taken to produce a label for dispensing gives an idea of prescribing time for a text-input prescribing system.

Labelling time was measured by direct observation at four combinations of London hospitals and computer systems. The time to produce 2167 labels was measured and 59 operators were observed. There were significant differences in the average labelling time between the studied hospitals/systems (16.6 to 39.3 seconds); with a general trend that labelling time decreased with increasing operator experience. This would have an important training implication on CPS, especially for locums and junior doctors.

The thesis concluded that CPS could potentially offer many advantages to its users. However its success will depend critically on the software design and the method of system implementation and pharmacists must evaluate and develop their roles in CPS.

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Abbreviations

ANOVA	Analysis of Variance
CBS	Common Basic Specification
CPS	Computerised Prescribing System
CX	Charing Cross hospital, London
DoH	Department of Health
DRG	Diagnosis Related Groups
DUR	Drug Use Review
GP	General Practitioner
HH	Hammersmith hospital, London
HIS	Hospital Information System
HO	House Officer
IMC	Information Management Centre
IMIS	Integrated Medical Information System
IP	In-patient
ICU	Intensive Care Unit
IV	Intravenous
MAR	Medication Administration Record
NEMC	New England Medical Centre, Boston
NET	North East Thames Regional System
NHS	National Health Service
NYUMC	New York University Medical Centre, New York
OP	Out-patient
PAS	Patient Administration System
RM	Resource Management
RMH	Rochester Methodist Hospital, Minnesota
SHA	Special Health Authority

SHO	Senior House Officer
SM	St. Mary's hospital, London
TDS	Technicon Data Systems
TPN	Total Parenteral Nutrition
TTO	discharge medicine to take out
UCH	University College hospital
UCMC	University of Chicago Medical Centre, Chicago
UDD	Unit dose drug distribution system
WMUH	West Middlesex University hospital, London

CHAPTER 1 INTRODUCTION

In a fully computerised prescribing system (CPS), doctors would prescribe on computer terminals placed on wards and out-patient departments in the hospital. The prescribing information would be passed on electronically to the pharmacy department. The resultant prescription would exist as a computer file which could be accessed by any authorised user through terminals in the hospital and possibly in the community.

CPS has been available in the USA for nearly twenty years and is now being introduced and developed in the UK. Such a system will substantially change the traditional prescribing process and the ways in which pharmacy is practised. Its success will depend greatly on users' acceptance of the system. In order to consider the implications of CPS in hospitals in the UK, it is first necessary to understand the current prescribing process and some of its potential problems.

1.1 History of current standard UK drug charts

In the early 1960s the in-patient drug chart was a written order from doctors to nurses for administration of drugs to patients. When a drug was not available on the ward, the doctor's order was taken physically to pharmacy for supply and might be left in the pharmacy for

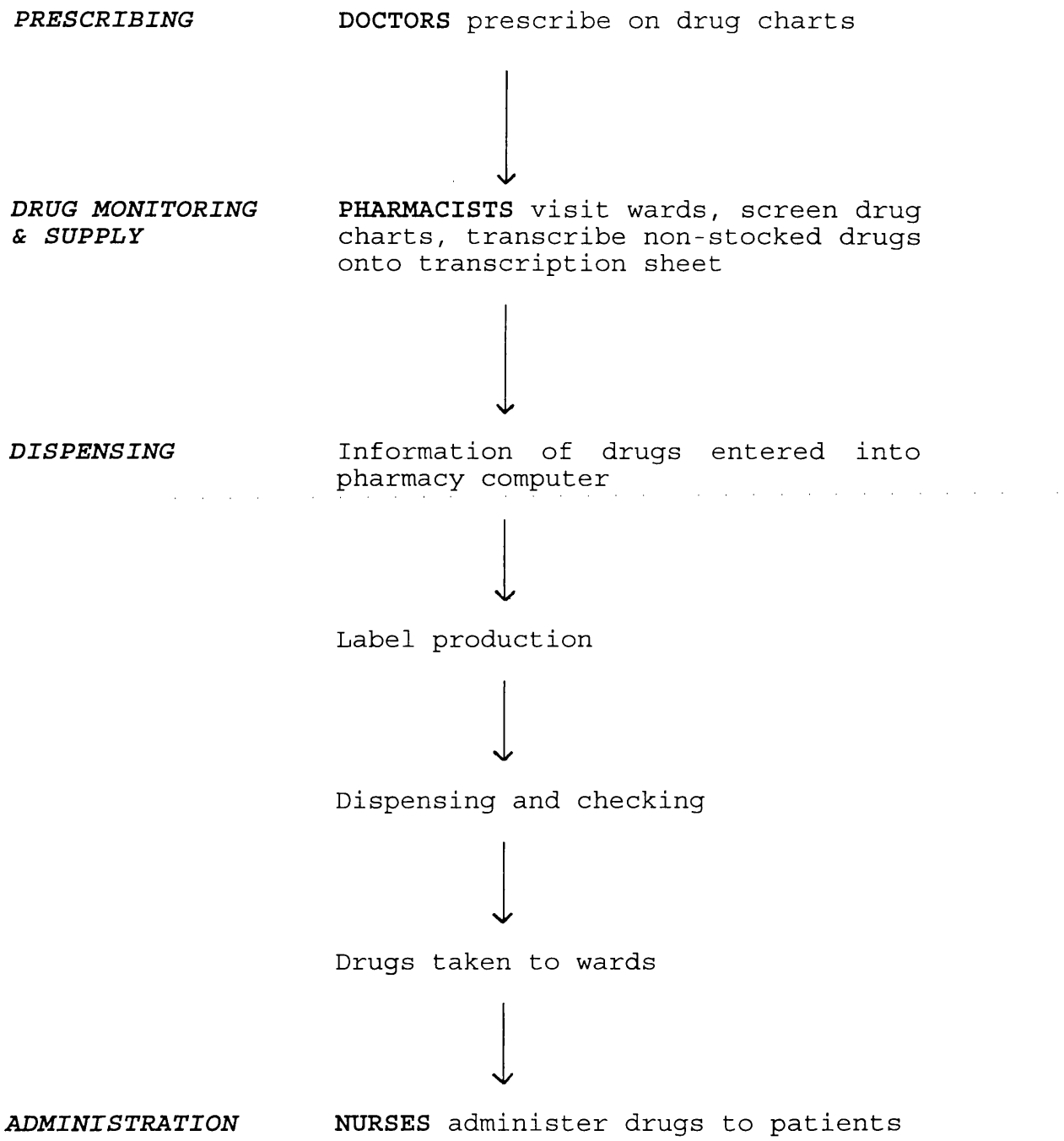
some time. In order to administer drugs meanwhile, nurses would transcribe a daily "medicine list". These lists were a prime source of drug administration error (Vere, 1965; Crooks et al, 1965; Calder, 1965). To overcome this, the drug chart was redesigned (Aberdeen General Hospitals, Pharmaceutical Services Committee, 1967) and pharmacists started to visit wards daily so that drug charts would be able to stay on wards (Baker, 1967; Calder and Barnett, 1967; Hill and Wigmore, 1967). The prescription chart, together with the patient's appearance and surroundings, end-of-bed charts and case notes, supply the basic information for drug monitoring by clinical pharmacists (Batty and Barber, 1991).

The drug chart is collectively used by doctors to prescribe drugs, nurses to record their administration and pharmacists to supply them, to clarify instructions and to monitor therapies. A simplified flow diagram of the current prescribing and drug administration process is shown in figure 1. The drug chart usually bears the following information:

Patient details - patient's name, age and sex
location
drug allergy

Medication details - drug name
dose
route
frequency of administration

Figure 1 Current prescribing, dispensing, drug administration process



duration of medication

signature of prescriber

Nurses administer medications according to the instructions in the prescription chart, usually at fixed drug rounds, and record them on the chart. Any missed doses, which may be due to refusal by patient, drug unavailable on ward, patient "nil by mouth" or presence of side effects, are also recorded together with the reason. This information may be useful in monitoring the supply function of a pharmacy or the appropriateness of a patient's current therapy. However, the reason for missed doses may not always be recorded.

1.2 Potential problems in the current prescribing process

1.2.1 Legibility

One of the main problem of a written medication order is illegibility. This is not uncommon and is potentially dangerous (Shaw, 1991; Kurth et al, 1990) and may be fatal (Faber et al, 1991). Doses may also be missed while nurses try to ascertain the intended drug.

1.2.2 Completeness and accuracy of prescriptions

In a study by Jenkins et al (1993) it was found that for regular prescriptions, 71% of oral and intravenous antibiotic prescription entries were without any

specification of valid period and, depending on the type of prescription, between 12% and 32% of entries were not prescribed by approved names while 4 to 10% were illegible or ambiguous. In some of the entries, information such as dose and frequency had been omitted or the route of administration was ambiguous. In another study carried out by a research group in the North West Thames region, 3,273 patient specific drug related potential problems were identified. Of these, 29% were related to dose or frequency; 14% related to administration, formulation or route; 9% of prescriptions were illegal, illegible or incomplete and 5% had interaction or incompatibility (Batty and Barber, 1992).

1.2.3 Transcription errors

Since a drug chart has limited space, doctors usually have to rewrite charts every two to four weeks. It might be argued that this provides a chance for doctors to review the patient's medication and also to identify existing errors or ambiguities; but very often, doctors simply transcribe the previous drug regimes to the new chart. This transcription itself may be a source of error: treatment may be left out, doses or frequency of drugs may be altered unintentionally. This problem is particularly seen on discharge medication. In a study carried out by Batty and Barber (1992), 10% (339) of the

prescription monitoring incidents identified were related to discharge medications.

1.2.4 Availability of information at point of prescribing

1.2.4.1 Drug and cost information

Over the past 20 years, the information on new drugs has increased tremendously. It is difficult for doctors to keep up with all the prescribing information and to decide what is the best choice of therapy for their patients. Inadequate knowledge and confused motives may result in inappropriate prescribing (Editorial, 1978; Spector and Roberts, 1983). In this cost conscious environment, the cost-effectiveness of a drug has to be taken into consideration; yet this cost information is not easily available. Doctors may get information about new drugs from the pharmaceutical industry through the drug representatives. However information obtained this way may be biased and may not coincide with the local prescribing policy.

1.2.4.2 Laboratory results

Patients' laboratory data play an important role in the choice and monitoring of drug therapies. Results are traditionally printed on paper and suffer from many drawbacks. They are easily lost, may take a long time to

reach the patient's notes and can only be in one place at a time. This may cause delay in initiating effective and appropriate therapies or changing inappropriate ones, and may subsequently prolong patients' stays in hospitals (Browne et al, 1987). An example would be that "blind" treatments with antibiotics may not be followed up when the microbiological information becomes available (Volger et al, 1988).

In some hospitals in the UK and many in the USA, on-line laboratory results are presented on computer terminals and can be simultaneously viewed by physicians, pharmacists and other health workers in different places (Moore et al, 1984; Dotson, 1986; Larson and Blake, 1988; Bleich et al, 1985; Faulkner et al, 1987). This increases the timely and effective use of such information and should lead to improved patient care. However these results are not usually linked on-screen to the patient's drug treatment.

1.2.4.3 Prescribing protocols , policies and guidelines

Prescribing policies and protocols are widely used in the choice of anti-microbial agents and in therapies where a combination of drugs ~~are~~ is used, such as in the treatment of cancer and in bone marrow transplantation. With the relatively rapid turnover of junior medical staff, who are responsible for most of the prescribing, these

guidelines might not be followed. Periodic re-education and follow-up monitoring are necessary to reinforce policies (Volger et al, 1988). An effective way to communicate this information to prescribers, and to feed back to consultants any deviation through an audit cycle, would help to standardise treatment.

1.2.5 Lag time between prescribing and drug administration

In the UK, the majority of in-patient medication is supplied as ward stock items. Drugs that are expensive or less often used on the ward are usually individually dispensed. Orders for the latter are picked up by pharmacists visiting the ward, the frequency of visits varying from once a week to once or twice a day. If a new drug is prescribed between the pharmacist's visits, a nurse may still need to take the drug chart to pharmacy for supply, causing the drug chart to be temporarily unavailable on the ward and wasting valuable nursing time. Alternatively, the nurse may wait for the pharmacist's next visit; this may cause a delay in treatment and may subsequently increase length of bed stay. There has not been any large study on missed dose due to this problem and so its significance cannot be evaluated. However Ridge (personal communication) and Dean (1993) had estimated that about 1.2 to 1.5 percent of all drugs that should be administered on drug rounds

could not be given because they were unavailable on the wards.

1.2.6 Timeliness and accuracy of discharge letter

When patients are discharged from hospitals, they often need to be followed up by their general practitioners (GPs). Information about a patient's hospital stays is essential to the GP for the continuation of care. In the UK a discharge letter is usually issued at the time of patient discharge, followed by a more detailed discharge summary. The discharge letter may be posted to the GPs directly or patients be asked to take them to their GPs. Various studies (Penney, 1988; Mageean, 1986) have shown that there were usually considerable delays before either form of information reached the GPs and in some cases there was no communication at all. Mageean (1986) found that the content of the communications was variable and important information such as diagnosis and treatment were not always stated. When a discharge note which doubled as a prescription for discharge medicines was used, it took less time to reach the GPs (Kendrick and Hindmarsh, 1989). This was probably because doctors had to prescribe the discharge medication before the patient left the hospital.

1.3 Initiatives by pharmacy

1.3.1 Formularies and prescribing guidelines

In order to rationalise prescribing and to control drug expenditure, many hospitals have developed local guidelines on prescribing or a list of drugs available locally, known as the formulary. The question of prescribing freedom has been raised (Editorial, 1978; Bolt, 1984; O'Dowd and Wilson, 1991) but with the recent changes in clinical management structure and the devolvement of clinical budgets, clinicians generally now accept that formularies are an effective way of controlling drug costs. This is further supported by the Department of Health. The health circular 'The Way Forward for Hospital Pharmaceutical Services' (Department of Health, 1988) stated that 'experience has demonstrated that an effective way in which cost containment of expenditure on medicines can be achieved is through the implementation of formulary management systems'. Many hospitals have reported successes with the use of formularies (Baker et al, 1988; Lewis et al, 1989). However these successes may be short-lived unless accompanied by continuous education and peer review (Feely et al, 1990) and constant policing by pharmacy staff.

There is evidence that by incorporating a formulary into a computerised prescribing process the formulary may be followed more closely. At the Medical College of Virginia Hospitals USA, when doctors called up the menu to

prescribe, drugs in the formulary were presented first (Schroeder and Pierpaoli, 1986). The selection of a non-formulary drug took longer. Screens describing various protocols developed jointly by the infectious diseases division and the pharmacy and therapeutics committee were also available. The authors reported that in an informal study, it was shown that after the computer system was implemented, dosing protocols were followed more often and there was a decrease in the rate of non-formulary drug requests.

1.3.2 Drug use review (DUR)

Another method of rationalising drug treatment is by DUR. Pharmacists have been actively involved in DUR and have shown successes in reducing drug costs. There are two aspects of drug usage addressed by DUR: quantitative and qualitative. The quantitative arm is concerned about how often, how much and where a drug is used. This information may be obtained from purchasing information or from drug issues data. Most pharmacy systems can provide sophisticated quantitative information (Simpson, 1987; Jacklin and Willson, 1991).

The qualitative aspect concerns how and why a drug is used. For this, drug use data must be linked to diagnosis and possibly laboratory results to provide meaningful information. The manual collection of this information is

tedious and very time consuming. With computerised prescribing, this would be easily achieved.

1.3.3 Clinical pharmacy

One of the aims of clinical pharmacists is to promote the safe, effective and economic use of medicine while maintaining quality of life for the patients (Department of Health, 1988; Barber, 1991). Prescription monitoring is one of the principal ways to achieve this.

The incorrect prescribing of drugs is common and may lead to adverse drug reactions. In a study of the nature of adverse events of hospitalized patients, drug complications were the most common type of adverse events (19%); of these, 18% were preventable (Leape et al, 1991). Prescribing errors can be prevented by pharmacists, as is reported in several studies (Batty and Barber, 1992; Eadon, 1992; Folli et al, 1987; Hawkey et al, 1990).

The role played by pharmacists in the UK has usually been a reactive one. Most interventions are made after an error is committed by prescribers. However, the role of pharmacists is changing. With the ever-increasing information about new drugs and a constraint on resources, pharmacists as drug experts can provide valuable advice on the selection of drug treatment. Part

of this role is already present via formularies, prescribing guidelines and DUR. But increasingly pharmacists may be seen attending ward rounds with clinicians, taking part in clinical audit and teaching junior doctors and nurses. All these duties require substantial time from clinical pharmacists.

Prescribing errors in "take home" medicine, if not detected, may be subsequently perpetuated by GPs when patients are discharged. In a regional study by Batty and Barber (1992), 10% of all interventions performed by pharmacists were related to discharge prescriptions. In a survey by Orme et al (1990) interventions by pharmacists were necessary before 19% of discharge prescriptions could be dispensed. Most interventions concerned either unintentional differences between drugs prescribed for patients in hospital and on discharge or unintentional changes in dosage regimens of medication administered. With computerised prescribing, these sorts of errors might disappear. Lists of discharge medications based on patients' current regimes would be automatically available on screen for doctors and changes intended by prescribers would be explicitly noted. This would reduce queries from pharmacy.

1.4 Current development of pharmacy computer systems

To meet the increasing demand for cost and management information, integrated pharmacy computer systems have been developed in the UK which incorporate sophisticated modules on purchasing and stock control (Stainton et al, 1983; Downie, 1984; Editorial, 1987; Longshaw et al, 1983), distribution and in some cases clinical applications such as drug interaction and dosage checking (Hudson, 1985; Darby, 1983; Jackson, 1982; Craig and Benrimoj, 1985; Duckworth and Bailie, 1986).

Most of the pharmacy systems are designed for stock control and costing to centres, rather than patients, and do not incorporate prescribing systems. These systems record issues of stock items and makes order compilation easier by printing picking lists and packing notes. Costing information is collected at ward or departmental level. In such a distribution system, ward pharmacists are substantially relieved of the drug supply and manual information collection functions and can concentrate on clinical activities. Most such departmental pharmacy systems have been designed specifically for pharmacy practice and the cost of system implementation and staff training is relatively low. However, the current method of drug distribution and cost capture still has several drawbacks; it is labour intensive and time consuming, duplicates written information, involves staff moving

around the hospital and prolongs lapse times between initial prescribing and non-stock drug supply. The information collected is not yet patient specific and may be inadequate for use in the NHS initiatives such as resource management and clinical audit.

To meet the information needs of the NHS and the changing role of pharmacists, a new generation of pharmacy computer system is required (Rowbotham, 1989). A computerised prescribing system may be expensive to implement and maintain but it can remove problems of illegibility, decrease errors of omission and transcription and reduce the need to contact prescribers about trivial errors. Up to date treatment and formulary information would be available to prescribers at time of prescribing. Patient information such as reason for admission, diagnosis, discharge medication and the GP's address could be stored in the computer and formatted into a discharge letter when the patient is discharged. This should ensure completeness and timeliness of communication between secondary and primary care. All these would in turn improve inter-professional relationships as well as safety of drug treatment to patients.

