The Evaluation of an Automated Drug Distribution System

Using a Health Technology Assessment Approach

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Abstract

Aim
This study assessed the potential of Meditrol, an automated, ward based dispensing system from the USA. The system was claimed to reduce drug administration errors (DAEs), reduce staff costs, prevent pilfering and provide drug use information.

Methods
The study was conducted in a 625 bed NHS trust hospital. A health technology assessment (HTA) approach was used to examine clinical, economic and social impacts. A before and after study design was used. DAE rate was measured using an observation method. Impact on pharmacy and nursing time was measured using activity sampling, direct timing and examination of establishment changes. A variety of inventory parameters were calculated, including ‘absolute consumption discrepancy’, the sum of drug losses and gains (as opposed to the net discrepancy where these cancel out). Information management was examined using a case study technique. Staff attitudes were explored using structured interviews.

Results
DAE rate was unchanged (3.5 ± 0.7%). Nurses spent an additional 68 minutes (22%) per ward per day on drug rounds (p = 0.03). Pharmacists spent an additional 30 minutes (120%) on each ward per day. An additional 7.5 FTEs were employed in the pharmacy. The quantity of drugs on the wards was reduced by 48% (significant at 5% level), but the cost was unchanged. Absolute consumption discrepancy was 40 ± 3% before and 34 ± 8% after implementation. Information was not used during the study period. Staff attitudes were positive initially, though mainly negative afterwards.

Conclusions
The Meditrol system did not provide the benefits expected. There is little scope in the UK for funding systems by improved efficiency and inventory management. Further research should quantify the benefits of improved safety and information. This study measured proxy outcomes, later stages should examine real ones. Drug distribution systems should be considered in the NHS R&D process and attention should be directed to the examination of established technologies.
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1 Background

The drug distribution system currently operating on most UK NHS hospital wards starts with the doctor making a decision to treat a patient with drugs and writing a prescription on the drug chart. The pharmacy department supplies some drugs according to the prescription (though most are already kept on the ward as stock drugs), and the nurse administers drugs to the patient, making the appropriate records on the drug chart. Pharmacists scrutinise the drug chart in order to ensure that the patient is receiving optimum treatment. The patient’s response to treatment is monitored by medical, pharmacy and nursing staff. After discharge the drug chart is archived in the patient’s case notes. These processes are governed or influenced by local policies, professional codes of conduct and acts of parliament.

Of the steps in the drug distribution process only those carried out within the pharmacy department are normally supported by computer. These systems were originally introduced to support purchasing, stock control and dispensing, the incentive then being to improve operational aspects of the service and to generate management information; the drive to computerise came mainly from within the profession. The information generated by these systems is product-orientated with, at best, only a fraction of data relating to individual patients; a factor not recognised as important at the time of their design.

In the 1980’s the Resource Management Initiative (RMI) placed emphasis on costing down to case level, a task which the existing pharmacy computer systems were not
capable of achieving. Of the original six RMI pilot sites, two have now implemented ward-based computerised prescribing systems as an element of a hospital information support system (HISS), though incentives have shifted from that of obtaining costs of individual patient drug therapy to that of operational support and the creation of electronic patient records. However, for NHS trusts to be able to develop in line with market philosophy, the ability to cost all services to case level for the purposes of contract calculation remains a desirable goal, if not a necessity for survival. The application of communications and ordering systems with the capability to provide decision support have the potential to improve both the efficiency and quality of the drug use process. Orders for drugs can be relayed directly to the pharmacy department for processing (eliminating transcription of information), patient drug histories can be retrieved much faster than paper based records and the display of prescriptions in a standard, legible form may improve patient safety as well as process efficiency.

With these advantages considered and with the pressures to operate efficient and effective contracting systems, NHS trust hospitals may consider the procurement of ward based computerised and automated systems. Investment in an information and clinical support system carries both financial and clinical risks; the need to evaluate new health technology has been emphasised by the Department of Health (Advisory Group on Health Technology Assessment 1992).

This thesis explores the application of health technology assessment (HTA) techniques in the evaluation of automated drug distribution systems and draws implications for policy making. HTA principles involve the measurement or examination of a wide range of beneficial and adverse effects, using explicitly defined outcomes or outputs. The theory
of HTA has been used to develop a framework for the evaluation of an automated, ward-based dispensing system. The experience of a real life evaluation can provide valuable guidance for future HTA in this area.