1.5 Health Service Computing

Within the past ten years, there have been several initiatives within the NHS which required cost and

treatment information at individual patient level. These initiatives include Resource Management (RM), medical audit and the provider-purchaser split of service. Any development in the NHS and in health care computing would need to comply with these initiatives. Computerised prescribing is one of the options which provides some of the information required.

1.5.1 Resource management

1.5.1.1 Background

Management budgeting was introduced to the NHS in 1984 as an attempt to control the increasing expenditure in the health services. It tried to make clinicians more responsible for the resources they use by allocating budgets to a clinical specialty rather than by function (Editorial, 1985). However management budgeting was not successful as there was a lack of involvement of clinicians in the management structure and the level of reporting was too superficial ('Clinicus', 1985; Kerr, 1988). A way to relate hospital events to individual patients would be necessary before clinicians could effectively allocate their resources.

In 1986, management budgeting was revised and re-introduced as Resource Management (RM) which was a drive to improve the collection of data on the cost of treating patients with different conditions (Purkiss, 1991). The

aim of Resource Management is to enable the NHS 'to give a better service to its patients, by helping clinicians and other managers to make better informed judgments about how the resources they control can be used to the maximum effect' (Department of Health and Social Security, 1986). This necessitates a change in the NHS management culture and mechanisms to cost all treatment and services to individual patient level where feasible.

Six pilot sites were initially chosen by the Department of Health in late 1986 to look at different approaches towards RM. These were: Royal Hampshire County hospital in Winchester (Hewett, 1989), Guy's hospital in London (Rea, 1989), Pilgrim hospital in South Lincolnshire (North, 1990), Arrowe Park hospital in Wirral (Bagnall, 1989), Royal Infirmary in Huddersfield and Freeman hospital in Newcastle upon Tyne (Canning, 1989).

Learning from the lessons of management budgeting and following the recommendation of the Griffiths report (NHS Management Inquiry, 1983), clinicians were actively involved in the RM. The first, and probably most popular management model, was that of the formation of clinical directorates, first developed in the UK at Guy's hospital, London. In this model, clinical services in acute hospitals are divided into directorates (e.g Haematology, Neurology, Paediatric Medicine), each responsible for the management of their own services and

controlling a substantial proportion of their own expenditure, including the cost of drug treatment (Rea, 1989; Horne, 1991).

1.5.1.2 Information implication of resource management

Information technology has been widely employed in the NHS to provide the data required by RM. The information core of RM is the "case mix management system". The system contains a patient-specific database linking all the events, including cost of treatment, for each patient with a diagnosis code (Rea, 1989). The use of various coding frames such as diagnosis related groups (DRG) (Catterall, 1988; Benson, 1990; McKee, 1990) and Read codes (Chisholm, 1990; Radford and Wallace, 1990) is still being explored. The pilot sites had either developed their own feeder systems, each of which was able to transfer data to the case mix database, or had developed an integrated operational system with a network of terminals in wards and departments, which had a single interface with the case-mix database. By providing detailed information on each patient and comparing this against a standard profile of care for that type of patient, clinicians hope to review their own use of resources and have a basis of discussion with their peers.

1.5.1.3 Implications for pharmacy

To contribute to resource management, pharmacy departments needed to provide clinicians with information about the cost of drug treatment down to individual patient level (Ashford, 1991; Rowbotham, 1989). This posed a particular challenge for pharmacy departments in the UK. Traditionally, the bulk of in-patient drugs are issued to wards as stock items and cannot be costed to individual patients. New methods to capture cost of drug treatment at patient level are necessary. The number of bed days occupied by patients had been used to apportion ward stock costs to different consultants. However, a study by Miller and Ashford (1988) suggested that this method is inaccurate. An alternative would be to dispense individual patient medication with no or very few ward stock items. In such a system, the medication may be dispensed as multiple doses or as a unit dose.

Unit dose dispensing is widely employed in the USA to reduce medication errors and because of the need to charge patients for the drug treatment (Schwartau and Sturdavant, 1961; Simborg and Derewicz, 1975; Barker and McConnell, 1962; Appleby et al, 1983; Lee et al, 1992). An automated computer-driven unit dose distribution system has also been installed and reported at two UK hospitals, Hope and Watford General (Clark et al, 1990; Editorial, 1989). Although cost capture by dispensing individual patient medication, either by multiple doses

or unit doses, may overcome the problem of costing stock items, this method has not been considered as a solution for RM because it is very labour intensive and requires extensive support by pharmacy staff, which is unlikely to be available with the current and predicted pharmacy manpower situation in the UK (Counsell et al, 1981; Barber et al, 1992).

1.5.1.4 Methods investigated under RM

At the six pilot RM sites, various methods of drug cost capture had been explored (Editorial, 1990). Three main approaches were adopted: cost capture by computerised prescribing, capture at time of drug administration, or retrospective recharging from patient records.

The first option, computerised prescribing, has been adopted at four of the six sites. The Royal Hampshire hospital and Arrowe Park hospital had installed an American computer system called Technicon Data Systems (TDS). TDS is an integrated hospital system which allows doctors to prescribe and nurses to record drug administration on computer terminals using menus and light-pens. Computer screens replace the traditional patient drug charts; orders raised on wards for non-stock items and discharge drugs are printed out in the pharmacy departments. At the Royal Hampshire hospital, attempts are being made to link the TDS with the pharmacy departmental system. At Arrowe Park, the system had been

criticised as unsuitable for UK practice and substantial modification is still being made.

The Pilgrim hospital in South Lincolnshire and Guy's hospital in London are also moving towards computerised prescribing. The Pilgrim hospital has designed a specification for its own system, which should offer potential benefits for doctors, nurses, pharmacists, patients and managers, but the system is still being developed. At Guy's hospital an in-house developed computerised prescribing system was being tested on a few wards (Horne, 1991), however work has now ground to a halt.

At the Freeman hospital, drug cost data was collected at the time of drug administration. Nurses use light pens to read bar codes into hand-held Psion organisers on drug trolleys. This information is subsequently fed into a microcomputer (Berns et al, 1991).

Drug cost information at the Royal Infirmary in Huddersfield is captured by pharmacy staff from drug charts retrospectively. The data are entered into the pharmacy computer and then downloaded into the hospital's resource management computer system. This method does not require costly development of new computer systems. However it is labour intensive, poses an extra operational step, is insensitive (Miller and Ashford,

1988, Jenkins, 1990) and offers little prescribing information which would be useful for clinical audit.

1.5.1.5 Other developments

The development of pharmacy RM systems is not restricted only to the six RM pilot sites. A computerised ward drug administration system which uses bar codes for data capture is currently under test at the Morriston hospital in Swansea (Editorial, 1991; Fisher, 1991). In this system, the patient, the patient's prescription chart and the drugs in the trolley are all bar coded. Doctors prescribe on a computer built into a drugs trolley. A bar coded prescription is then printed out. Using a scanner, a nurse can check that patient, prescription and drug all match up. Drug administration is then recorded on the prescription sheet which is laid over a computer keyboard. Pressure sensitive keys under the prescription sheet allow the feeding of that information into the computer.

At the Royal Brompton hospital, London, an intensive care unit (ICU) system is being implemented (personal communication). This system will allow recording of drug administration on a flowsheet on computer screens and a prescribing module is also being developed. At Greenwich hospital, London, there are plans to incorporate a CPS as part of the Hospital Information System (Eames, 1989). Companies who currently supply dedicated hospital

pharmacy computer systems are also looking at their feasibility.

1.5.1.6 Brunel report

The Health Economics Research Group (HERG) at Brunel University was commissioned by the Department of Health (DoH) in May 1988 to undertake a three year evaluation of the costs and benefits of RM in the six acute hospitals (Packwood et al, 1989). Its final report was published at the beginning of 1991 (Health Economics Research Group, 1991). The evaluation exercise was found to be difficult and the report concluded that 'it was not possible to provide a definitive assessment of RM as an ongoing working process for hospital management.'

The research group estimated the cost of implementing RM at the six pilot sites to range from £354,000 at Arrowe Park (where the main computer systems were still being implemented at the end of the study) to £2.6m at Guy's. The cost of implementation was more than double the maximum expected by the DoH when RM was formally announced (Robinson, 1991).

With the introduction of the latest NHS reforms, RM has become an approved policy and is to be adopted in some form in all NHS hospitals. RM involves changes in culture and information technology is essential for its success. Although no definite solution to drug cost capture has

been provided by any of the six RM pilot sites, it seems that the trend is towards the development of computerised prescribing systems. The Brunel Report showed that this could be an expensive exercise. Hospitals which are going down this path must be aware of this and should consider clearly how the undoubted benefits are balanced against the possible cost.

1.5.2 Medical audit

In the White Paper "Working for Patients" (Secretaries of State for Health, 1989) the Government attaches great importance to the development of a comprehensive system of medical audit covering both Primary Health Care and the Hospital and Community Health Services. It aimed to secure medical audit in all NHS hospitals, including self-governing hospitals, by April 1991.

Medical audit is defined by the DoH as 'the systematic, critical analysis of the quality of medical care, including the procedures used for diagnosis and treatment, the use of resources, and the resulting outcome and quality of life for the patient' (Department of Health, 1989a). The term clinical audit is sometimes used to include multidisciplinary input, such as pharmacists and nurses. The principal aim of audit is to improve patient care. Clinicians were to be actively involved in the random retrospective review of case notes, prospective collection of information on outcomes,

the application and monitoring of guidelines and the design and introduction of computerised clinical information system for audit. A number of guidelines have been laid down on how audit could be set up (Ellis & Sensky, 1991; Shaw and Costain, 1989).

Audit is a continuous cycle, involving observing practice, setting standards, comparing practice with standards, implementing change, and observing the new practice. The importance of completing this feedback loop has been emphasised (Smith, 1990; Moss and Smith, 1991; McKee et al, 1989)

In order to perform audit, information which relates to individual patients, patient groups and patients' demographic details would be needed. Data would be collected by different disciplines; an integrated information system in which data are collected operatively may improve the quality of information. Although audit is not dependent on computerised databases (McKee et al, 1989; Crombie and Davies, 1991), computers can be used for storing, retrieving and correlating information to facilitate audit activity (Hamlyn, 1991; Allen, 1990; Department of Health, 1990a). Some of the data and facilities required for medical audit may be found within the case-mix system or clinical information systems; these systems had been developed in some

hospitals to enable detailed information to be captured and be used in medical audit (Allen, 1990; Jones, 1990).

For audit to be successful, it is important to complete the feedback loop. In a review by Mugford et al (1991) it was observed that information feedback is likely to have a more direct effect on practice if presented close to the time of decision making. Five of the studies reviewed by Mugford evaluated the effects of some form of online prompt to practitioners by computerised recording or ordering systems. The results of these studies all suggested that concurrent reminders of costs or protocols for treatment increased compliance with agreed standards, and on-line computers may be an effective medium for influencing practice. This method may also be used to monitor any deviation of prescribing from the standard agreed.

1.5.2.1 The role of pharmacy in medical audit

The monitoring of patients' drug treatment and sometimes its outcome, has long been performed by pharmacists. This may take the form of prescription screening by pharmacists during ward visits and while dispensing, or may be in the more organised setting of Drug Use Review. In these ways the use of drug treatment on patients and its outcome may be monitored, analysed and critically assessed. However, in most cases, due to the lack of

explicit standards and difficulties in closing the feedback loop, such monitoring so far cannot be considered as true audit.

Pharmacy departments can provide valuable information on drug usage such as costs and trends of prescribing and choice of therapy (Simpson, 1987). This information can be used for audit. In some hospitals, pharmacy departments are actively involved in the medical audit process (Davies, 1989; Eccles et al, 1992) and the role of pharmacists in medical audit in hospitals has been explored (Harris et al, 1993; Cotter et al, 1993). The quantity and quality of information available may be enhanced by well-designed pharmacy computer systems. Currently drug treatment audits are mostly performed on specific patient cases or on specific groups of drugs. In the future it is likely that audit would be performed on patients or patient groups receiving a particular drug or treatment regimes. This would require more extensive drug treatment information relating to individual patients. Such information would be difficult and time consuming to collect manually. A computerised prescribing system which records all drug treatment on individual patients would be able to provide the necessary information and provide a powerful tool for audit.

1.5.2.2 Information Technology need of audit

Medical audit is probably one of the least controversial issues of the NHS reforms. Unlike resource management, it does not rely directly on information technology. However, medical audit and resource management have much in common. The data required for both overlap considerably and the information derived from each is relevant to the other (Ellis and Sensky, 1991; Ellis et al, 1990). As the volume and complexity of medical audit activity increase, information systems will become a key tool in audit. It is important that the information needs of medical audit are integrated into corporate information strategies.

1.5.3 Internal Market

One of the most significant changes introduced by the white paper "Working for patients" may be the setting up of the 'internal market', in which hospitals and District Health Authorities are divided into purchasers and providers of healthcare (Department of Health, 1989b; Gilby, 1991). From April 1, 1991, services from provider hospitals and community units may be bought by District Health Authorities or general practitioner fund holders through arrangement of contracts. The decision may be based on the cost of the operation or the size of waiting list. Providers would need to set prices for the services they provide and set up contracts with buyers.

There are mainly three types of contracts. The first one is the "block contract" which states that a provider will make available a certain facility at a given price. This is the easiest method but providers carry much of the risk if demand exceeds that originally agreed.

The second type is the "cost and volume" in which a predicted volume of work is specified, with an agreed price. Should the number of patients rise above this level, then extra money will be provided, and some payment would be withheld if the number of patients falls below the target.

The last type is "cost per case" payments. This method is probably the most satisfactory one in theory; however this would required the costing of every episode to individual patient level, including drug treatment.

It can be anticipated that as the 'internal market' becomes more refined, there would be a move towards the "cost per case" type of contract. A RM system may help to provide information about the cost of individual patient treatment and the use of a computerised prescribing system can provide an accurate cost of drug treatment for each patient. As purchasers become more sophisticated in contracting, such systems will be playing their part in a complementary growth in sophistication of costing and pricing.

1.5.4 Common Basic Specification (CBS)

The Common Basic Specification (CBS) is a set of activities and supporting data requirements for the NHS. It describes what the NHS does and the information needed to do it. It is produced by the NHS information management centre (IMC) and was first published in September 1990 and is regularly expanded and revised. The rationale behind CBS was that the design specification of a hospital computer system should essentially be the same for any hospital in the country (Dallimore, 1990).

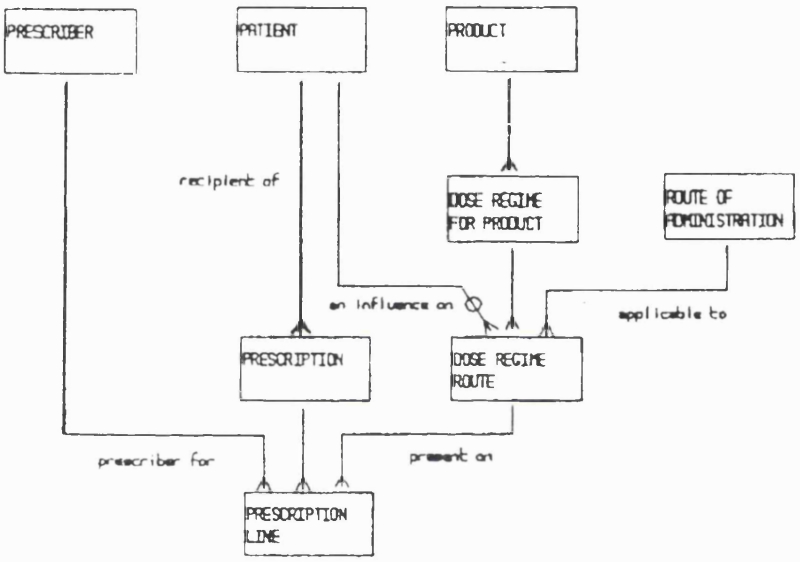
CBS looks at the underlying similarity between areas normally treated separately but makes no attempt to identify who should do tasks or how they should be done (Bailey et al, 1991). The CBS covers a large area of subjects, ranging from pathology and audit to pharmacy. One of the advantages of using CBS to design a system would be that all systems based on the CBS should be able to integrate successfully and share common data (Dallimore, 1990). This would reduce the cost of producing new systems and may also offer long term savings since new elements may be introduced without the need to substantially rewrite the whole system.

The pharmacy CBS (Bailey et al, 1991) is one of many commissioned by the NHS information management centre. The project was completed in April 1991. The purpose of the project was to "provide an input to the NHS CBS by

analysing the information needs of a Hospital Pharmacy service and its interfaces and subsequently specifying a system to meet those requirements". It is hoped that this generic model would provide the basis for developing, procuring and implementing pharmacy systems throughout the NHS and, potentially, outside the NHS.

The pharmacy CBS covers the data entry, storage, manipulation and enquiry functions necessary to accomplish the pharmacy tasks and to provide the required interfaces with other systems. It has also included prescribing as part of the process. Figure 2 illustrates the relationships between different data items or entities in a prescribing process, such as prescriber, patient and prescribed items. For example, a "prescription" may contain zero, one or many "prescription lines"; however, a "prescription line" will always relate to just one "prescriber" and one "prescription", and the "prescription" will only relate to just one "patient". The "prescriber" and "patient" are related through the "prescription line". Any development or procurement of a computerised prescribing system should therefore follow the CBS model to ensure compatibility with other developing computer systems, such as the HISS and Resource Management system, which use the NHS data model.

Figure 2 **CBS data model showing the general relationship between a patient, what is prescribed to treat the patient and who is responsible for the prescribing.** (extracted from Pharmacy CBS Project, Information Management Centre, 1991)



Conventions:

For any one occurrence of A, there will be zero, one or many occurrences of B. For any one occurrence of B, there will be only one occurrence of A.

Descriptions shown by the side of relationship lines describe the master-detail relationship.

The IMC encourages authorities and their suppliers to develop relevant information systems from the CBS models (Department of Health, 1990b). This will help ensure compatibility and consistency of systems and information within the NHS which may be essential for the future development of audit and for contracts' handling between the provider and purchaser units. Thus any development or selection of computer systems should be consistent with the CBS while considering the need for more detailed information used locally.

1.5.5 Discussion

There is an increasing need in the NHS to capture data regarding individual patient episodes. Initiatives such as resource management, medical audit and the purchaser/provider split of services all require treatment information to individual patient level. Pharmacy departments would need to develop strategies to meet such demand. While the sense of clinical ownership of the information must not be lost, medical audit activities, resource management, contracting, and other management processes will benefit from the use of a shared database (Bowden and Walshe, 1991; Department of Health 1990b), probably based on the CBS. The development of a computerised prescribing system might be a logical path to follow . However, the cost and benefits of such a system should be carefully examined.

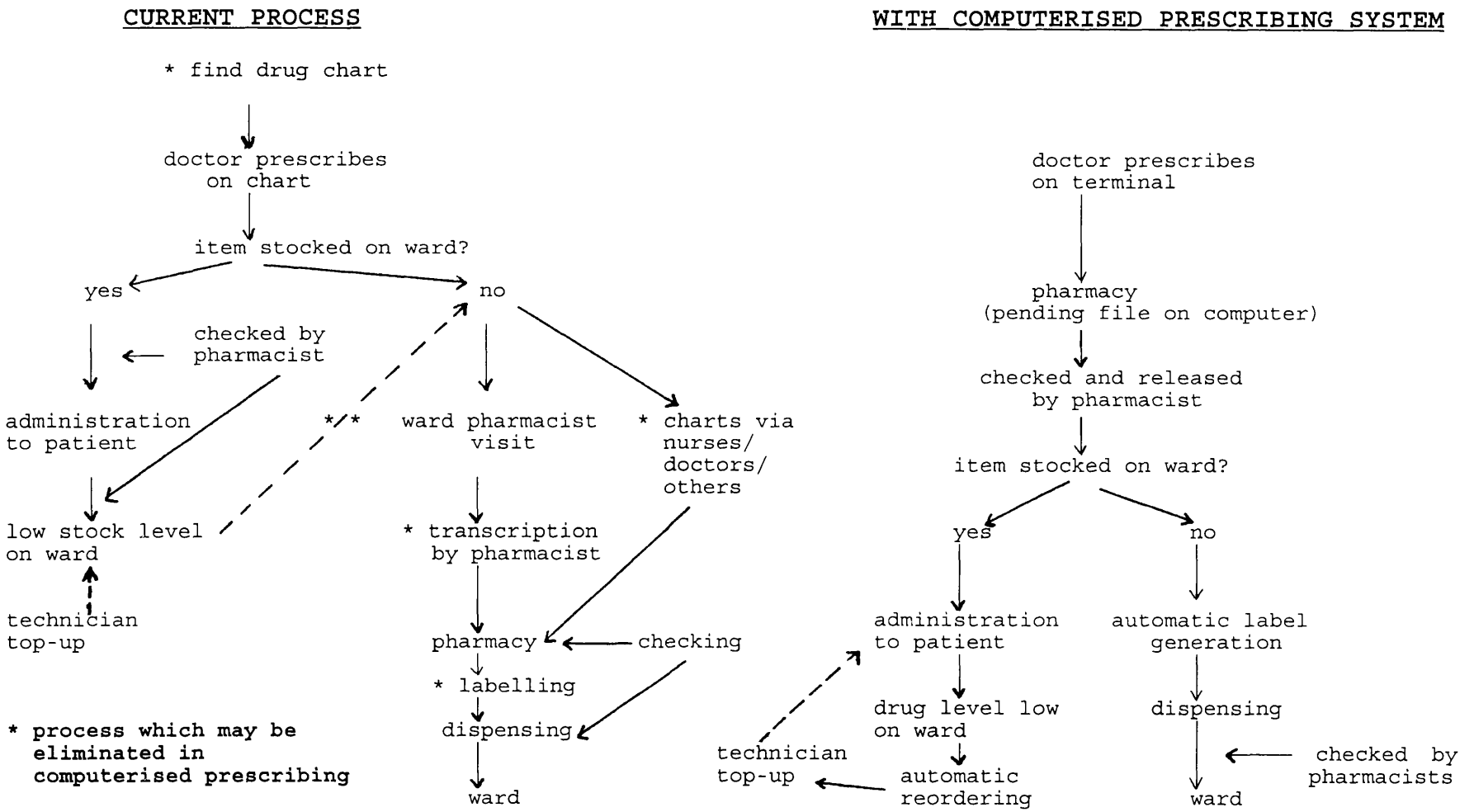
1.6 Advantages and disadvantages of computerised prescribing

Computerised prescribing systems have been implemented in a few hospitals in Japan (Lun et al, 1986; Hisakazu et al, 1985) and in the USA (Schroeder and Pierpaoli, 1986; Larson and Blake, 1988; Serpa et al, 1990; Craghead and Wartski, 1989; Kawahara and Jordan, 1989). In hospitals in the UK, however, such systems are only at an early stage of development. Literature documenting any of these systems is scarce; little evaluation of computerised prescribing has been done and none of that in the British health care system. Most of the advantages described for CPS are usually subjective or anecdotal rather than quantitative.

1.6.1 Advantages

Some of the potential advantages in computerised prescribing have been outlined in the correspondence of Clutcher and Scherpbier (1990) and Ellinoy and Gilroy (1990). The benefits include improved legibility, decreased errors of omission and a reduced need to contact prescribers about trivial errors. Prescription details are available to all authorised users as soon as they are entered into the computer, and lost charts or the need for nurses to take charts to pharmacy are eliminated (figure 3). Prescribing information may also be used in retrospective drug evaluation to determine the trends of prescribing, its effect on patient therapy and

Figure 3 Comparison of computerised prescribing with conventional prescribing-dispensing process



its financial implication.

In a study by Tierney et al (1993), the use of a network of microcomputer workstations for writing all inpatient orders was found to significantly lower patient charges, length of hospital stays and hospital costs. A saving of more than $3 million per year was projected. It was suggested that the reduction in costs was due to presentation of timely and relevant information to prescribers when decisions were made, ie. at point of prescribing, and also from increased efficiency in the transmission of prescription orders to pharmacy.

Computerised prescribing may be used to influence prescribing habits by including informative messages in the prescribing pathways for certain drugs as done in a few hospitals in the USA (Larson and Blake, 1988; Schroeder and Pierpaoli, 1986; Kawahara and Jordan, 1989). Information might just be a warning or could be further directions: examples are sodium content of injectable antibiotics, recommended antibiotic therapy based on site of infection, therapeutic alternatives or various dosage regimens and the cost of related drugs. This would permit prescribers to make more informed choices.

Kawahara and Jordan (1989) described a program in which informative text was inserted into a computerised drug

order-entry screen to alter prescribing patterns and contain costs. For example the use of cefonicid was recommended instead of cefuroxime. The cost and relative use of cefonicid and cefuroxime were examined retrospectively in specific patients with pneumonia. The percentage of patients who were prescribed cefuroxime decreased from 100% to 22%, while those receiving cefonicid increased from 0% to 78%. The average combined acquisition cost of the two antibiotics decreased from $123 to $48. However, because this evaluation was retrospective, other factors which might have affected these prescribing changes could not have been isolated or eliminated; a controlled prospective study would be needed to confirm the results. Nevertheless the authors felt that the use of informative text inserted in the order-entry pathway did provide accessible and consistent information when the therapeutic decision was being made.

This might be expected to reduce the time pharmacists devote to retrospective intervention activities. However, for the use of informative text to be effective, physicians had to assume responsibility for order entry. Computerised intervention would be ineffective if the physician relied on a clerk to transcribe handwritten orders into the system. Other limitations were that the size and capacity of the computer system might constrain the space available for informational text and the

information might not be applicable for all uses of a particular drug.

At the Medical College of Virginia Hospitals, USA, the hospital was able to standardize drug therapy ordering and encourage adherence to a limited hospital formulary by presenting lists of drugs in the formulary on screens and incorporating information about various protocols developed jointly by the infectious diseases division and the pharmacy and therapeutics committee (Schroeder and Pierpaoli, 1986).

In hospitals which had installed computerised prescribing systems, benefits often resulted though these benefits have not usually been quantified. At Community Memorial Hospital, USA, it was perceived that telephone calls from pharmacy inquiring about illegible or incomplete orders were reduced (Larson and Blake, 1988). Physicians also found that the facility to print lists of patients alphabetically or by hospital geographic characteristics useful for note-making during patient rounds.

At the University of California San Diego Medical Centre, USA, a computer system linked prescribers in a diabetes centre to a satellite pharmacy (Serpa et al, 1990). As a result, patient waiting time at the pharmacy decreased and the pharmacy department was able to process more prescriptions. Pharmacists could spend more time

counselling patients since less time was needed to enter prescription information into computer terminals. Prescribers' awareness of the drug formularies had also increased, thus decreasing the number of prescription changes necessary after the patient had arrived at the pharmacy.

At Richland Memorial Hospital, USA, a computer program allowed physicians to order neonatal parenteral nutrient solutions by entering the infant's demographic data and 24-hour TPN requirements, thus eliminating calculation, transcription, and identification errors (Thomas, 1987). This resulted in a better working relationship between pharmacists and neonatologists, increased accuracy, reduced waste, and saving of time. The authors felt that this computer program had released professional time to concentrate on the infant's total therapy, rather than on a set of intricate calculations.

At the Osaka Prefectural Habikino Hospital in Japan (Lun et al, 1986), as part of an evaluation of the hospital information system, it was found that since the implementation of a prescription order entry system, patient waiting times at the hospital pharmacy had been considerably reduced from a mean waiting time of 30 minutes to 10 minutes in the morning clinics. Similar evaluation was also carried out at the Kochi Medical School in Japan. On the hospital's Integrated Medical

Information System (IMIS), it was found that on average it took 102 seconds to issue a new prescription order, 76 seconds to re-issue an old one, 76 seconds to order a clinical test and 54 seconds to request the radiological examination of a patient.

1.6.2 Potential disadvantages

Computerised prescribing can offer many potential benefits to staff and patients, but there are also many issues, such as system security, patient confidentiality and system reliability, that need to be addressed. For computerised prescribing to be effective, doctors must be willing to prescribe via a terminal instead of on paper. User acceptance will depend on many factors including availability of terminals, screen design and ease of data entry (Kawahara and Jordan, 1989). At the University of California San Diego Medical Centre USA (Serpa et al, 1990), the pharmacy department's prescription-entry screen was reprogrammed and a 'default' list of the most frequently prescribed drugs was generated to simplify direct order entry. However, because prescribers found it easier and faster to write prescriptions on paper and only one terminal was available for order entry, prescriptions were frequently hand-written rather than being entered onto the computer. The prescribers received insufficient training in the use of the system and so were not familiar with it. Computer 'down time' was also frustrating for both prescribers and patients.

A computerised prescribing system may be expensive to implement and maintain. Both users and technical support have to be provided at all times. At Community Memorial hospital, USA, for the initial implementation of the system 12 nurses were selected and trained to provide subsequent training to the 200 physicians (Larson and Blake, 1988). Each training session involved one trainer and one physician for a 2-hour period.

Besides training new staff and locums, revision courses will need to be provided for any updates in the system. A well designed system which is user friendly and contains directions for the users to follow should make the task of training easier.

At Suburban County Hospital in the USA, although the hospital system had the facility for direct prescription entry by doctors on screen, an administrative decision was made not to give physicians this due to the prohibitive cost of training the rotating residents and the desire to have a stable population of computer users during the implementation process (Aydin, 1989). This was compounded by the doctors' reluctance to change their work patterns to use computers. As a result nurses had to enter the doctors' written order onto the terminals, thus abolishing the potential benefits which could be obtained from computerised prescribing and risking increases in transcription errors.

Craghead and Wartski (1989) found that the implementation of a computerised prescribing program at the Ireland Army Community hospital at Kentucky, USA, resulted in an increase in the number of unclaimed prescriptions from pharmacy. Suggested reasons included patients' inexperience with and confusion over the new system and the identification of non-compliant patients who, before the system was implemented, would not have taken the prescriptions to pharmacy to be dispensed. The latter information might be useful for prescribers to identify non-compliant patients. However it is difficult to assess the extent to which the USA's private insurance based payment systems might have affected this.

Both in the UK (Barber, 1990) and in the USA (Poikonen, 1990), concerns about the effect of computerised prescribing on the role of pharmacists have been expressed. Poikonen gave examples of on-line prescriptions received in the pharmacy which were dispensed without any pharmacist review, and at another hospital there were no clinical reviews or electronic checks before dispensing. Both Barber and Poikonen cautioned that the development of a computerised prescribing system should not bypass the pharmacist's clinical responsibility and should always support rather than impede pharmacy services which are already being provided.

1.6.3 Computerised prescribing in general practice

In the UK, although computerised prescribing is still in its infancy in the hospital setting, its use in general practice is quite widespread (Aylett, 1985; Donald, 1989; Purves, 1991). General guidelines have been issued by the General Medical Services Committee and the Royal College of General Practitioners Joint Computing Policy Group (1985) regarding the use of computers in the prescribing process. The growth of computer use in general practice was initially encouraged by two major suppliers offering systems in exchange for GP's prescribing information. More recently, growth has been sustained by the introduction of partial Department of Health reimbursement of system costs and the demands of the 'new contract'. In the 1991 survey of GP practice computing in England and Wales (Department of Health, 1991) it was found that 63% (6,130) of all practices were using a computer. One of the most common usages was to issue repeat prescriptions (91% of practices that had a computer), while 48% of practices used the computer for acute prescribing. Figure 4 shows an example of the prescribing screens from the VAMP computers, one of the main suppliers of GP computer systems in the UK.

As with computerised prescribing systems in hospitals, such systems in general practice have potential benefits and drawbacks (Aylett, 1990; Chase et al, 1990). Compared to the hospital systems, a GP CPS is essentially

Figure 4 An example of an prescribing screen for General Practice (VAMP computer system, UK)

CLEWS ANN MAY 57y Female Permanent 33 TOMKINSON AVENUE
THERAPY HISTORY Repeat till 11/12/91 days/script 30 3yr exam: Completed 05/05/91

	Date	Pharmaceutical name	Frm	Strngth	Dosage	Days	Qty	op	Rp	Is
69	02/04/91	INDOCID-R	CAP	75.00	1 NOCTE		30			SP
70	02/04/91	MODURETIC	TAB	0.00	2 MANE		60			SP
71	05/05/91	INDOCID-R	CAP	75.00	1 NOCTE		30			SP
72	05/05/91	NAPROSYN	TAB	250.00	1 QDS		150			SP
73	05/05/91	MODURETIC	TAB	0.00	2 MANE		60			SP
74	03/06/91	INDOCID-R	CAP	75.00	1 NOCTE		30			SP
75	03/06/91	NAPROSYN	TAB	250.00	1 QDS		150			SP
76	03/06/91	MODURETIC	TAB	0.00	2 MANE		60			SP
77	07/07/91	MODURETIC	TAB	0.00	2 MANE		60	6	1	SP
78	07/07/91	INDOCID-R	CAP	75.00	1 NOCTE		30	6	1	SP
79	07/07/91	NAPROSYN	TAB	250.00	1 QDS		150	6	1	SP
80	09/08/91	INDOCID-R	CAP	75.00	1 NOCTE	30	30			SP
81	09/08/91	NAPROSYN	TAB	250.00	1 QDS	30	150			SP
82	09/08/91	MODURETIC	TAB	0.00	2 MANE	30	60			SP

Allergic to: NO SIGNIFICANT PROBLEMS KNOWN

Date	Pharmaceutical name	Frm	Strngth	Dosage	Days	Qty	op	Rp	Is P/N/+
02/09/91									

CLEWS ANN MAY 57y Female Permanent 33 TOMKINSON AVENUE
THERAPY HISTORY Repeat till 11/12/91 days/script 30 3yr exam: Completed 05/05/91

	Date	Pharmaceutical name	Frm	Strngth	Dosage	Days	Qty	op	Rp	Is
1	31/10/91	MODURETIC	TAB	0.00	2 MANE		60		6	4 SP
2	31/10/91	INDOCID-R	CAP	75.00	1 NOCTE		30		6	4 SP
3	31/10/91	NAPROSYN	TAB	250.00	1 QDS		150		6	4 SP

SELECT LINE ALL except

No of days per script (30) No of prescriptions required (1)

simpler. It usually involves only a relatively small number of drugs prescribed and less complex regimes at any one time. There is a stable user base so training is less of a problem. Prescriptions are printed out for doctors to sign, obviating legal problems.

Concerns had been expressed about disruptions which computerised prescribing may bring in the consultation process and its effect on doctor and patient relationships (Evans et al, 1984). A postal survey by Pringle et al (1984) sent to 350 patients from two rural practices showed that 17% of patients were opposed to doctors using computers and 31% of patients feared that confidentiality of information would be reduced. However, the questionnaires in this study were distributed to patients before introduction of terminals in the practices, thus the results only reflected the patients' anticipated concerns regarding computer systems.

In a postal survey conducted in a GP surgery in the Netherlands, patients' views of their relationship with their doctor before and after installation of a computer in the consulting room were assessed (Rethans et al, 1988). More than 96% of the patients (n=263) stated that contact with their doctor was as easy and as personal as before. Most stated that the computer did not influence the duration of the consultation. However, 30% stated that they thought that their privacy was reduced. The

authors concluded that patients had little difficulty in accepting the presence of a computer in the consultation room and that personal computers did not make doctors seem less personal.

The usefulness of a computerised prescribing system as a tool to issue repeat prescriptions has been described (Lockley, 1990; Donald, 1990). CPS had eliminated transcribing errors by secretaries who usually wrote out repeat prescriptions and it helped to identify patients who asked for their drugs too frequently or not often enough. Lockley (1990) felt that by using a computer to issue routine repeat prescriptions, doctors could concentrate on non-routine items. This would help to reduce fatigue and ensure that items which needed attention were identified.

In a prescribing system used by Donald (1986), drugs were accessed by a simple five character code. The time taken to produce a prescription was found to be around 30 seconds from start to finish. Ten seconds were spent keying the information required and the rest of the time could be spent talking to the patient or amplifying advice while the script was being printed. Time was also saved because it was not necessary to refer to drug information for tablet strength or quantities, and there were no telephone queries from pharmacies to interrupt the consultation. The author also felt that the computerised

prescribing systems had improved safety, saved time, decreased prescribing costs, and provided an instant audit of all important prescribing parameters. In addition, treatment was rationalised, legibility had vastly improved, reducing queries from pharmacists about prescriptions. In another study by Donald (1989), it was found that prescribing costs were reduced when a computer was used to issue all prescriptions in conjunction with a personal computerised formulary.

The use of computers and computerised prescribing system in general practice have generally been accepted as an useful tool (Difford, 1990; Goves et al, 1991). This probably is due to encouragement and incentives from the Government as well as the relatively simple prescribing process in general practice. Patients usually receive only a small number of drugs with few changes in therapy between each visit; the route of administration is usually oral so there is little need to consider complicated intravenous regimes. Since GPs are responsible for the management of their own practices and formularies, benefits are more tangible to them than would be in a hospital environment. The nature and process of out-patient prescribing is quite similar to that in general practice, so if computerised prescribing systems are to be introduced in OP departments, experiences may be drawn from general practice.

CHAPTER 2 PHARMACY COMPUTER SYSTEMS IN THE USA

In the previous chapter it was demonstrated that if technically and financially feasible, CPS seems to be a logical approach to meet the changing information needs in the NHS. This chapter reviews several systems studied during a visit to the USA.

2.1 Background to visits

CPS has been available in the USA for about twenty years. However its use is neither widespread nor well documented. At the Royal Hampshire County Hospital, UK, one of the resource management sites, a computerised prescribing system from the USA had been introduced. During the implementation, it was found that many modifications were needed to make the system suitable for use in the UK.

By looking at the current prescribing, dispensing and drug administration process in the UK, core features for a computerised prescribing system were derived by the author (figure 5). Requirements were then drawn up according to features in this proposed computerised prescribing system for the Hammersmith & Queen Charlotte's Special Health Authority (SHA) (Willson et al, 1990, table 1).