1.1 Aims of the study

This study was carried out to investigate the use of a health technology assessment model in the evaluation of automated drug distribution systems. The aims of the study were:

1. To apply HTA philosophy to the production of a framework for the assessment of an automated technology which supports the drug distribution process.

2. To evaluate an automated drug distribution system using this framework.

3. To provide direction for the future development of drug distribution systems and their assessment.
2 Introduction

2.1 Drug distribution systems - a brief history

2.1.1 UK Hospitals

A drug distribution system should ensure that the right drug should be readily available for administration to the correct patient according to the prescriber’s instructions and held securely to prevent misuse. Accurate records should be compiled in order to create an audit trail. For the purposes of this thesis, the components of a drug distribution system are defined as:

1. The prescribing of drugs.
2. Supply of drugs to the ward by the pharmacy department.
3. The storage of drugs on the ward.
4. The administration of drugs to the patient.

Up to the late 1960s doctors prescribed onto order sheets. The details on this sheet were then transcribed by nursing staff onto a ‘medicines list’ which acted as the document against which drugs were administered. In 1958, as a result of the recognition that the transcription stage was a major source of error, the Aitken report recommended that the doctors prescription sheet should act as the guide to drug administration (Central Health Services Council 1958). This advice was largely ignored for three reasons. Firstly, the transcription of prescription details meant that the original prescription could be presented to pharmacy as an order for drugs not available on the ward, whilst keeping the transcribed version on the ward. Secondly the format of the order sheet (often a blank
page) was such that it was not considered suitable as a guide to drug administration.

Thirdly it is likely that many workers were ignorant of the true scale of drug
administration errors and so the incentive to change was lacking.

In the late 1960s the results of research into drug administration error rates provided the
incentive to re-think drug control systems. Studies in London (Vere 1965) and Aberdeen
(Crooks et al 1965) showed that the drug administration error rate was unacceptably high
(15%). The old systems were perceived to be outdated for the following reasons:

1. The complexity of prescribing; the range and potency of drugs available was
   increasing.

2. The transition to metric measurements was causing confusion.

Over the next few years and in response to these findings, groups from The London
Hospital (Sykes and Oakes 1968, Lee et al 1971), Westminster Hospital (Baker 1967),
Aberdeen Royal Infirmary (Calder 1965, Crooks et al 1965, Calder and Barnett 1967),
the Royal Free Hospital (Walsh 1969) and other hospitals, developed new systems which
promoted safety, efficiency and the integration of the pharmacist into the ward team.

The solution proposed by the Aberdeen group consisted of the following components:

1. A purpose designed prescription sheet served as a guide for the administration
   of drugs (Calder 1965, Crooks et al 1965).


3. The pharmacist visited the ward on a daily basis to review prescription sheets
   and was responsible for ordering and maintaining drug supplies on the ward (Anon
   1967, Calder and Barnett 1967)

4. Drugs were dispensed in smaller ward packs as opposed to bulk containers and
   were labelled in a standard, uniform manner (Calder 1967).
'The London system' was essentially the same except that:

1. The drug chart formed the common record of prescribing and administration (Sykes and Oakes 1968).

2. The use of a stock/non-stock system\(^1\), where stock drugs were those which were used frequently on the ward (or those which may be have been needed in an emergency) and were suitable for storage in the ward environment (Lee \textit{et al} 1971). These were supplied in bulk containers (for example, pots of 50 tablets, packs of 10 ampoules). Non-stock drugs were supplied on an individual patient basis; a pharmacist needed to see the drug chart before the drugs were supplied and the containers were labelled with the patient's name.

Following the introduction of the revised system for drug distribution at The London Hospital, the drug administration error rate was found to have been significantly reduced from 15.3 to 6.1\% (Hill and Wigmore 1967).

In 1970, the Gillie Report, a health circular entitled 'Measures for controlling drugs on wards', formally recommended the innovations described above (DHSS 1970a). In the same year the Noel Hall report on the structure of the hospital pharmaceutical service (DHSS 1970b) further emphasised the need for a patient orientated rather than the traditional product orientated approach.