Table 1 Pharmacy Resource Management System Requirements

1. **Facility for prescribing**
   - present relevant patient information
   - provide drug administration orders for nurses
   - easy to use and secure

2. **Locally agreed treatment protocols available at point of prescribing**
   eg. symptom and reason for admission, cost information and comparison

3. **Facilitate prescribing review**
   - current review and retrospective information for clinical audit

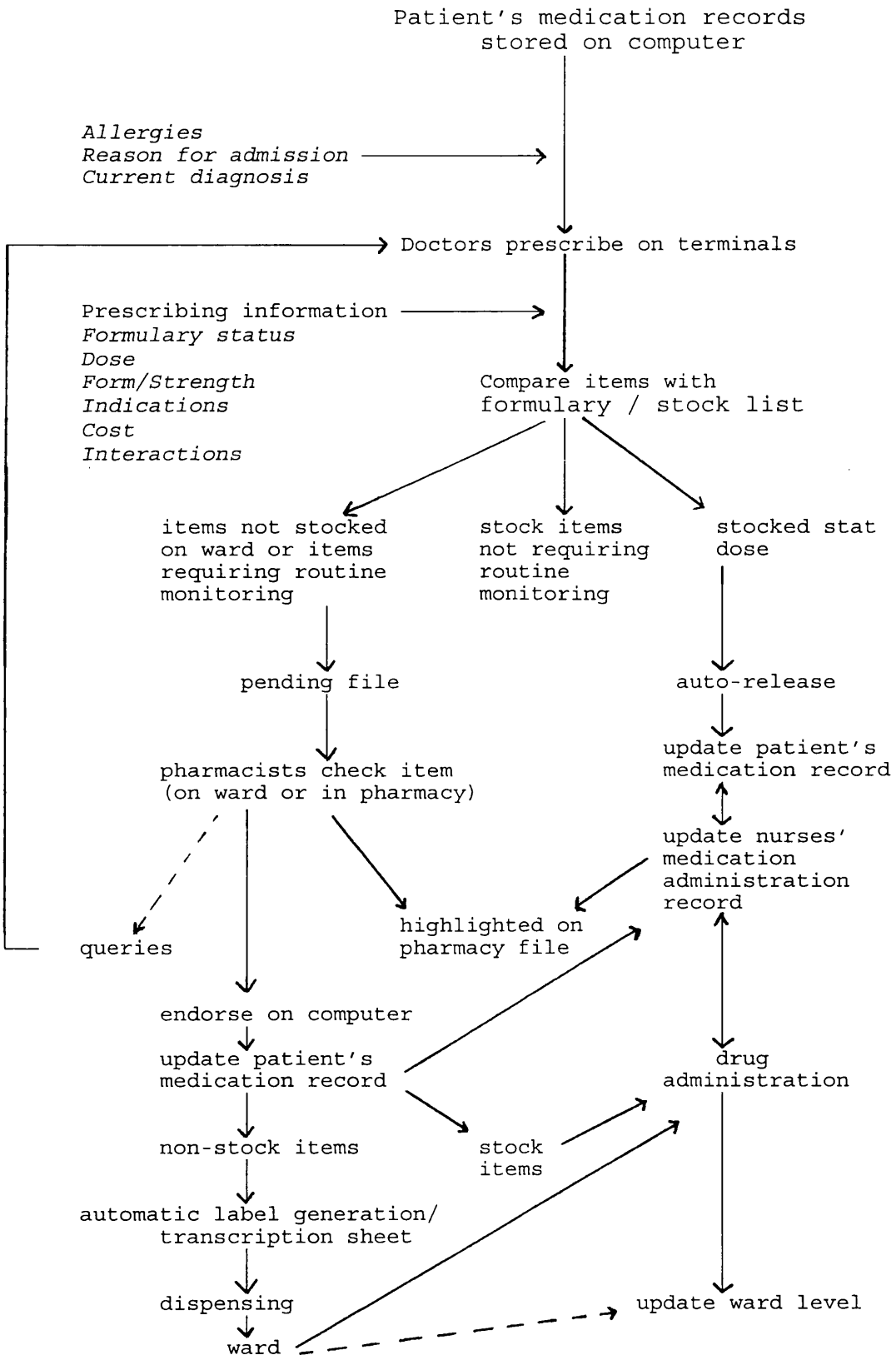
4. **Incorporation of prescription information into discharge summaries**

5. **Direct and rapid transfer of prescription information to pharmacy**

6. **Resource Management**
   - allocation of cost to diagnosis and directorates
   - separation of finance information so that responsibility follows ability to control

7. **Costing/billing for private patients**

Figure 5 Proposed core features of a computerised prescribing system



During March 1990 the author had the opportunity to visit the USA to look at how drug cost could be captured at individual patient level and to investigate if the requirements drawn up for the SHA were achievable. The following hospitals in the North Eastern coast of America were chosen based on literature and recommendation: Rochester Methodist Hospital in Minnesota (RMH), University of Chicago Medical Centre in Chicago (UCMC), New England Medical Centre in Boston (NEMC), and New York University Medical Centre in New York (NYUMC). The characteristics of the four hospitals are shown in table 2.

The aims of the US visit were to compare the proposed requirements against the various pharmacy systems to examine their feasibility and to investigate any potential problems which might arise in or deter the development of CPS.

2.2 Observations

There are some fundamental operational differences between pharmacy departments in the USA and the UK. The following were observed at the four US hospitals visited:

. Pharmacy departments were open 24 hours a day, 7 days a week.

Table 2 The four US hospitals visited

Hospital	Number of beds	Computer System
Rochester Methodist Hospital, Minnesota (RMH)	800	in-house development pharmacy based
University of Chicago Medical Centre, Chicago (UCMC)	600	Megasource (commercially available) pharmacy based
New England Medical Centre, Boston (NEMC)	400	Digimedics (commercially available) pharmacy based
New York University Medical Centre, New York (NYUMC)	800	Technicon (commercially available) Computerised prescribing system

- Unit dose drug distribution system (UDD) were used in all four hospitals.
- Extensive intravenous reconstitution services were present.
- The absence of a medication chart collectively used by doctors, pharmacists and nurses. Nurses were responsible for copying out each patient's medications every seven days onto a chart -- medication administration record (MAR), for recording drug administration.
- Patients' medication profiles were generated as a by-product of order entry.
- Out-patient departments were usually separate from the in-patient pharmacy, operated like a retail pharmacy and were independent of the in-patient computer system.

The following gives a description of some of the observations made during the visit. Findings are described under headings corresponding to the ideal pharmacy system requirements shown in table 1.

2.2.1 Prescribing

Of the four hospitals visited, NYUMC was the only one that operated computerised prescribing. The pharmacy system at NYUMC formed part of an integrated hospital information system. The same system (Technicon) had been installed at two UK resource management sites, the Royal

Hampshire County Hospital and the Arrowe Park Hospital. In this system doctors used lightpens and keyboards to prescribe. Dosages and administration instructions were chosen from menus on-screen or were free-typed into fixed fields. Laboratory results were also available on-screen and could be called up by function keys. Medication administration records were printed on wards hourly to prompt nurses for doses due and drugs administered were recorded on computer.

At the other three hospitals, doctors prescribed manually on duplicate or triplicate order sheets. Prescription information details were then entered into the computer by pharmacists and/or pharmacy technicians at a satellite or a central pharmacy. Although these computer systems were pharmacy based, many features present were comparable to those in a physician prescribing system. Drug name, dose, form, frequency and route of administration were entered using keyboard and codes.

In all four hospitals, patient medication profiles were generated as a by-product of prescribing or order entry. These served as records of prescribing and also for costing. A password, with or without user name, was necessary to get into the system. The passwords would identify the authority level and identity of user and appropriately limit the menus available.

2.2.2 Treatment protocols

At NYUMC, reason for admission, diagnosis and allergies were entered by prescribers. Doctors could use a special order pathway to prescribe regularly used drug combinations. Prescribers' passwords also controlled their access to investigational drugs.

At RMH, UCMC and NEMC, reason for admission, diagnosis and allergies were entered by pharmacists. There were special screens for ordering regularly used drug combinations. Information about chemotherapy and clinical trials, and cost information linked to drugs on patient medication profiles were also available on-screen. However, because pharmacy staff were responsible for keying in the prescription details, the potential benefits of providing timely prescribing information for prescribers were not realised.

2.2.3 Prescribing review

Patients' medication profiles were summarised on-screen at all four hospitals. Patient demographic information was either manually input into the pharmacy system (RMH) or captured via a link with the patient administration system (NYUMC,UCMC,NEMC).

Capture of cost data is the priority in the majority of pharmacy systems in the USA but most are unable to

collate prescribing information and are not designed for clinical audit. At UCMC pharmacists were asked to feed in extra information such as microbiological culture and antimicrobial sensitivities and laboratory results to help validate the use of drugs.

2.2.4 Discharge summary

Discharge medication is not routinely given to in-patients in the USA. At NEMC the use of discharge summaries automatically generated by computers had been attempted. This was discontinued due to opposition by some physicians, claiming that this would invalidate a valuable learning process for the junior doctors. Thus the feasibility of this option will depend very much on the consensus of the physicians involved.

2.2.5 Transfer of prescription information to pharmacy

At NYUMC prescription details were transmitted electronically to pharmacy as soon as doctors had finished prescribing on terminals on wards. Labels were produced in the pharmacy which were then checked by the ward pharmacists. Since there was no filing or sorting facility present in the computer to group labels together, a clerk was employed to sort the labels according to wards. At the time of the author's visit, because the clerk was absent, pharmacists had to sort the labels into appropriate wards.

At the other three hospitals, frequent visits were made by pharmacy staff to various nursing units to collect written prescription orders. The orders were brought back to central or satellite pharmacies to be processed. Upon order entry, labels or picking lists were printed in the appropriate sections of the central pharmacy.

When a patient was transferred between wards, the original profile would be stopped and a new one generated. The original drug supply was retrieved and fresh stock provided for the new destination. Bearing in mind that unit dose dispensing was used and a maximum of 24 hours' supply of doses was involved in these hospitals, this method would need to be modified if it were to be adapted in the UK where multiple dose dispensing and partial stock systems are commonly used.

2.2.6 Resource management and private patient costing

As a result of the healthcare structure in the USA, most patients are covered by medical insurance which is responsible for paying for their drug treatment in hospitals. Thus there is a need to capture all drug treatment costs at individual patient level. Cost might be captured during dispensing and credited when doses were returned from wards (RMH, UCMC, NEMC) or captured upon drug administration (NYUMC). Patients were identified by account numbers which might be linked to

the types of insurance cover stored in the Patient Administration System (PAS).

Billing was efficient and accurate in all centres. Service fees and markup structures could be incorporated into bills. Patients were billed on the day of discharge or on the following day. For RM, this data might be related to Diagnosis Related Groups (DRGs) and drug cost could be analysed as one aspect of total patient cost. However, the data collected by the US systems may be both too detailed for RM and yet inappropriate for clinical audit in the UK: a system that could store and collate prescribing information would be needed.

2.3 Discussion

Among the hospitals visited, NYUMC which used the Technicon system, was the only one that had the facilities for computerised prescribing. Since Technicon is a total integrated system, at NYUMC, training of staff and maintenance was performed by the Hospital Information System department. The author's impression was that pharmacy probably had little ownership of the system. The Director of Pharmacy agreed that though he was quite happy about the system generally, it could not produce much useful management information for pharmacy.

At NEMC, there had been an attempt to develop a CPS; but due to the inadequacies of computer technology at that

time and a lack of co-operation from doctors, the development had been abandoned. Instead, a dedicated pharmacy system had been developed in which pharmacists and technicians were responsible for entering the prescription details manually in order to capture drug cost.

The use of patient profiles and unit dose dispensing can accurately capture drug cost at patient level but is very labour intensive and time consuming, especially if pharmacists have to constantly update the profiles. The three hospitals which did not have computerised prescribing claimed that they would be going towards computerised prescribing in the future. However, they also cautioned that the success of such a system depended very much on the working relationships between pharmacists, doctors and nurses. The attitude of doctors towards the use of computers is also important, as shown by the failed attempt at NEMC to introduce CPS and computerised discharge summaries because of physicians' claim that this would invalidate a valuable learning process for the junior doctors.

Technicon seemed to be the most well known and established computerised prescribing system in the USA. However, although Technicon and other computerised prescribing systems have been available in the USA for more than ten years, sites which had adopted CPS were

relatively few (Ellinoy and Gilroy, 1990). The cost of the system and the support required in training and maintenance might be contributing factors, but the reluctance of doctors to use computer terminals to prescribe probably played a more important part. As a result of such reluctance, nurses, ward clerks or pharmacists had to enter prescription orders onto the computers instead (Aydin, 1989, Schroeder and Pierpaoli, 1986) or else written prescriptions were still sent to pharmacy (Serpa et al, 1990). Concerns about the time needed for order entry, voiced by doctors who had not used a computerised prescribing system before, were also reported by Larson and Blake (1988).

2.4 Conclusion

Although CPS has been available in the USA for a long time, the number of hospitals that have implemented it is small. Pharmacy departments are usually responsible for entering prescription details into pharmacy based systems themselves in order to capture drug cost. Many of these systems have incorporated features which are similar to and suitable for use in CPS. The visit to the four hospitals in the USA has shown that though no one system fully fitted the proposed 'ideal' CPS, most of the requirements could be individually met. This confirmed the feasibility of the requirements and the proposed CPS. However, though technically feasible, the success of a CPS will depend very much on the willingness of doctors

to prescribe on computer terminals. Their concerns about CPS must be addressed and any potential benefits to them as prescribers must be demonstrated to motivate them, obtain their cooperation and thus ensure smooth operation of the system.

CHAPTER 3 DOCTORS' ATTITUDES TO COMPUTERISED PRESCRIBING SYSTEMS

3.1 Introduction

There have been major advances in computing science in the last few decades. However, the lack of use of computers in medical care is well documented in the literature (Young, 1984; Anderson et al, 1986). Various reasons have been suggested as contributing to the non-acceptance of computer systems (Young, 1981): computer systems may be inflexible, they may threaten the standing of doctors, the use of such systems may be time-consuming and may increase work-load, the physical interface between patient/computer or physician/computer is unfamiliar, and patient care may not be significantly improved by the use of computers. Although the role of computers and their abilities have developed since the start of the 1980s it is not clear that things are improving.

Computerised prescribing systems (CPS) have been around in the USA for almost 20 years. However, the number of hospitals which use such a system is still small. This may be due to the lack of consultation with doctors regarding CPS, doctors' own reluctance in participating in the project or their fear of use of computers. The

observations in the USA (Chapter 2) showed that doctors' co-operation and their willingness to use computers to prescribe is essential for the success of computerised prescribing. Many studies have investigated doctors' attitudes towards the use of computers; however, none have focused on doctors' attitudes to CPS. In order to find out how doctors in the UK feel about CPS and the potential barriers which may hinder its implementation, interviews were conducted at two London hospitals to explore doctors' attitudes towards CPS.

3.2 Aims and objectives of study

The aim of the study was to assess doctors' attitudes towards computerised prescribing systems and possible factors determining these attitudes.

Objectives:

1. to investigate doctors' perceptions of computerised prescribing systems;
2. to investigate the perceived potential advantages and problems of computerised prescribing systems;
3. to find out what information would be required on-screen for computerised prescribing and what would be a suitable user interface;
4. to investigate if any relationships exist between doctors' attitudes to computerised prescribing and characteristics of the doctors, such as previous

computer training, usage, and year of registration, etc.

3.3 Study Design

Face to face interviews were conducted at a postgraduate teaching hospital (Hammersmith hospital (HH), London) and a district general hospital (West Middlesex University hospital (WMUH), London). A structured interview schedule was used for the interviews (Appendix 1). At the end of the interview, a list of issues which might arise in CPS was shown to the doctors and they were asked to rate the importance of these issues (Appendix 2). The interview schedule design was based on a literature search, observations made during the author's USA visits and by talking to staff in hospitals in the UK which were developing CPS. The interview schedule was piloted on one consultant and two junior doctors at each site with the interviews being tape recorded. After revision the full study was conducted. The final interviews were taped, the answers transcribed, coded and analysed.

3.3.1 Subjects

Two groups of doctors were studied: doctors who were responsible for most of the in-patient prescribing and consultants who were involved in policy making. Prior to the study, surveys were conducted at the two hospitals to find out the grades of doctors who did most of the prescribing on wards. Ward pharmacists were asked to

Table 3 Results showing the relative proportion of in-patient prescribing by different grades of doctors

Hospital	no. of wards surveyed	no. of drug charts surveyed	Total no. of items surveyed	no. of items prescribed (%)						
				consultants	senior registrar	registrar	senior house officers	house officers	dietician	information not available
HH	17	83	798	0.1	10.3	16.2	71.4	0	0.3	1.8
WMUH	13	62	337	1.5	8.9	20.2	26.7	41.8	0	0.9

record the grades of doctors and the number of items prescribed on the first five drug charts they came across during any one ward visit within one week. The results are shown in table 3. SHOs and HOs were found to be responsible for prescribing about 70% of all items in the two hospitals during the study. Using this as a guideline, 10 senior house officers at HH (10 in 50 sample) and 4 SHO and 6 house officers at WMUH (10 in 58 sample) were recruited for the study. Ten consultants were also recruited at HH (10 in 207 sample) and at WMUH (10 in 43 sample) for the study.

All doctors practising at the two hospitals were included in the group from which the sample was selected apart from the followings:

- locum doctors;
- doctors who had only an academic or research interest;
- doctors in specialties which involved little or no prescribing eg. diagnostic radiology, chemical pathology, histopathology, virology and bacteriology.

Subjects were randomly chosen within the two strata, using random number tables, and were sent a letter inviting them to take part. The letter also gave the following brief description of computerised prescribing systems: "In computerised prescribing, doctors would prescribe on computer terminals which would probably be

placed on each ward and out-patient departments in the hospital. The prescribing information would be passed on electronically to the pharmacy department. A drug chart would be printed out on the ward and kept by the patient's bed." Interviews were then arranged; each interview lasted approximately half an hour.

3.3.2 Analysis of Results

A coding frame was derived from the interview results. The computer statistics package SPSS/PC+ was used for the analysis of results.

3.4 Results

In total, 39 doctors were interviewed (20 consultants, 14 SHO, 5 HO); one HO at WMUH dropped out at the last minute. The specialties of the doctors interviewed are listed in table 4. There was no significant difference in the year of qualification or in past computer training between doctors at the two hospitals (using Chi-square test, $P>0.05$).

Of the 39 doctors interviewed, 16 prescribed mainly or solely at out-patient clinics, 17 on wards and the rest (6) in theatres and on wards, or in the Accident and Emergency department. Eighteen (46%) doctors said they did most of their prescribing at patients' bedsides, 7 (18%) in doctors' or nurses' offices, 6 (15%) at both sites in roughly equal proportions and the rest (8) were

Table 4 Specialties of doctors interviewed

Specialty	Consultants	SHOs and HOs
Accident & Emergency	1	3
Anaesthetics	2	1
Cardiology	2	-
Clinical Pharmacology	1	-
Dermatology	1	-
Gastroenterology / Haematology	2	2
Geriatric Medicine	1	3
Obstetrics & Gynaecology	1	1
Orthopaedics	2	-
Paediatrics	2	3
Renal Medicine	1	1
Respiratory	2	1
Surgery	2	4
Total	20	19

consultants who only prescribed at out-patient clinics.

3.4.1 Computing experience

The majority of doctors (36/39) had had experience of computers in some form. Of those who had computing experience, 27 had used a hospital information system (HIS). A hospital information system was in use at HH but not at WMUH. Out of the 19 doctors who were currently using HIS, only one was from WMUH (this doctor had a joint post at another London hospital and used the HIS there). The frequencies of using HIS varied from daily (10/19), or weekly (4/19), to rare users who usually delegate the task to secretaries (5/19).

About a quarter (10) of the interviewees had come across or heard about computerised prescribing systems before the study (4 about CPS used in hospitals and 6 about CPS used in general practice); one doctor had used a hospital CPS before and one had used a programme for ordering total parenteral nutrition.

3.4.2 Expectations and concerns

The most common responses given by the doctors when asked about possible benefits and problems in CPS are shown in tables 5 and 6. Only one doctor could not see any advantage in CPS and two doctors did not cite any disadvantages.

Table 5 Potential advantages of CPS

Advantages	no. of times mentioned (%)
Improved legibility	17 (44)
Better record keeping	13 (33)
Speed of transfer of information to pharmacy	11 (28)
Pharmacy benefits	11 (28)
Time or labour savings	10 (26)
Decreased prescribing errors	9 (23)
Decreased waiting time for drugs (for patients or nurses)	9 (23)
Dosage information and dose check	9 (23)
Instantaneous feedback of errors or drug interactions	9 (23)
No need to find chart or no lost chart	6 (15)
Safer for patients	6 (15)

number of doctors studied = 39

Table 6 Potential disadvantages of CPS

Disadvantages	No. of times mentioned (%)
Computer breakdown	18 (46)
Might take time to prescribe	13 (33)
Might take time to walk to terminals to prescribe /might have to leave patients	10 (26)
No. of terminals available	10 (26)
Ward rounds	10 (26)
Print-out might not be up to date; a lot of paper work	9 (23)
Response time of computer; computer slow at peak hours	8 (21)
Easier to write	6 (15)

number of doctors studied = 39

When asked about the usefulness of CPS in audit, 28 doctors felt that it would be useful while 9 felt that it would not be useful or there would be no difference. Seventeen thought that CPS would be useful or very useful for setting prescribing guidelines, 8 thought that it might be useful while 11 felt that this was not useful to their own specialty, not useful at all or there would be no difference.

3.4.3 Would there be any legal implications in CPS?

The most common replies in response to this question were about system or password security, and the issue of signature (15/39 in both cases). Three doctors felt that CPS would lead to better records and reduced prescribing errors and hence would be beneficial from the medico-legal point of view.

Training in the use of CPS was not seen as a problem by 41% (16) of the doctors. Six doctors (15%) felt that the system should be easy to use or instructions could be given on-screen so that minimum training would be required, 41% (16) felt that training might present some problems.

3.4.4 Would CPS affect workload?

When asked if CPS might affect their workload, 17 (44%) doctors (6 consultants, 11 junior doctors) thought that their workload would be increased, 6 (15%) thought it would be decreased while 14 (36%) thought there would be

no difference; the rest (2, 5%) did not comment. When asked about ward rounds, 44% (17, including 14 junior doctors) thought that workload would be increased. 15 (39%) thought that CPS would make reviewing treatments easier, 12 (31%) thought there would be no difference and 6 (15%) thought it would be less convenient. When asked about using computers to prescribe discharge medication, only one doctor (3%) felt that his workload would be increased, 19 (49%) felt that it would be easier and 9 (23%) felt that there would be no difference.

3.4.5 What information should be available on screen to aid prescribing?

The ten most common responses are shown in table 7. When asked about the possible use of retrospective analysis of prescribing data, the most common suggestions were audit (23, 59%), monitoring of prescribing patterns and habits (21, 54%) and expenditure reporting (14, 36%).

3.4.6 Would CPS affect patients, doctor-patient relationship or relationship with other departments?

A large number of doctors (17, 44%) thought that there would be no difference for patients but 14 (36%) felt that CPS would be beneficial. The benefits mentioned included increased safety and reduced waiting time for medication. Regarding the possible effect of CPS on doctor — patient relationship, 32 (82%) did not feel

Table 7 Information suggested for display in CPS

Information required	no. of times mentioned (%)
Drug interactions	22 (56)
Recommended dose (eg. mg/kg, usual dose range)	18 (46)
BNF or mini BNF	16 (41)
Side effects of prescribed drug	13 (33)
Patient allergy or past history of drug reactions	10 (26)
Contra-indications or precautions	10 (26)
Availability in hospital	9 (23)
Cost	7 (18)
Current and previous drug history of patient	7 (18)
Indications of use of drugs	6 (15)

number of doctors studied = 39

there would be any difference; 5 doctors (13%) worried that they might be tied down by computers and thus spend less time with patients or they might miss the chance to explain about the medication to patients.

When asked if computerised prescribing might affect relationships between medical staff and other departments, 21 (54%) thought that there would be no difference, 4 (10%) thought that relationships between doctors and nurses might improve. Regarding the relationship with pharmacy, responses were about evenly divided; 13 (33%) felt there would be no difference, 13 (33%) thought that relationship might improve while 8 (21%) felt that the relationship with pharmacy might become impersonal.

3.4.7 Practical aspects of CPS

When asked about the most convenient place to put terminals on wards, 26 (67%) mentioned the nursing station and/or the doctor's office, despite most doctors having previously expressed concerns about the number of terminals available and the time taken to walk to computer terminals to prescribe. Only 11 (28%) mentioned the possibility of portable terminals or terminals at the end of each bed or throughout the ward. However, when asked about out-patient departments, for those who responded, 17/18 consultants and 11/12 of junior staff felt that there should be one in each consulting room.

Most doctors (31, 80%) felt that there would be no problem in using a computer keyboard to prescribe. When asked for alternatives to a keyboard for data entry, a mouse, codes, pull down menus or lightpens were mentioned. However, no doctors felt that any of these alternatives alone would be better than a keyboard.

In computerised prescribing, protocols, regimes and discharge letters can be generated automatically. When asked how they felt about this automatic generation of information, 24 (62%) felt that this would be useful or very useful. When asked if this automation might hinder junior doctors' learning process, 28 (72%) disagreed while 11 (28%) partly or totally agreed.

In response to the question as to whether a doctor's contract should state that he or she had to use computers to prescribe, 20 (51.3%) said they would not mind, and the rest felt that this should not be mandatory or felt unhappy about it.

When asked who should enter the prescriptions onto the computer terminals, all doctors responded that it should be their responsibility. Eight of them made additional suggestions that demographic details should be entered by ward clerks and one suggested that in some cases nurses or pharmacists might be able to prescribe certain items as part of their new extended roles.

3.4.8 Rating scale

Doctors were asked to rate the importance of some issues which might arise in CPS on a scale of 1 (of low importance) to 4 (of paramount importance). The results are summarised in table 8. The following issues were each rated as important by at least 75% of doctors (ie. with a score of 3 or 4): availability of computer terminals (98%), data lost due to system breakdown (91%), system breakdown (91%), response time of computer (87%), time required to prescribe on computers (85%), system security (82%) and improved legibility (77%). The following were rated as of lesser importance (score of 1 or 2): control of drug expenditure (46%), training (39%), patient confidentiality (33%) and medication reaching patients more quickly (32%).

3.5 Discussion

Nearly all doctors interviewed in this study had not used a CPS before and the results illustrate some of their expectations about such a system. Most recognised certain benefits of CPS such as improved legibility and better record keeping. However few of them perceived any personal benefits and pharmacy was seen as a major beneficiary. This perception might hinder the involvement of doctors in the design and implementation of CPS. The main worries of the doctors interviewed were about the practicalities of CPS: the time taken to prescribe on computer terminals, the reliability and accessibility of the

Table 8 Results of doctors' rating scale

Issues which might arise in CPS	no. of times mentioned (%)			
	1 (of low importance)	2	3	4 (of paramount importance)
Patient confidentiality	7 (18)	6 (15)	9 (23)	17 (44)
Response time of computer	2 (5)	3 (8)	14 (36)	20 (51)
Better audit information	2 (5)	9 (23)	22 (56)	6 (15)
System breakdown	0 (0)	4 (10)	8 (21)	27 (70)
Improved legibility	0 (0)	9 (23)	17 (44)	13 (33)
Time required to prescribe on computers	0 (0)	6 (15)	14 (36)	19 (49)
Training	3 (8)	12 (31)	15 (39)	9 (23)
System security	2 (5)	5 (13)	11 (28)	21 (54)
Data lost due to computer breakdown	0 (0)	3 (8)	14 (36)	22 (56)
Medication reaches patients more quickly	1 (3)	11 (29)	19 (50)	7 (18)
Availability of computer terminals	0 (0)	1 (3)	12 (31)	26 (67)
Control of drug expenditure	2 (5)	16 (41)	18 (46)	3 (8)

number of doctors studied = 39

(due to rounding errors total percentage may exceed 100)

system and the user-friendliness of screens. The majority of doctors, however, were not concerned about using a keyboard to prescribe. This differs from Young's suggestion that a man-machine interface might have inhibited the use of computers by doctors (1981).

Ward rounds seemed to be the one activity that has caused the most concern. It was mentioned as one of the major problems in CPS. Most junior doctors felt that their workload would increase because there would only be limited computer terminals available on wards and it might take substantially longer to prescribe by using a computer than by writing on a drug chart. However, when doctors were asked where the ideal place was to put the terminals on wards, only a few replied that there should be a number of terminals placed around the ward. This may have been because most doctors felt that the financial constraints in the NHS would not allow more than one or two terminals per ward. The problem of ward rounds might be overcome by using portable computers or small computers which could transmit information to a main computer placed on the ward; but solutions tailored to the need of individual firms might be required. To overcome the worry that the system would be inflexible and difficult to use, system designers should ensure that doctors participate in the design and implementation of a computerised prescribing system.

From the 1991 survey of general practices (Department of Health, 1991) it was estimated that a total of 63% (6130) of all general practices in England and Wales had their own computers or shared facilities with other practices. Of these practices 91% used computers for repeat prescribing and 48% for acute prescribing during consultation. However, the majority of doctors in this hospital based study had not heard about CPS and had given little thought to it. This probably was due to the lack of published reports and little overlap between hospital and general practice. Since CPS in the hospital is usually introduced by management and driven by resource management, doctors might not feel any ownership of such systems. These systems might also be inflexible and not suitable to the needs of doctors since physicians were not usually included in the system's planning, design and development. Moreover, management would be introducing the system in the hope of benefits such as audit information, rationalisation of drug use and better control of formulary, that have been documented in the literature (Donald , 1986; Larson and Blake, 1988; Schroeder and Pierpaoli, 1986; Kawahara and Jordan, 1989). However, in this study, few doctors had raised these benefits as major advantages in CPS.

Contrary to worries in general practice that the use of computers during consultation may affect doctor and

patient relationship (Evans et al, 1984), few doctors felt that CPS would have any effect at all in hospital settings. Security of the system was expressed as an important issue. Some doctors were concerned about who would be responsible if there was an error in the computer software leading to an error on the prescription. Clear guidelines on legal liability would thus be needed.

All doctors interviewed felt that doctors should be the person who entered prescription details into computer terminals. Some of them regarded prescribing as one of the main duties of doctors and were protective about this right. Some realised that if doctors did not prescribe on the terminals themselves, most of the potential benefits of CPS such as prescribing guidelines would have been lost. From the results of this study, there seemed to be little desire that, as in the USA, pharmacists or nurses would have to input prescription information on behalf of doctors.

The grades and computing experience of doctors did not seem to have any influence on their views on CPS. Issues and concerns raised by doctors at the two hospitals were similar. Most doctors in this study had a positive view of CPS and thought that it was a good idea. However they also felt that it was a remote possibility, especially at West Middlesex hospital where the hospital

information system was still to be implemented. A few consultants felt that CPS might not be cost-effective in the Out-Patient department since little prescribing was allowed due to the hospital policies. Most of them did not feel CPS would offer much benefit to them as prescribers and they would need more information about it.

Computerised prescribing can improve legibility, prescribing and patient care. It can act as a tool to aid prescribing, provide useful prescribing information for users and collect drug treatment information for research and audit. For CPS to be successful, doctors have to realise these benefits, play an active role in the design and implementation of CPS and demand a system which will meet their clinical need.

CHAPTER 4 STUDY ON TIME TAKEN TO PRODUCE COMPUTER LABELS FOR DISPENSING

4.1 Introduction

Production of labels forms part of a routine process for dispensing individual patient medications in hospital pharmacies in the UK. Information on a typical label consists of drug name, strength and quantity of drug, patient's name, date of dispensing, and for discharge and out-patients medication, dosage instruction and additional warnings. Information for preparing a label may come from an in-patient prescription chart, a transcription sheet written by a ward pharmacist or from an out-patient prescription. Most UK hospital pharmacy departments have installed pharmacy computer systems in which drug names, dosage instructions and additional warnings are stored and can be called up by codes to enable the rapid production of labels. In most integrated pharmacy systems the prescription data, once entered, is also used for stock control and drug costing to specified users. These specified users are usually identified by codes, known as cost centres, which are entered into the computer as part of the labelling process.

In the study on doctors' attitudes towards computerised prescribing systems (CPS) reported in Chapter 3, one of the main concerns expressed by the doctors was the time

that it might take them to prescribe on a computer terminal. Since the labelling process requires similar information to that needed for a prescribing system (table 9), the time to produce labels should be proportional to the amount of prescribing time required for a text-input, rather than a menu driven, prescribing system. A study of labelling time would thus give an indicator of this time and factors which might affect it.

In addition, since all the information required to produce labels is derived from prescribing details, if a computerised prescribing system and a pharmacy system were linked, prescribing information might be processed to produce a label for dispensing with little further intervention. Once the information held in the computer had been checked by a pharmacist, a label could be produced by the touch of a single key in the dispensary. In theory the labelling time currently required for the dispensing process would be almost eliminated.

There have been no documented studies of how much time is spent on the labelling process or to what extent the speed of label production is affected by factors such as experience and grade of operators and interruption of the labelling process. This study aimed to quantify the time taken to produce medicine labels for dispensing in hospital dispensaries and to use this information to predict the prescribing time with a CPS.

Table 9 Information required for prescribing and for labelling

	Information required for prescribing	Information required for labelling
Name of patient	✓	✓
Location of patient / Cost centre	location if in-patient	cost centres
Age	✓	
Weight	✓	
Date	✓	✓
Drug Name	✓	✓
Drug form	✓	✓
Drug strength	✓	✓
Dose	✓	✓
Frequency	✓	✓
Other instructions	✓	✓
Duration of treatment / Quantity	Duration of treatment	Total quantity dispensed
Signature	✓	(✓) password may be required in some systems

4.2 Methods

The study was conducted at the pharmacy departments in four London teaching hospitals: Hammersmith Hospital(HH), Charing Cross Hospital (CX), St. Mary's Hospital (SM) and University College Hospital (UCH). These hospitals were chosen because they were all busy teaching hospitals which had installed integrated pharmacy computer systems for labelling, stock control and ordering. The pharmacy computer systems used at each hospital are summarised below.

HOSPITAL	COMPUTER SYSTEM
Hammersmith Hospital (HH)	HORIS
Charing Cross Hospital (CX)	JAC
St. Mary's Hospital (SM)	HORIS
University College Hospital (UCH)	North East Thames Regional System (NET)

HH and SM used the same system and allowed between-sites comparison of the same system. At SM two versions of the HORIS system were used. The new version SM(new HORIS) runs on a personal computer and was used in one of the OP clinics. Two of the systems (HORIS and JAC) were commercially available and one (NET) was developed in-

house by the North East Thames Regional Health Authority. Labelling and dispensing procedures were similar at all sites except that at HH and CX, receptionists were present to take in out-patient prescriptions. At CX, the receptionist routinely added cost centre codes to the prescriptions.

Eight randomly selected 30 minute observation periods at a single terminal (4 at in-patient terminals and 4 at out-patient terminals) were conducted each day for 5 days (Monday to Friday) during normal dispensary opening hours at each hospital. Each working day was divided into seventeen 30 minutes sessions and a random number table was used to select the observation periods and terminals.

Staff at all grades operating the dispensary computer to produce labels during the observation periods were studied. They were informed of the nature and the purpose of the study before observation commenced. Each operator's length of experience in using the departmental computer, his or her grade and the amount of time spent in the dispensary per week were recorded.

Labelling time was measured by direct observation, recording the time from the operator first hitting a key on the keyboard to hitting a key which resulted in the printing of a label. All dispensing computer activities which resulted in label production were measured. However

reprinting of labels already held on the computer without any editing or amendment, such as repeating the previous label by pressing the print key, was excluded. Any computer activities which did not result in label production, such as the labelling process being abandoned halfway or stock enquiries were also excluded from the study.

Labels were categorised as in-patient (IP), out-patient (OP) or discharge medicine to take out (TTO). In-patient prescriptions could be from patient charts or transcription sheets. All three computer systems studied could retain the name of the patient previously entered into the computer, thus if labels were produced for the same patient consecutively, it would not be necessary to re-enter the patient's name. Whether a patient's name was typed into the computer and any interruptions during the labelling process were noted. An interruption was defined as any activity which would distract an operator from the keyboard operation of the labelling process. Interruptions were divided into two categories and time recording was handled differently. For interruptions which were considered as part of the labelling activities, such as looking for a cost centre to enter into the computer, annotating a drug chart or transcription sheet, or calculating the quantity of drugs to be dispensed, time recording was continuous. For all other interruptions unrelated to production of the label

in hand, such as phone-calls, conversations, queries or clinical checking using reference books, time recording would be suspended for as long as the operator had to leave the labelling process, and recommenced when the operator hit any key on the keyboard to resume labelling. However, if the labelling process was not suspended despite the interruption, time recording would be continuous until a label was produced.

In a separate study the number of keystrokes required to produce four standard labels using the three systems was also measured. Prescription details of four items (figure 6) were shown to an operator who was then asked to produce labels for these items in the order presented. For each label the number of times when the keyboard was hit was recorded; keystrokes due to typing errors and corrections were excluded.

4.2.1 Statistical Methods

The time taken to complete a label was analysed using analysis of variance (ANOVA). The factors used were hospital/system (UCH(NET), CX(JAC), HH(HORIS), SM(HORIS), SM(new HORIS)), experience (<=1 month, 1 month - 3 months, 3 months to 1 year, > 1 year), type of label (IP, OP, TTO), interruption (yes, no), entry of patient's name (yes, no). Since each operator worked at only one hospital and had only one level of experience and all operators would be involved with all of the other three

Figure 6 Standard prescriptions used for assessing number of keystrokes required for labelling

Prescription 1:

Name: Joe Blogg Department: A&E

a. 20 Paracetamol tablets 500mg

ii QDS PRN. Max: 8 in 24 hours.

b. 28 Flucloxacillin capsules 250mg

i QDS for 7 days

Complete the course, before food.