\(^1\) The stock/non-stock system is frequently referred to in this thesis; the terms 'stock drugs' and 'non-stock drugs' refer to the definitions provided here.
Further progress was made with drug distribution systems by the introduction of pharmacy technician ‘top-up’ services which relieved nursing staff of the role of ordering ward drug stocks (Hetherington 1972). This placed the responsibility of ordering stock drugs with the pharmacy department; pharmacy technicians visit the ward at regular intervals to assess stock levels and compile an order to be processed by the pharmacy distribution section. Other hospitals adopted the card-based ‘Shotley Bridge’ ordering system (Lidgate 1970) which still involved nurses ordering stock, though minimum and maximum stock levels were allocated to each item. The nurse filled in a card (one for each stock item) which was then sent to the pharmacy for processing, often accompanied by an empty container. Neither system was widely adopted until the publication of an economic evaluation of technician top-up which demonstrated financial savings due to improved stock control (Collins et al 1985). Technician top-up is now the most commonly used system for ordering stock drugs. Few developments have been made with the basic concepts of drug distribution systems since these reports were produced, with most hospitals now adopting the London or less commonly the Aberdeen system. Technician top-up is operated in most acute hospitals, though the Shotley Bridge system is still used, particularly for long-stay care. Exceptions are the adoption of the American unit dose system in at least two hospitals (Ellis et al 1973, Anon 1989, Clark et al 1990) and more recently two hospitals report pharmacy services which have been de-centralised as part of the hospital’s shift to a patient-focused approach to health-care (Bunn et al 1994, Blain et al 1994). Most systems are now supported by computerisation and/or data capture technology and unit dose systems by automated unit dose packaging and labelling systems.
Development of clinical pharmacy services in UK hospitals

The modern practice of clinical pharmacy is essentially a process of individualising drug treatment, balancing the efficacy of the drug against its safety and cost, taking into account the patient’s clinical status and respecting the patient’s choice. Probably the most significant step in the development of clinical pharmacy was the integration of the pharmacist into the ward environment (originally to prevent the need for the drug chart to leave the ward). Soon after this strategy was introduced, the benefits of the ward pharmacist’s contribution to patient care were reported (Calder 1967, Hetherington, 1969, Anon 1972) and formally recognised in the Gillie Report (DHSS 1970a) and the Noel Hall Report (DHSS 1970b).

Throughout the 70’s and 80’s pharmacists developed their skills further, clinical pharmacy specialists emerged and descriptions of prescription monitoring by pioneers in clinical pharmacy demonstrated the complex and professional nature of the process of tailoring drug treatment to the individual patient (Cairns and Prior 1983, Wilson 1983). The schools of pharmacy responded with changes in the undergraduate curriculum and introduced post graduate MSc courses and, later, diploma courses in clinical pharmacy.

In 1986 a report of inquiry into pharmacy commissioned by the Nuffield Foundation (1986) recommended that clinical pharmacy should be practiced in all hospital. Two years later the Department of Health (1988) responded with firm direction for clinical pharmacy services in the health circular entitled ‘The way forward for hospital pharmacy’ (HC(88)54). This document described clinical pharmacy as ‘the developing role of pharmacists in which pharmaceutical skills are systematically applied to medicine usage both at the policy-making level and in the treatment of individual patients’. This
formalised the role of the pharmacist in processes such as drug use evaluation (Griffiths 1989) and formulary management (Collier and Foster 1985, Baker et al 1988).

The recent health reforms (Secretaries of State 1989) introduced the directorate system into hospitals and promoted medical audit. Clinical pharmacy services are in the process of responding to these changes by developing methods of supporting clinical directorates (Barber 1993) and contributing to the medical audit process (Barber et al 1992).

The main aim of clinical pharmacy is to promote good prescribing. The aims of good prescribing have been described as "appropriate, safe, effective and economic" (Parish 1973). These were incorporated into the original definition of clinical pharmacy, though (Barber 1991) argued that the patient's quality of life should be a prime consideration and has more recently refined this aim to that of respecting the patient's choice (Barber 1995).

In summary, the introduction of the pharmacist onto the ward served as a foundation for the development of clinical pharmacy as a discipline. The mission of the clinical pharmacist has been refined to consider the cost effectiveness of prescribing as well as safety and efficacy. Further changes in philosophy have gradually occurred to adopt a much more global approach. The health reforms have lead to new roles in medical audit and directorate liaison.