Prescription 2:

Name: Sacred Ngo Department: TTO

a. 24 Prednisolone ec 5mg tablets

30mg od for 2 days,

20mg od for 2 days,

10mg od for 2 days,

stop.

Swallow whole.

b. 100ml Simple Linctus

10ml QDS PRN.

Shake the bottle

factors, the first two factors were regarded as between-subjects factors, and the remaining three as within-subjects factors.

The GLIM package (GLIM, 1986) was used for the analysis, and the residuals were checked for Normality using the Shapiro Wilk W test (Royston, 1982), and for equal variances in the groups cross-classified by the five factors using the Schweder test (Schweder, 1981).

4.3 Results

In total the time to produce 2,167 labels was measured and 59 operators were observed:

34 pharmacists

17 technicians

4 pre-registration pharmacists

4 student technicians

There were 637 (29.4%) in-patient, 953 (44.0%) out-patient and 577 (26.6%) TTO labels. Out of all the labels measured, 770 (35.5%) were interrupted, the patient's name was typed on 1274 labels (58.8%). 2020 (93.2%) labels were produced by staff who spent at least half of their working week in the dispensary, 1315 (60.7%) labels were produced by staff with more than 1 year experience and 174 (8.0%) by those with less than 1 month experience.

The Shapiro Wilk W test and the Schweder test indicated that the time data needed to be log transformed to normalize it for the ANOVA - the data were so skewed that not using log data would have seriously compromised the results. Consequently the means and confidence intervals have been back-transformed into seconds for presentation. When differences between pairs of groups are assessed, the log transform means that the comparisons are in terms of ratios of geometric means (or percentage changes) instead of differences between arithmetic means. Therefore the differences and confidence intervals for these comparisons are presented as a percentage change for one group compared to the other, which is then converted to a change in the number of seconds.

The ANOVA of the time taken to complete a label is summarised in table 10. It can be seen that labelling time significantly differed between the hospitals/systems, between the types of prescription, and was significantly affected by operator experience, interruption and typing of a name: $P<0.0001$ in all five cases. There were also significant interactions between hospital/system and type of label ($P=0.0001$), and between interruption and name ($P=0.0032$), indicating that the effect of an interruption was different if a name was being entered from when a name was not being entered. No interactions beyond 3-way were considered since they would involve few labels done by only one or two

Table 10 Analysis of variance results

	df	F	P
Hospital/System	4, 43	25.75	<0.0001
Experience	3, 43	20.65	<0.0001
Interruption	1, 49	279.9	<0.0001
Type	2, 54	29.72	<0.0001
Name	1, 49	403.7	<0.0001
H x E	8, 43	1.28	0.28
H x I	4, 49	2.46	0.057
H x T	6, 54	6.15	0.0001
H x N	4, 49	1.63	0.18
E x I	3, 49	1.04	0.38
E x T	5, 54	1.37	0.25
E x N	3, 49	0.80	0.50
I x T	2, 38	1.35	0.27
I x N	1, 38	9.89	0.0032
T x N	2, 33	0.02	0.98
H x E x I	8, 49	1.01	0.44
H x E x T	10, 54	0.75	0.68
H x E x N	8, 49	0.71	0.68
H x I x T	6, 38	0.68	0.67
H x I x N	4, 38	1.98	0.12
H x T x N	6, 33	1.44	0.23
E x I x T	5, 38	0.23	0.94
E x I x N	3, 38	0.18	0.91
E x T x N	4, 33	0.24	0.92
I x T x N	2,1826	1.83	0.16

Notes : H = Hospital/System
E = Experience
I = Interruption
T = Type
N = Name

operators and would therefore be likely to be misleading.

The mean times taken (with 95% confidence intervals) for each hospital/system, level of experience, type of prescription, with and without typing a name, and with and without interruption are shown in table 11, figures 7, 8 and 9 and are examined in detail below.

4.3.1 Effect of experience

Experience of operators was categorised according to their total experience with the computer system in use in their hospital. Table 12 shows the numbers of labels produced by staff of various experience using the different computer systems. Operators with less than one month's experience were only found at HH and SM (HORIS). There was an overall trend that labelling time decreased with increasing experience (figures 8 and 10, and table 11; $P<0.0001$ test for linear trend); the largest fall occurring after between three to twelve months' experience.

4.3.2 Effect of interruptions

Interruptions significantly increased labelling time by an average of 12.7 seconds (figure 9 and table 11). The relationships between name and interruption is illustrated in figure 11 and table 13. Without typing a name the percentage increase for an interruption is, on

Table 11 Mean labelling time, analysed by hospital/system, experience, types of labels, interruptions and names

Hospital	System	No. of labels	Mean time (sec)	95% CI
UCH	NET	395	39.3	34.7 to 44.5
CX	JAC	720	33.4	30.4 to 36.6
HH	HORIS	553	29.3	26.4 to 32.6
SM	HORIS	366	21.8	19.1 to 24.8
SM	new HORIS	133	16.6	13.4 to 20.6
Experience				
Less than 1 month		174	40.6	33.7 to 49.4
1 month to 3 months		262	37.6	32.3 to 43.8
3 months to 1 year		416	33.8	29.9 to 38.2
Greater than 1 year		1315	26.0	24.3 to 27.9
Interruption				
Interrupted		770	38.4	37.2 to 39.7
Not Interrupted		1397	25.7	25.1 to 26.3
Type of Label				
OP		953	31.9	30.7 to 33.1
TTO		577	30.4	29.0 to 31.8
IP		637	26.1	25.0 to 27.3
Typing of Name				
Name		1274	35.0	34.3 to 35.8
No Name		893	23.4	22.8 to 24.1

Figure 7 Effects of hospital and system on labelling time with 95% confidence intervals

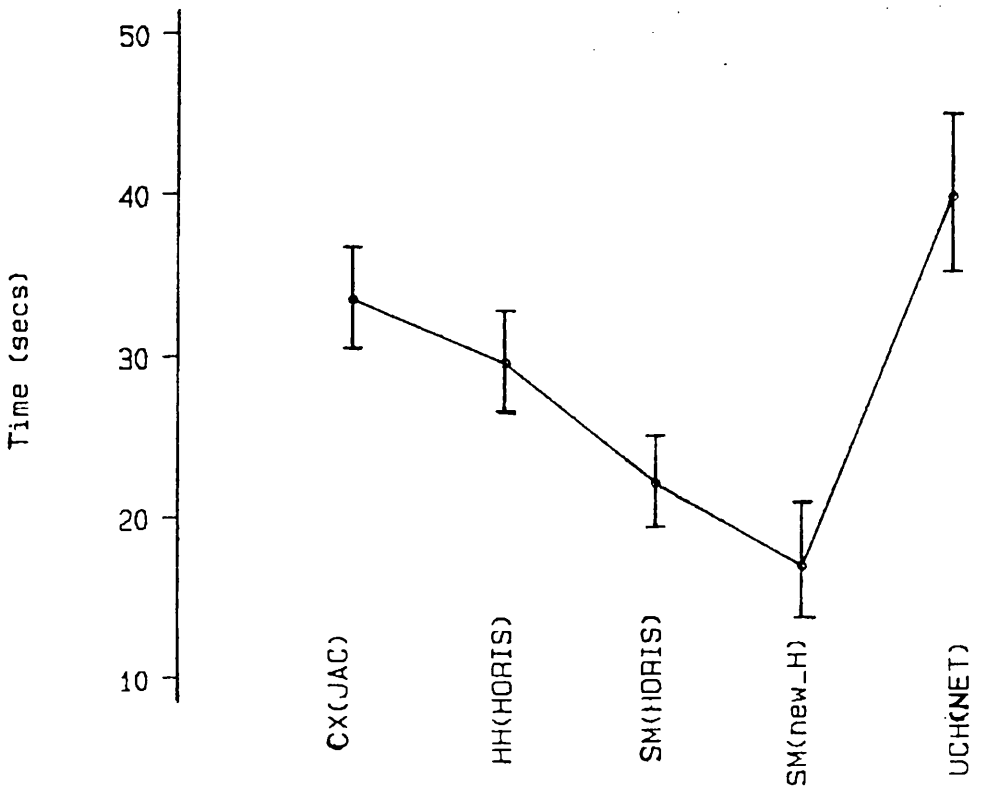


Figure 8 Effects of experience on labelling time with 95% confidence intervals

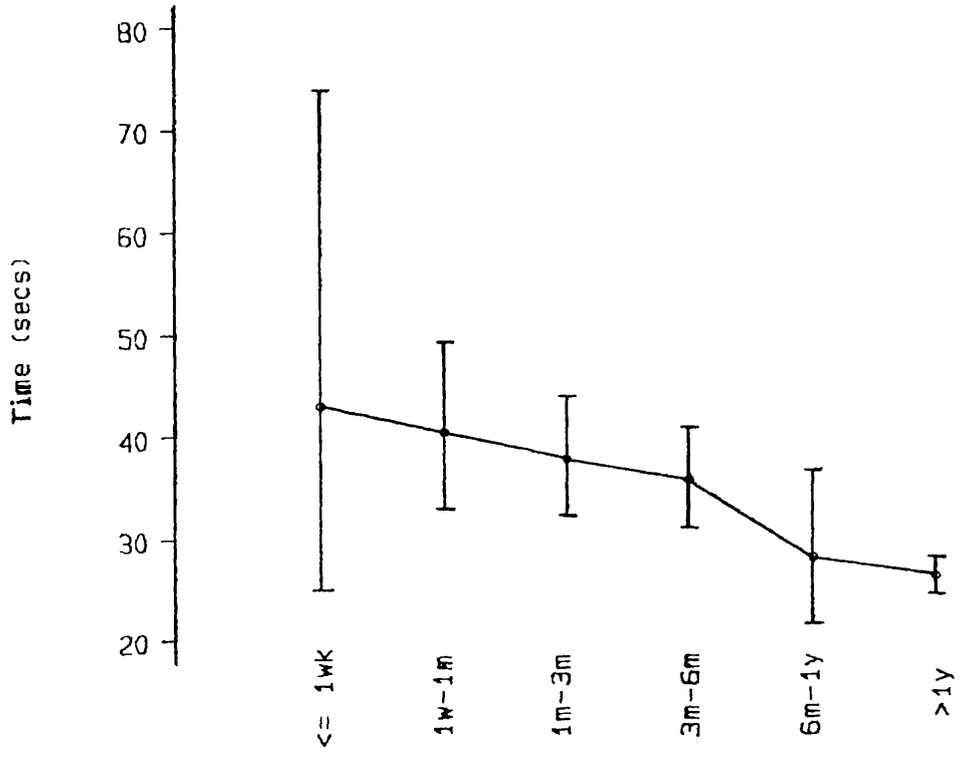


Figure 9 Effects of interruptions, type of prescriptions and typing of names on labelling time with 95% confidence intervals

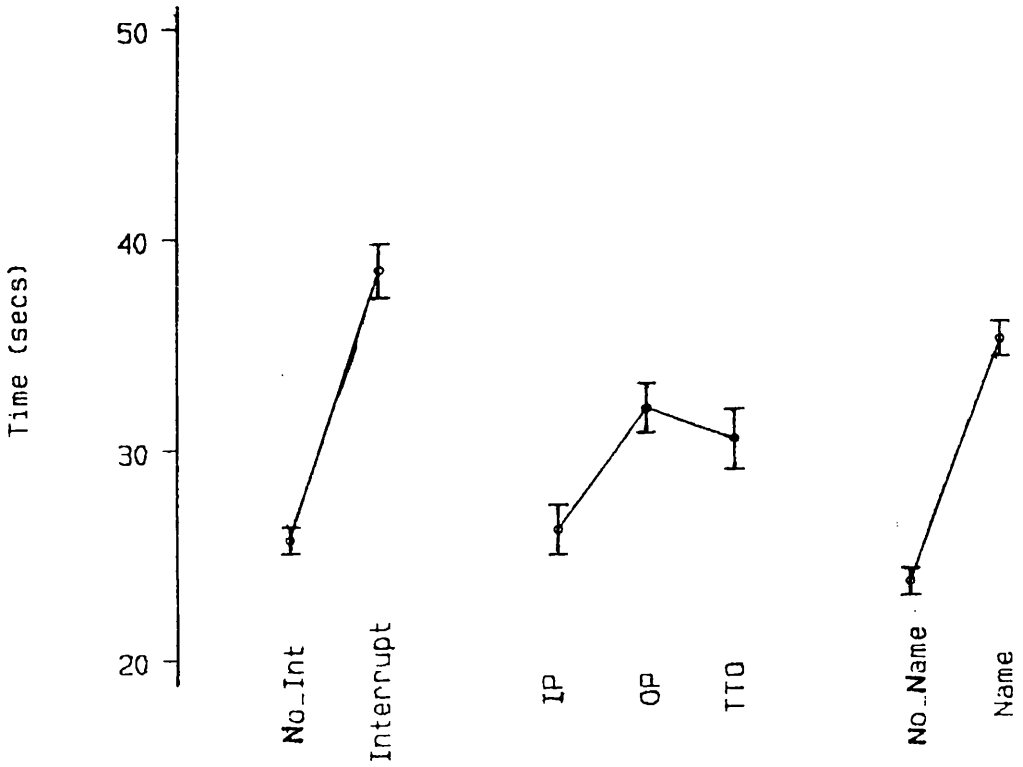


Table 12 Number of labels produced by staff of different experiences at different sites

Hospital/ System / Experience	CX (JAC)	HH HORIS	SM HORIS	SM NEW HORIS	UCH NET	TOTAL
<= 1month	0	83	91	0	0	174
1-3 months	52	138	43	0	29	262
3-12 months	243	85	7	18	63	416
>1 year	425	247	225	115	303	1315

Figure 10 Effects of experience and interruptions on labelling time with 95% confidence intervals

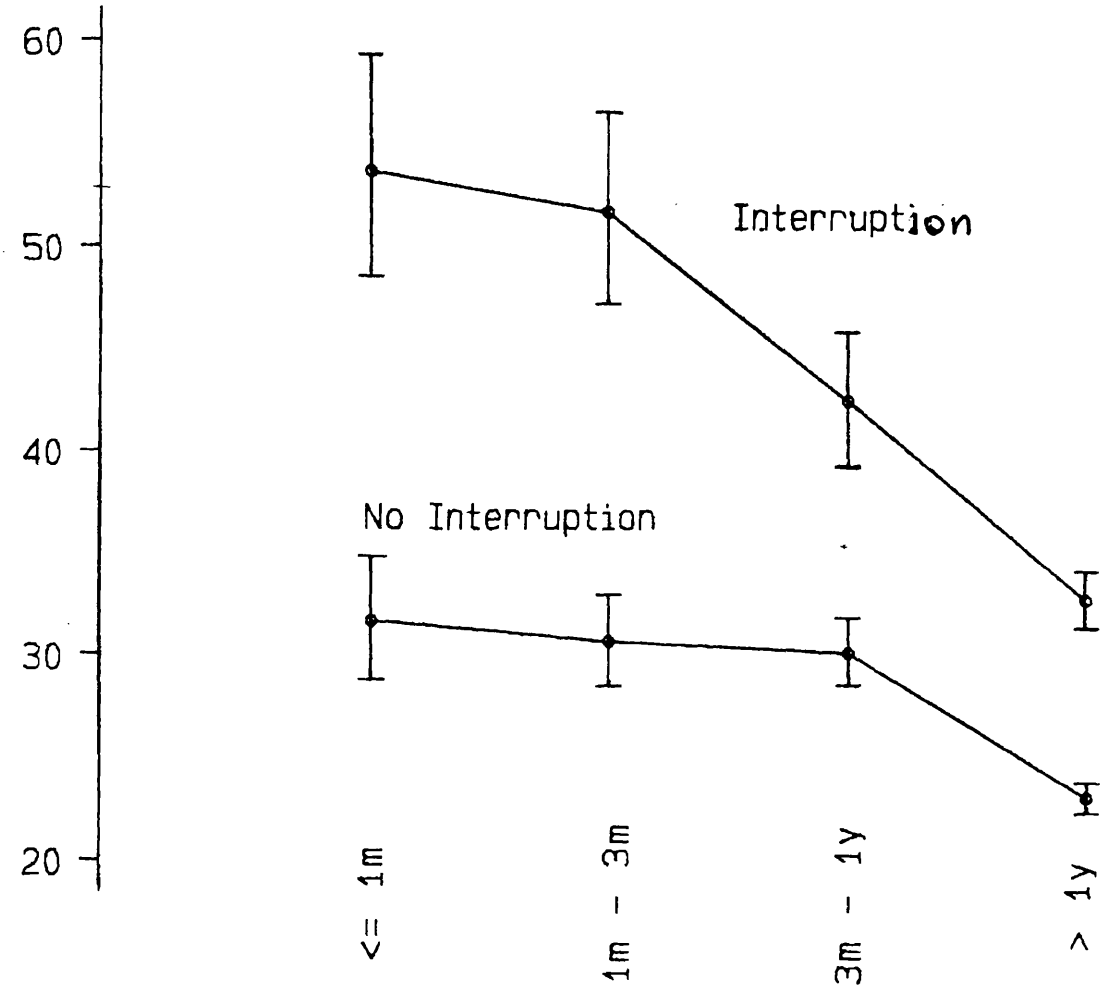


Figure 11 Relationships between typing of names, interruptions and labelling time with 95% confidence intervals

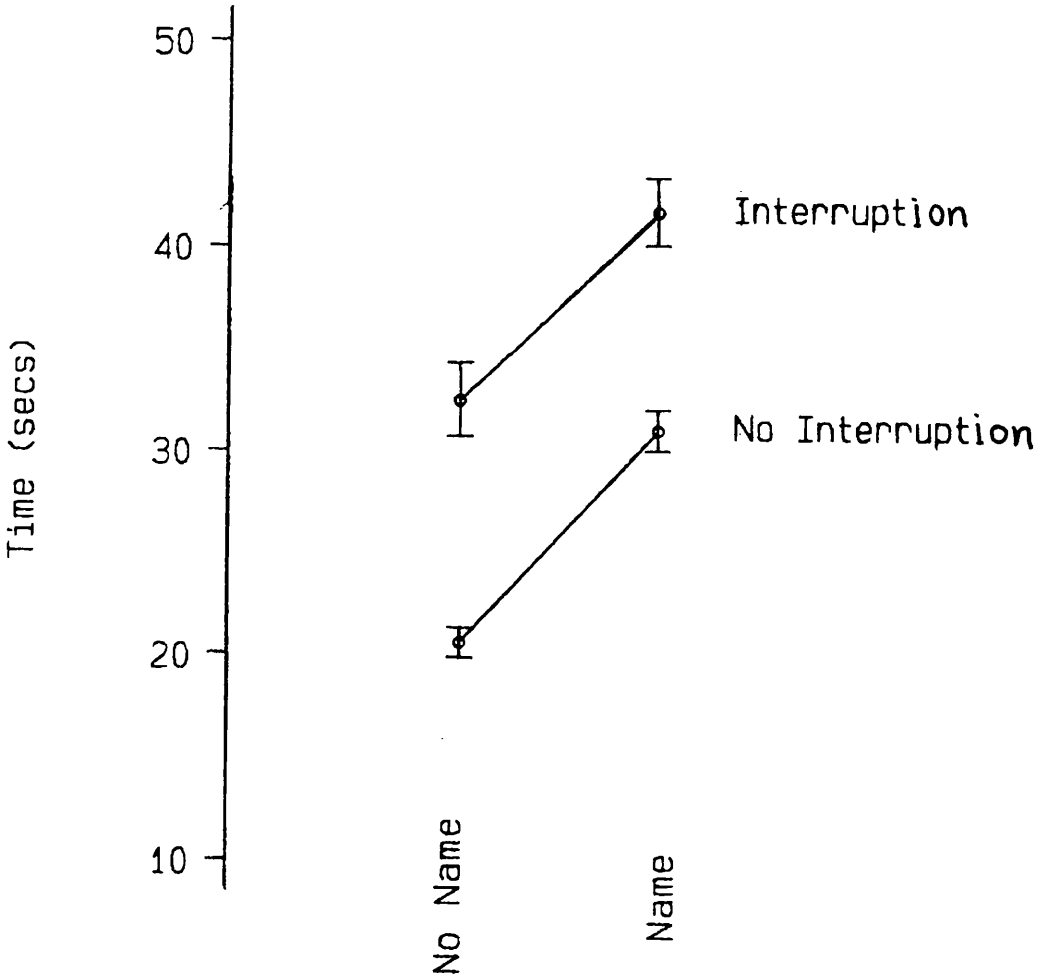


Table 13 Effect of interruptions on labelling time

Name	Interruption	No. of labels	Time [sec] (95% CI)	Increase due to Interruption	
				Percentage (95% CI)	Time [sec] (95% CI)
No	No	641	20.6 (19.9,21.4)		
	Yes	252	32.5 (30.7, 34.4)	58 (48, 69)	11.9 (9.8, 14.1)
Yes	No	756	31.0 (30.0, 32.0)		
	Yes	518	41.7 (40.1, 43.4)	35 (28, 42)	10.7 (8.6, 12.9)

average, 58%, but with a name it is 35%. This is a significant interaction from the transformed ANOVA. However, when the percentages are expressed as absolute time increases (in seconds), the values are very similar (11.9 and 10.7 seconds). This indicates that in terms of actual time there is no practical difference i.e. on average an interruption added about eleven or twelve seconds to the labelling time whether or not a name was typed. There was also a significant trend towards fewer interruptions for the more experienced staff (Chi-square test for trend: P=0.0015), from 47.1% for those with <1 month experience to 34.1% for those with >1 year (table 14). Moreover, when interrupted, inexperienced staff also took more time to complete the labelling process. The interaction was not significant in percentage terms (P=0.38 for interaction between experience and interruption from ANOVA), but when expressed as seconds it varied from 32.8 seconds for staff with >1 year experience to 53.7 seconds for those with <1 month experience (table 15 and figure 10).

4.3.3 Differences between hospitals/systems

There were significant variations in mean labelling time among the hospitals studied (figure 7, table 11). This is partly due to differences between sites and partly due to differences in systems. SM(HORIS) and HH had identical computer systems but despite SM having a higher proportion of interruptions (159/366 = 43.4% vs 202/553 =

Table 14 Interruptions analysed by level of operator experience

Experience	Number with interruption	Number without interruption	Total	Percentage interrupted
<= 1 month	82	92	174	47.1
1- 3 months	102	160	262	38.9
3-12 months	138	278	416	33.2
> 1 year	448	867	1315	34.1
Total	770	1397	2167	35.5

Chi squared test for trend

Overall Chi squared = 13.77 df = 3 P = 0.0032
Trend Chi squared = 10.03 df = 1 P = 0.0015
Departure from trend Chi squared = 3.75 df = 2 P = 0.1535

Table 15 Labelling time - analysis by experience and interruptions

Experience	Interruptions	No. of Labels	Mean Time (sec) (95% CI)	Increase due to Interruption	
				Percent (95% CI)	Time (sec) (95% CI)
<= 1 month	No	92	31.7 (28.8, 34.8)		
	Yes	82	53.7 (48.6, 59.4)	69 (48, 95)	22.0 (15.1, 30.0)
1- 3 months	No	160	30.7 (28.6, 33.0)		
	Yes	102	51.7 (47.3, 56.6)	69 (50, 89)	21.0 (15.4, 27.3)
3-12 months	No	278	30.2 (28.6, 31.9)		
	Yes	138	42.5 (39.4, 45.9)	41 (28, 55)	12.3 (8.5, 16.6)
>1 year	No	867	23.1 (22.4, 23.9)		
	Yes	448	32.8 (31.4, 34.2)	41 (34, 49)	9.7 (8.0, 11.4)

36.5%; P=0.042), it was quicker in producing all types of prescriptions (table 16, figure 12).

Table 16 and figure 12 also show the interaction between hospital/system and type of prescription. It can be seen that the time taken varies very little between the three types of prescription at UCH, and there is little difference between OP and TTO at CX, with IP being a few seconds quicker. However at HH and SM there is no real difference between the time taken to produce IP and TTO labels, while the OP labels take quite a lot longer. Logically, one would expect that labelling time for OP and TTO to be similar. Inexperienced staff (<1 month experience) were only present at HH and SM (HORIS). They produced a large proportion of the OP labels at these two hospitals: 79/179 (44.1%) at HH; and 91/191 (47.6%) at SM (HORIS). Since labelling time was related to experience, the presence of these inexperienced staff at these two sites could account for the relatively longer OP labelling time. Most of the labels produced by the inexperienced operators (170 of 174) were for OP, thus the comparison of IP and TTO between SM, HH and the other hospitals are unaffected.

4.3.4 Number of keystrokes to produce standard labels

The number of keystrokes to produce labels for the four standard prescriptions are summarised in table 17. The

Table 16 Labelling time - analysis by type of prescription by hospital/system

Hospital/ System	Type of prescription	No. of labels	Mean time	
			(sec)	95% CI
UCH(NET)	IP	96	37.7	33.5 to 42.3
	OP	172	38.0	34.9 to 41.5
	TTO	127	42.5	38.4 to 47.0
CX(JAC)	IP	273	28.8	26.9 to 30.8
	OP	278	37.8	35.3 to 40.5
	TTO	169	34.6	31.7 to 37.8
HH(HORIS)	IP	172	25.0	22.9 to 27.2
	OP	179	37.5	34.4 to 40.8
	TTO	202	27.0	25.0 to 29.3
SM(HORIS)	IP	96	14.8	13.2 to 16.6
	OP	191	28.7	26.4 to 31.1
	TTO	79	18.0	15.8 to 20.4
SM(new HORIS)	IP	-	-	-
	OP	133	16.6	15.0 to 18.3
	TTO	-	-	-

Key: CI Confidence intervals
IP In-patient
OP Out-patient
TTO Discharge medication to take out

Figure 12 Relationships of hospital/system, type of prescriptions and labelling time with 95% confidence intervals

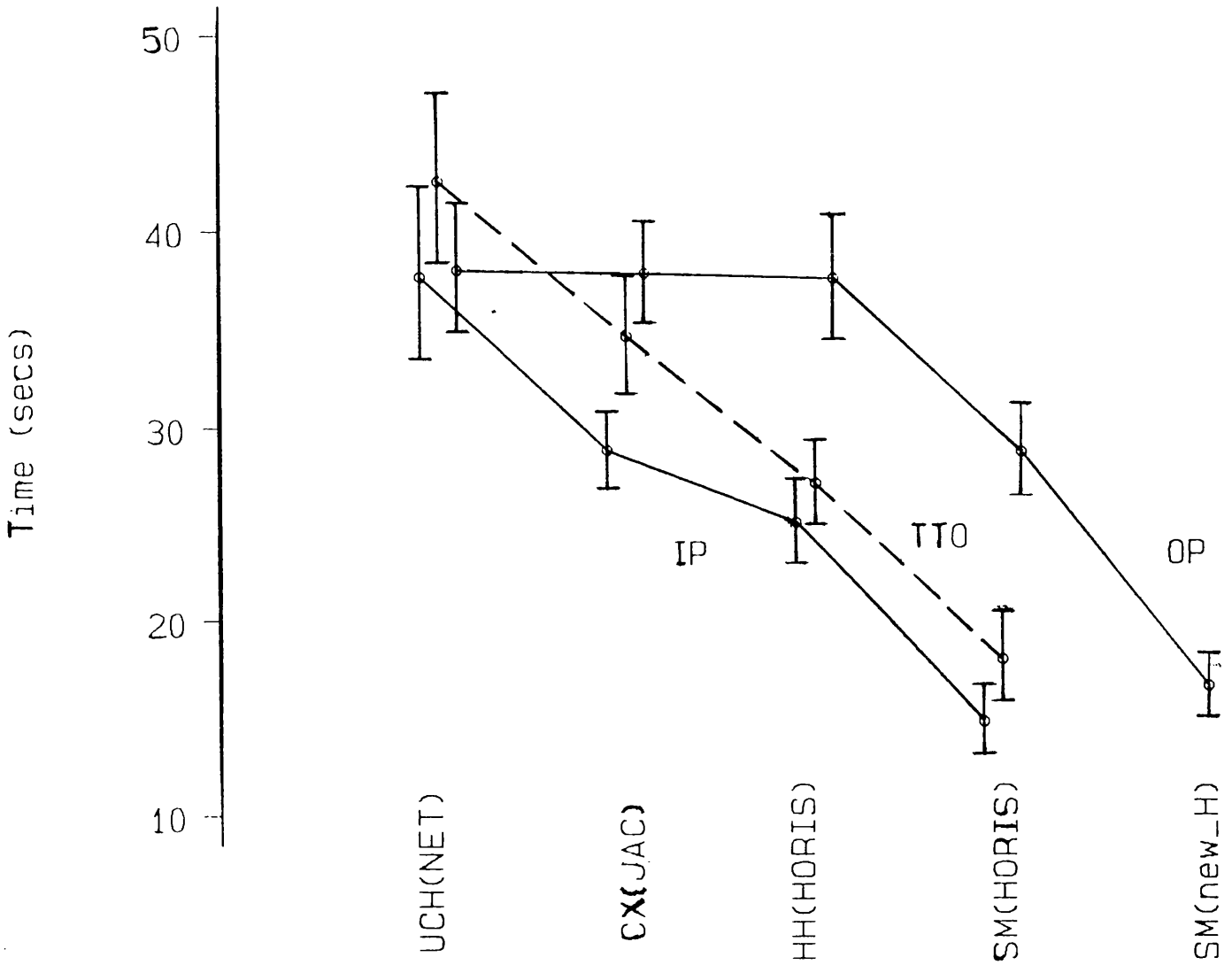


Table 17 Number of keystrokes required to produce four standard labels

Prescription details (see figure 6)	Number of keystrokes		
	HORIS	JAC	NET
1a.	37	45	52
1b.	24	34	37
Total for label 1	*61*	*79*	*89*
2a.	68	75	124
2b.	24	30	32
Total for label 2	*92*	*105*	*156*

HORIS system required the least number of keystrokes for each of the four labels while NET required the most. This was consistent with the results from the labelling time in which, on average, the HORIS system was the quickest while the NET system was the slowest. One reason for the greater number for NET was the need for the operator to enter a password in order to print a label.

4.3.5 Total time spent and annual cost

Annual dispensary workload figures were obtained from each hospital (from May 90 to April 91) and the time spent on label production was calculated. The mean labelling time was multiplied by the annual number of labels to give an estimated number of hours per year, and assuming a 37 hour week for a full time pharmacy technician, the number of person-days per year. Technicians' hours of working were used to calculate the number of person-days since technicians were responsible for producing most of the labels in this study.

The cost of labelling was also predicted. The estimated labelling time was multiplied by the salaries of the staff in the different grades (assuming they produced the same proportions of labels as in this study) to give a cost per label and a cost per year (table 18).

Table 18 Estimated time and cost of labelling per year

Sites	SM(new HORIS)	SM (HORIS)	HH	CX	UCH
mean labelling time (sec)	16.6	21.8	29.3	33.4	39.3
annual workload (no. of labels)	46112	99301	101297	174590	99185
estimated hours spent per year	213	601	825	1619	1083
no. of *person-days/year	28.8	81.2	111.5	218.8	146.4
staff cost per label (pence)**	5.05	6.09	7.28	8.00	9.72
staff cost per year(£)	2329	6044	7370	13974	9642
staff cost per 100,000 labels (£)	5050	6090	7280	8000	9720
no. of *person-days spent per 100,000 labels	62.3	81.9	110.0	125.4	147.6

* estimated as 7.4 working hours per day, excluding holidays

** based on Whitley salary scale 1990-1991

4.4 Discussion

This study has attempted to quantify prescription labelling time in hospital pharmacies and to investigate factors affecting it. It shows that there is a marked difference between hospitals and between systems and confirms the general belief that increased experience results in faster labelling. Experience also appears to influence the frequency of interruptions and the ability to handle interruptions, which subsequently affects the overall labelling time.

4.4.1 Sites with same system

At SM two versions of the HORIS system were used. The new version runs on a personal computer and was used in one of the OP clinics. This clinic received prescriptions only from AIDS patients and patients with sexually transmitted disease. Names on prescriptions were replaced by a number as means of identification. The clinic was manned by relatively experienced staff, and the OP labelling time using the new HORIS system was found to be quicker than that of the old HORIS. The staff perceived the new HORIS to be quick and efficient and preferred this to the old version. This implies that response rate of a computer system directly affects an operator's perception and thus acceptance of that system. This would be an important factor in computerised prescribing, the success of which would depend very much on acceptance of the computer system by medical staff.

For identical systems (HORIS at HH and SM) different labelling times were obtained at the two hospitals. This variation was probably due to differences in the mix of staff experience, extent of training and typing skills of the operators and possibly in the way the dispensary was managed. Touch typists were present at SM whereas at HH, most of the staff did not know how to type.

4.4.2 Sites with different system

There was significant variation in labelling time among the hospitals studied. Overall UCH took longest to produce labels and SM (both old and new HORIS) was the quickest. A number of factors contributed to the time at UCH. The NET system required more keystrokes than the other two systems to produce labels. A password was required to produce each label, which would account for 2 to 3 seconds of the labelling time measured. The computer system was slow to compile information entered on screen; it took approximately 4 seconds. Some of the operators waited while others left the screen temporarily to attend to other business, thus resulting in either increased labelling time or an increased interruption rate.

It is difficult to isolate all the factors affecting labelling time and study them individually since many of them are interrelated. A larger study would be needed to achieve this. Variables such as interruptions and patient names may be eliminated by studying only labels with no

interruptions and no entry of names. The categories can be further sub-divided according to hospital and system, types of prescriptions and experiences. However, for this study, the resultant number of labels in each group became very small and the effect of individual operators became dominant.

Another way to eliminate the effect of experience, entry of name and hospital variation is to use identical prescriptions and present them to operators of similar experience at various sites. However this method is 'artificial' and the result might be affected by the degree of nervousness of the operator. In this study the Hawthorn effect, that operators might have behaved differently because they were under observation, should be minimal because the study periods were randomised, the study was performed over a relatively long period and the operator was driven by the amount of work present.

Since labelling time was affected by many variables simultaneously, it was not possible to isolate and quantify the effect of computer systems. However, comparison between HH and SM (HORIS) had shown the effect of hospital differences, and variation between CX and the two HORIS sites (HH or SM) would be partly due to hospital and partly due to system differences. The vast differences in labelling time between UCH and CX, between UCH and SM or HH suggested that NET was slower than JAC

or HORIS. The results from the study on number of keystrokes to produce standard labels also showed that the NET system required more keystrokes than the other two systems to produce labels. This was partly due to the extra step required for inputting passwords, and partly the screen design of the system and the absence of some labelling instruction codes. Thus when designing screens for labelling program or for CPS, attention should be paid to reduce the number of keystrokes required for inputting labelling or prescription details.

4.4.3 Effect of interruptions and experience

Interruptions were found to increase labelling time by eleven to twelve seconds on average. Inexperienced staff were found to take longer to complete an interrupted label than the more experienced staff, implying that they were less efficient in handling interruptions. Procedures that can minimise interruption should speed up the dispensing process. The causes of interruptions were not systematically investigated in this study, but it appeared to the investigator that for new staff, interruptions arose because of unfamiliarity with the dispensary procedures and the computer system used. Examples of interruptions included operators enquiring about non-formulary drugs and looking up cost codes and direction codes to input into the computer. Good training in these two areas, in ways of handling interruptions and

an increased awareness of where and how to look for relevant information such as cost centre and computer codes should reduce the occurrence of interruptions or the time in handling them. Manufacturers of computer systems and managers should also consider producing training packages. Prescriptions should be screened to sort out any problems before reaching the labelling process. Lists of cost centres should be readily available and easy to use. Cost centres might be clearly marked on out-patient prescriptions by a receptionist, or on charts by a ward pharmacist during ward visits.

When choosing a pharmacy computer system, consideration must be given to the system's labelling efficiency. Any time saved in the labelling process, even a few seconds per label, might have an important impact on the overall running of a busy dispensary. This study has quantified the labelling time in the hospitals studied. The result throws light on the hospitals' relative efficiency in the labelling process. This information may be used by managers to assess and improve the dispensary procedure in their departments. The results may be used as a baseline measurement to monitor the effect of implementing a new dispensary procedure, such as the use of new cost centres, or changing to a different pharmacy computer system. The information could also be incorporated into an operational requirement of a

labelling system and be used as a guideline for choosing and comparing pharmacy computer systems.

4.4.4 Implications for computerised prescribing system

In a study by Ogura et al to find out the time taken to prescribe on a CPS in 1985, the mean time to prescribe a new item was estimated as 102 seconds. This was much longer than the mean labelling time found in this study, which varied from 17 to 39 seconds depending on systems. This large difference might be explained by several factors. In the study by Ogura, time estimation was obtained from the time registered on the computer from when an operator started to prescribe till an exit was made from this function. There was no way to record any interruptions during which the prescribers might have suspended the prescribing process; thus the times measured might have been an overestimation. Complicated regimes, such as intravenous infusions, which took longer to prescribe might have been included. There have also been many advances in computer technology since 1985 and faster and more powerful computers are available nowadays resulting in quicker response times.

The labelling time found in this study might act as an indicator of the prescribing time required using a computer terminal. In a CPS however, there would be no

need to key in any cost centres since this information should be automatically linked to the patient. Input of password would probably be required for each item prescribed in order to identify the prescribers, as used in the NET system.

Experience of staff was found to be an important factor affecting labelling time. Speed seemed greatest after twelve months' experience. This would have an important training implication on CPS, especially for locums and junior doctors who usually rotate through each hospital at intervals of six months and are responsible for the bulk of prescribing. In a study by Tierney et al (1993) to assess the effects of using a network of microcomputer workstations to write all inpatients orders, it was found that during the 17-month study there were significant improvements in doctors' opinions about workstation speed (P=0.04) and ease of use (P=0.005). Thus for CPS to be successful it has to be user-friendly and easy to use so that as little training as possible would be required. Screens should be designed so that minimum keystrokes would be needed. Bodies responsible for developing different computerised prescribing systems should also meet and agree on common screen design format or a common basic specification so that when doctors move from one system to another, they would not need to have extensive training before they can use the system.