A critical appraisal of the UK drug distribution system

The drug distribution system which is currently being operated in UK hospitals is based on work which was carried out 30 years ago. Since this time there has been little research
indicating the performance of this system. Furthermore, there are several inefficiencies and inadequacies in the processes that constitute this system. These are:

1. **Hand-written prescriptions** - Written prescriptions can be illegible or ambiguous (Jenkins *et al.* 1993) which may contribute to the occurrence of errors. Doctors are remote to all but the most basic paper-based drug information sources (usually the British National Formulary and possibly a local formulary).

2. **The pharmacist's transcription of doctors' orders** - This process is time consuming (Jenkins *et al.* 1992) and could also contribute to errors. Furthermore, there is a time lag between when the prescription is written and when the pharmacist transcribes the order, often producing an unnecessary delay before the drug reaches the ward. Electronic order transfer has the potential to alleviate these problems and smooth out the flow of work into the pharmacy department.

3. **Manual ward-based stock control** - Pharmacy computer systems in most UK hospitals facilitate stock control within the pharmacy department only; manual methods are used on the wards. Computerisation of this process has the potential to streamline the supply of drugs from pharmacy to the wards and reduce the quantities of drugs held on wards by exploiting 'just in time' delivery methods.

4. **Paper-based drug orders** - Nurses are required to visit every patient while carrying out the drug round in order to establish if the patient needs any drugs prescribed for that time. Computerised scheduling methods could improve the efficiency of this process. Drug administration is one of the only nursing processes performed as a 'round', that is one nurse performing a task for all patients on the ward; other activities are carried out according to the primary nursing model, where all the care for any patient is provided by a specified nurse or nurses.
5. **Paper-based archiving** - Health services in general have been extremely slow in adopting computerisation. The computerised recording of drug prescribing and administration could have a profound impact on resource management, clinical audit, contract calculation, the provision of seamless pharmaceutical care and the efficiency of record retrieval.

The above list represents the main weaknesses in the current drug distribution systems in the UK. Research assessing the performance of the system may reveal further inadequacies or provide insight into the extent of these problems. This would provide direction for the development of technologies aimed at improving system performance and efficiency. Nevertheless, these observations still provide useful direction.

2.1.2 **North American hospitals**

At the same time as concerns were being expressed over the safety of drug administration in the UK, the issue was also raised on the other side of the Atlantic (Barker and McConnell 1962). The then current system of drug distribution consisted of the hospital pharmacy supplying all drugs to wards as floor stock and required nursing staff to order drugs, organise their storage and prepare them for administration to the patient. Nurses were found to be spending 45% of their time on medication activities (Blumberg 1961) in a time when there was a shortage of nurses. The issue of best utilising professional expertise (i.e. the optimal application of the pharmacist’s superior knowledge of drug products) was also raised (Jeffrey 1967). American pharmacists also identified unacceptable drug losses in existing systems (Kurtz and Smith 1961) and problems with incomplete billing of patients for pharmaceuticals were described in a historical overview by Barker and Pearson (1986).
The American solution was more idealistic than that of the UK and focused on the role of the pharmacy department. The dedicated prescription and administration chart(s), the focus of the UK solution, was not viewed as a viable option (Philips Roxane Laboratories Inc. 1978). Instead, developmental work focused on the philosophy of delivering exactly what was needed for an individual patient just before the time of administration and so almost eliminated the need for wards to keep drugs as floor stock (Schwartau and Sturdavant 1961, Barker and Heller 1963a). This was achieved by the pharmacy supplying the exact number of doses needed by a patient at any one time in a single envelope for the nurse to open and then administer all of the contents. This concept of pharmacy based unit dose production was essentially taking away the nursing responsibility of preparing doses for administration to the patient. The resultant systems often required the use of multiple-carbon copy forms of the doctors orders (typically records for nursing, pharmacy and the accounts department) and some transcription of prescription details.