The annual time and cost of label production has been estimated for each hospital studied. With a computerised prescribing system, there would be no need for pharmacy staff to type in labelling information since all the details would have already been stored in the computer during prescribing. The guesswork of matching prescribers to cost centres would also be eliminated as costing information would be linked to individual patients directly and would be more accurate. In theory, most of the labelling time and cost estimated from this study could be saved. Such a linked computerised prescribing system was being developed in the UK at the Royal Hampshire hospital at the time of this study and the validity of this assumption would still need to be tested.

Label production is only one of the areas for which computerised prescribing has implications. Doctors, nurses and pharmacists involved in the prescribing, drug administration, drug monitoring and discharge process would also be affected. A computerised prescribing system should be designed such that the efficiency and safety of these activities are enhanced rather than compromised. The findings of this study should be interpreted in conjunction with other manpower studies to confirm if the theoretical time and cost saved can be realised or they have been transferred to other areas of the computerised prescribing process.

CHAPTER 5 DISCUSSION

Computerised prescribing in hospitals is a very new concept in the UK. It was first introduced by the government through the Resource Management initiatives as an attempt to control the increasing expenditure in the health services. The drive behind Resource Management was to capture and provide cost information. A computerised prescribing system (CPS) was seen as one method to capture cost of drug treatment to individual patient levels. Although CPS can offer many clinical benefits, such as treatment protocols and timely drug information at the point of prescribing and information for audit and research, in Resource Management these features were seen as secondary to cost capture.

The introduction of CPS in hospital would have major implications on the current prescribing process and on the ways in which pharmacy is practised, in particular clinical pharmacy. There have been concerns and debates about the impact of CPS on the role of clinical pharmacists in the UK. Since prescription details would be transferred electronically from wards to pharmacy, there might be the danger that pharmacists would stay in pharmacy without going up to the wards to visit patients. This would be detrimental to the development of the profession and might potentially set hospital pharmacy back decades.

Apart from pharmacists, doctors and nurses will also be affected by the introduction of CPS. However, due to the great urgency of the government in implementing the Resource Management initiatives, there had been no evaluation on the impact of CPS on doctors, nurses and pharmacists before its introduction. A CPS (as part of the Hospital Information System) was brought in from the USA and was implemented in two the six Resource Management pilot sites.

CPS had been available in the USA for almost twenty years. However its use was not widespread. In order to understand the impact of computer systems and CPS on hospital pharmacy in the USA, the author visited four hospitals in the USA during 1990. The findings from the visits showed that doctors' participation and endorsement in the use of CPS would be essential for its success. In a lot of hospitals in the USA, due to the lack of support by doctors in CPS and the associated high cost, pharmacists have to enter prescription details on computer terminals to ensure that costs of drug treatment are captured (Department of Health, 1994). In a study by Dean (1993), it was found that the rate of medication errors in the USA was higher than that in the UK, one reason being due to incorrect computer entry by pharmacists. In CPS this should not be a problem if all prescriptions entered by doctors were screened by

pharmacists, as in the current practice in the UK with prescription charts.

For CPS to be successful, prescribers' co-operation and willingness to use the system are of paramount importance. In order to find out if the climate in the UK was suitable for the introduction of CPS, face to face interviews were conducted with 39 doctors at two London hospitals. The study on doctors' attitudes showed that most doctors at the two studied hospitals had not heard about CPS nor thought about its application. Unlike CPS used in general practice, there has been little published literature discussing the pros and cons of CPS in hospitals. Hence if a CPS were to be implemented in a hospital it would be difficult for most doctors to state clearly what features would be desirable and beneficial to them. More discussion and assessment of CPS in hospitals would be needed if the system is to meet the clinical needs of doctors. Most doctors seemed to welcome the idea of CPS but concerns had been expressed on issues such as legality, reliability of the computer and time required to enter prescriptions.

Since the time required to prescribe on computer terminals might be one of the major factors affecting doctors' acceptance of CPS, a study was designed to estimate this time. At the time of the study there was no fully implemented CPS available in the UK, so hospital

pharmacy systems were used as a model as similar data would need to be entered onto the screen with both systems. Thus the time required to produce medicine labels was studied at four London teaching hospitals.

The study on labelling time showed that experience, training and screen design might have direct effects on labelling time and hence prescribing time. In a study by Tierney et al (1993) at the Wishard Memorial hospital, USA, it was found that it took longer to prescribe on computers than to write a prescription. It was suggested that newer technologies such as voice recognition or portable pad computers and better understanding of the ordering process might help to reduce the time taken. The median number of inpatients was six per intern at the Wishard Memorial hospital; in the UK doctors are usually responsible for a much larger number of patients and so the impact of prescribing time using a CPS would be more significant. Since users' training and experience with a system may affect the prescribing time, as suggested in the labelling time study, adequate training must be given to doctors. This may be a problem for locums and for junior doctors who remain at any particular hospital for only a few months.

In the past five years, several hospitals in the UK have attempted to develop or implement a computerised prescribing system. However so far, apart from the

Technicon system implemented at the Royal Hampshire County hospital and the Arrowe Park hospital, all other projects in CPS have either failed or are still in the development stage (Department of Health, 1994). At the United Bath hospital, UK, an attempt was made to implement the Technicon system in 1993. On-line prescribing was one the first modules to be implemented. Since doctors were not used to using the computer as part of daily life and were unaware of the possible benefits from a hospital information system, such as ordering and viewing laboratory tests on-screen, they were sceptical about the prescribing system. Training was also a major problem. It was planned that all junior doctors should be released from ward duties for one week for training. However this was said to be unrealistic and thus doctors were never adequately trained. The CPS was rejected by junior doctors as being unsafe two months after implementation and before the whole hospital was computerised.

At the Royal Marsden hospital, the complexity of a CPS and the need for staff training and support had been underestimated. The system was developed in-house and there was inadequate computing support. There had been problems in gaining support from nursing staff right from the beginning of the project. Nurses were employed to train doctors and this might have been seen by medical

staff as inappropriate. The project lasted about five years.

At Guys hospital, one of the resource management pilot sites, the development of CPS had stopped because the US company which wrote the software had ceased to trade in the UK and funding for further development had run out. The system had been piloted on one ward on a mainframe and was found to be too slow. If the project were to continue, the software would have been run on a network of personal computers which should have been faster than the mainframe. It had been difficult to get the software to perform as desired, and because the software company was American based, sometimes it was difficult for them to understand the practice in the UK and design accordingly.

At Guys hospital the ward pharmacist was responsible for training doctors how to use the CPS. Since the system was only piloted on one ward, training was not a problem. From the results of the pilot, the time taken to prescribe on terminals was not felt to be substantially longer than writing on a prescription chart. Time had been saved in discharge prescriptions when current medications were automatically copied and there was no longer need to rewrite drug charts. The ward pharmacist felt that she had spent more time on the ward as a result of the system and there was no danger that pharmacists

would end up entering prescription details on the computer, as in the USA. Doctors were more interested to find out why certain drugs were not allowed on the system and there had been improved communication between doctors and the ward pharmacist. The project had taken about four years.

At the Pilgrim hospital, Lincolnshire, a specification had been written for a CPS and the contract had been awarded to a UK based company. The system has yet to be piloted.

So far the only fully functional hospital CPS in the UK is the Technicon system. Technicon is a US integrated hospital system and much modification was required before it could be used in the UK. There have been major problems with the administration and recording of intravenous (IV) fluids so the traditional paper system is still being used for IV fluids prescriptions at the Royal Hampshire County hospital. Linkages to the pharmacy system and out-patient departments are still being modified and developed. The observations in the USA and the experiences in the UK have shown that the CPS module of Technicon is designed as an ordering rather than as a clinical support system and drug usage information captured was not easily extracted. Thus some clinical benefits from an ideal CPS, such as audit, may not be realised by the Technicon system.

Technology could have been one hindrance in the development of CPS. Systems might be slow and inflexible. However with the advances in information technology, some issues may now be overcome. The price of computer terminals have come down significantly, so a hospital may now be able to afford to place several terminals in each ward and thus overcome the potential problem of physical accessibility of terminals. Hand held computers are now more powerful and can be used as an alternative. The development of pen-based computers may overcome some doctors' reluctance to use keyboards to prescribe and the legal issues about signatures on prescriptions. The increasing power, reducing physical size and lowering cost of portable computers may mean that one day they would be used as a general communication system around the hospital instead of the bleeper.

So far the development of CPS has mostly been led by the government through Resource Management. Some hospitals have realised the potential benefits of CPS and decided to move in this direction. For pharmacy, CPS can potentially free up pharmacists' time from the supply function and allow them to spend more time on the ward and become part of the care team looking after the patient. The role of pharmacists would be advisory and as the provider of information. There would be more pharmacy involvement in policy making and protocol setting, maybe at directorate level.

However there are still many issues that need to be addressed before CPS can be widely implemented in the UK. Training of doctors, especially locums, may be a problem. Most hospitals are still unsure about the legal implication of CPS: who would be legally responsible if data is lost due to computer breakdown; how does an electronic prescription without signature stand; what if data is hacked, especially with outside communication links? It is not until questions like these are answered and guidelines are set by the Home Office that CPS will be fully accepted. A test case presented to the Home Office may help to clarify some of these questions and might help to scrutinise issues which might arise in CPS.

The introduction, implementation and maintenance of CPS may also be expensive. In the USA since most hospital pharmacies are open 24 hours a day and 7 days a week and have labour intensive unit dose systems, the cost of CPS is relatively cheap and may provide savings. In the UK hospital pharmacy systems are leaner and more cost effective; thus if only judging on cost, CPS may not be a viable option (Barber et al, 1992). In a study commissioned by the NHS Management Executive Information Management Group HISS Central Team (Department of Health, 1994), it was reported that the business case of CPS in the UK was currently difficult to prove, when comparing the tangible costs against cash-releasing benefits. This

was partly due to the lack of quantified evidence of benefits at sites with CPS and the difficulty in translating US experience to the NHS environment.

In many hospitals interest has been expressed in an electronic charting system used in intensive care units (ICU). These systems are patient based and might be linked to monitors and infusion pumps so that readings, such as blood pressure and drugs administered, are registered automatically on the charting system. Prescribing is not usually part of the original module but companies are developing it as an extension. Such systems would collect patient-based information but usually are not cost-orientated. These systems have gained popularity among physicians and nurses because of the need for regular charting in ICU and the charting system can offer clear benefits in recording such information accurately. Intensive care units may be ideal surroundings for computerised prescribing because of the complex drug regimes and the clear clinical benefits to doctors and nurses in presenting drugs prescribed and administered together with vital signs, and the limited number of beds usually makes it possible to have one computer terminal per bed.

Enormous amounts of time and money have been invested in the UK in the development of CPS. However many projects have failed. The development of CPS in the UK has been

generally led by management and the computing department. One of the main purposes of the system was to capture cost information and the design of the system is based on ordering and costing. This may not have met the need of clinicians and hence there was lack of support leading to failure of system. The complexity and impact of a prescribing system such as the need for training and support is also usually under-estimated. Computing departments and management may have a simplistic view of CPS. They may see the prescribing-pharmacy system as an extended laboratory test ordering or supplies system. Such a system would not offer much clinical support to the end users and lose the opportunity to 'improve' the quality of prescribing. Also there is no sharing of knowledge among hospitals as to why a system has failed, so the same mistake may be repeated when another CPS is developed.

The concept of a paperless prescribing system can offer many advantages and may be the norm in the future. However the current state of technology and the cost involved may mean that the use of CPS will not be widespread in the UK in the near future. For a CPS to be successful, it must offer direct tangible benefits to its users. The system must be robust, reliable and fit in the practice in the UK.

The prescription chart in the UK is a well designed document which allows doctors, pharmacists and nurses to see prescribing, drug administration, advice on drug administration and supply information at a glance. So far there is no CPS that could mimic this drug chart or offer an alternative that is as good and simple to use. The computerised flowsheet used on ICU may be the nearest version but still needs development.

For doctors, benefits of CPS should take the form of clinical support. Timely and up to date information and guidance about drug dosage, indication, side effects and cost would help doctors to make more informed judgement on treatments and this should subsequently improve the quality of prescribing. Protocols would standardise treatment and may be helpful for junior doctors who need to prescribe unfamiliar drugs. Other firm's protocols can also be viewed when treating diseases outside one's own specialty. The success of CPS at Wishard Memorial hospital, USA, as reported by Tierney et al (1993) was partly due to the wealth of data held on the system. There were almost 50 million pieces of data for more than 500,000 patients; thus the system contained substantial data about past tests, treatments, and diagnoses to display.

There is the argument that by using CPS, junior doctors may rely too much on information and protocols presented by the computer, thus impairing their learning process.

This would probably depend on the setup of CPS; whether the system would just dictate the use of certain groupings of drugs, as in a recipe book, or it would give reasons and background information why certain drugs were chosen.

CPS can also be a powerful tool in research. It can collect drug usage data transparently. This information may be linked to disease codings and can be used to monitor outcomes. This would help to build up safety and efficacy profiles of individual drugs. Such information would be very useful in clinical trials, drug use review and audit. Pharmacists can also play an important role in these areas.

With CPS, the role of pharmacists would change significantly. Potentially, a well designed and developed CPS could offer much of the advice given currently by ward pharmacists eg. drug interaction monitoring, dosage information and side effect profiles. There is the danger that one day, doctors or management may feel that there would be no need for pharmacists to screen drug charts, or in the extreme case, no need for pharmacists any more. To prevent this from happening, pharmacists must assess and develop their roles in CPS. They must become the information provider to the system, become part of the care team on ward rounds and play an important role in drawing up protocols, guidelines and in audit. These are

the areas where pharmacists should go in the future, with or without CPS. CPS may open up these opportunities to the pharmacy profession further, but these opportunities must be seized before it is too late.

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Appendix 1 Interview schedule to assess doctors' attitudes towards computerised prescribing system

1. Previous experience

This interview is to do with computerised prescribing systems, but before we get to that subject, it would help me if you could start by telling me about your experience of using computers in general.

prompt: What for?
Anything else?
Where?
in hospital
at home
How often? get frequency (hours if everyday)
past
present
Do you still use computers? If no:
Why have you stopped?
Do you use the computer yourself or do you delegate?
To whom? get frequency of own use

2. Computerised prescribing

As I said in the letter, I am interested in systems in which doctors prescribe on computer terminals. These terminals would probably be placed on each ward and out-patient departments in the hospital. The prescribing information would be passed on to the pharmacy department. A drug chart would be printed out on the ward and kept by the patient's

bed. This would be the definition of 'computerised prescribing' used throughout this interview.

2.1 First, it would help me if you told me about your prescribing practices.
Where do you usually do your prescribing?

prompt: OP clinics
wards
where on wards -- ward office
patient's
bedsides
What sort of proportion/ percentage?
(How often? get hours per day/week?)

2.2 Before this study, have you come across any computerised prescribing system?
If yes: What have you heard about?

prompt: when
where - hospital?
general practice?
who used it?

2.3 What are your general feelings about the prescribing system I described earlier?

rephrase: What do you feel are the main advantages or disadvantages of computerised prescribing?

prompt: IP
OP

probe advantages or disadvantages, depending on answers

2.4 What other benefits or problems do you, as a prescriber, see in computerised prescribing?

rephrase: Can you think of any other practical advantages or disadvantages if you had to prescribe onto computer terminals?

prompt: would it affect your workload?
how about during clerking?
during ward rounds
when reviewing treatments
discharge
how about its use in audit
- in setting prescribing guidelines
are there any legal implications
(eg. signatures, CDs if asked)
what about training

If not discussed,
How would you think computerised prescribing may affect patients?

prompt: effect on doctor/patient relationship

3. Information

As you are aware, computers can be very powerful in handling information. I want to ask you about the information which could be available for doctors at the time of prescribing and also about the analysis of prescribing, which could be broken down by patient, prescriber, consultant or directorate.

3.1 If you think about the information you need at the time of prescribing, what could be available on screen to help you?

prompt: financial information
prescribing policies
information about drugs

3.2 Retrospective analysis of data can provide information at individual patient and prescriber level.

What do you think this could be used for?

prompt: How about audit

How about expenditure reporting

4. Practical aspects

And now, I would like to talk about the practical aspect of computerised prescribing.

4.1 If you were going to use computer terminals to prescribe, from the point of view of prescribing on wards, where would be the most convenient place to put these terminals?

prompt: any particular reasons?

What about OP?

prompt: any particular reasons?

4.2 How would you feel if you had to use a computer keyboard to prescribe?

prompt: Have you got any alternatives to a keyboard that you think are better?

4.3 Would computerised prescribing affect relationships between medical staff and other departments?

prompt: pharmacy departments

In what ways?

Is it good or bad?

4.4 In some hospitals, a doctor's contract states that he or she must use computers to prescribe. How do you feel about this?

4.5 In computerised prescribing, information such as protocols, regimes and discharge letters may be generated automatically. How do you feel about this?

Some doctors feel that this may hinder junior doctors' learning process. Do you agree or disagree?

4.6 Whom do you think should enter the prescriptions onto the computer terminals?

prompt: the options are: ward clerks;
nurses;
pharmacists;
doctors.

if answer includes pharmacists:

Under what circumstances should a pharmacist enter such information onto the computer terminals?

Ref. no _____ Tape no._____

Date _____

5. Background information

Default: HH or WM **Size and type of hospital**
Computer system used in hospitals :
PAS
HISS
laboratory results
others

Grade _____

Specialty _____

Sex _____

Year of registration _____

Previous computer training: school/ college

current involvement in computer projects

_____

research commitment

_____

involvement in audit

_____

Appendix 2 Rating scale to assess doctors' attitudes towards computerised prescribing system

Some people have expressed the following as issues which may arise in computerised prescribing. Please rate their importance to you as a prescriber by circling the appropriate number on the following scale.

		of no importance			of paramount importance
a.	patient confidentiality	1	2	3	4
b.	response time of computer	1	2	3	4
c.	better audit information	1	2	3	4
d.	system breakdown	1	2	3	4
e.	improved legibility	1	2	3	4
f.	time required to prescribe on computers	1	2	3	4
g.	training	1	2	3	4
h.	system security	1	2	3	4
i.	data lost due to computer breakdown	1	2	3	4
j.	medication reaches patients more quickly	1	2	3	4
k.	availability of computer terminals	1	2	3	4
l.	control of drug expenditure	1	2	3	4

Would any of the above items deter you from using a computerised prescribing system? Yes / No

If the above answer is yes, please list the corresponding letters of item(s) which would deter you from using a computerised prescribing system:

_____

To conclude this study, can you please summarise your feelings about computerised prescribing system?

Would you use a computerised prescribing system?

_____

Thank you very much for taking part in this study. The information has been very useful and all material will be kept confidential.