The task of assembling and delivering all doses to the ward just before administration to the patient required a 24 hour pharmacy service, a rapid response to new prescriptions and a resultant increase in staffing levels. A comprehensive study of the cost of drug distribution systems conducted by the US General Accounting Office (1972) concluded that although 50% more pharmacists and 100% more technicians were required for a 259 bed reference hospital, savings on nursing time would offset this and bring about a net saving over a 25 year life-cycle. For hospitals handling small numbers of prescriptions a net saving was not predicted, however this study did not consider savings from reduced drug ‘losses’, more accurate billing or the intangible financial benefit of reducing the incidence of drug administration errors.
In the 1960’s several studies demonstrated a reduction in error rates following the introduction of unit dose systems (Barker and Heller 1963a-b, 1964a-b, Heller et al 1964, Barker et al 1964, Black and Tester 1969, Barker 1969a-b). However, a study carried out in the mid 80’s with the aim of improving an established unit dose system, detected an error rate comparable with that of the traditional American systems (Barker et al 1984a). This deficit in reliability was attributed to the operating of a system which deviated from the original unit dose philosophy; not all doses were supplied as unit dose, some requiring further manipulation by the nurse, others supplied as bulk containers. Also the supply of drugs to the ward was occurring only twice daily which meant that doses for several administration times were present in the unit dose cart and problems occurred when patients' drug orders were amended. Furthermore response times were slow mainly due to inefficient drug delivery. On the basis of this study a new system was designed (Barker et al 1984b), however due to the incomplete implementation of this system, particularly with respect to computerisation and dose preparation, the drug administration error rate remained unchanged when the new system was evaluated (Barker et al 1984c).

The lesson from the studies described above is that, for unit dose systems to be effective, the original concept of unit dose must be adhered to rigidly; deviation from the ideal of supplying the precise doses in a form ready for administration, just prior to the time they are required may lead to a significant deficit in performance. Efficient communication systems, accurate and efficient record compilation and data sorting, dedication to true unit dose packaging and efficient delivery systems are essential, yet inevitably labour intensive. For these reasons automation is a common feature and is being widely adopted (Somani and Woller 1989). Applications include unit dose packing, information support systems,
data capture tools and computerised systems for checking the drug administration process.

2.2 Computerisation and automation in the drug distribution process

2.2.1 Computer applications in hospital drug distribution systems in the UK

In 1895, in response to the introduction of eyesight testing machines in railway stations, the British Medical Journal predicted (most likely tongue-in-cheek) that the pharmacist’s shop would ultimately be crammed full of slot machines which would diagnose complaints and produce typed prescriptions which would be dispensed by the pharmacist’s assistant while ‘the chemist, free from all responsibility, will take the fee and flourish accordingly.’ (Anon. 1895). While to date automation has not produced a major threat to the roles of most health care professionals, pharmacists have readily utilised and developed the application of computers; a VDU and keyboard are a familiar sight in both hospital and community pharmacies.

Computer systems were originally introduced into hospital pharmacy in the UK to facilitate purchasing and stock control (Stainton et al 1983, Downie 1984); manual systems were extremely labour intensive and unreliable. An additional advantage of these computerised system was the ability to generate information which, although limited to the volume and cost of issues from the pharmacy department (usually to ward or consultant cost centres) was found to offer great advantages over manual system for drug budget management (Stainton et al 1983, Downie 1984, Longshaw and Berg 1986; Lewis and Rushforth 1989). Information produced could be used to monitor expenditure and prescribing patterns and to keep managers and clinicians informed on spending.
Most hospitals in the UK operate a stock/non-stock system for drugs; that is the majority of drugs (about 80% by cost) are supplied to and kept on the ward in bulk containers (typically a pot of 50 or 100 tablets or a box of 10 injections), with the remainder (usually less frequently used drugs) being supplied for individual patients in smaller quantities (typically one week's supply). The pharmacy computer facilitates the processing and documentation of stock orders (most commonly compiled by the 'top-up technician') with remaining non-stock issues (about 20% by cost) being issued to individual patients. As a result, a major limitation of these systems is that no or very little patient specific information is held on computer. A solution adopted by some centres is to use computers to create patient medication profiles (Allan 1985, Batson 1985, Bunn et al 1990). Such profiles act as an aid to prescribing review and dispensing and may also be used for costing purposes (Holmes and Taylor 1988). In a long-stay environment this strategy may be feasible, however in the acute setting the time commitment required to maintain such records would be considerable.

Capture of prescription data has been largely by keyboard entry for non-stock drugs, dispensary staff using either the drug chart or a ward pharmacist’s transcription of prescription details as the source of information. Re-ordering of stock items directly into a portable computer using bar-code scanning tools has proved successful (Edwards and Ehrenzweig 1987) and is now not uncommon in UK hospitals. Light sensitive and touch sensitive screens have been used in the US (Schroeder and Pierpaoli, 1986, Larson and Blake 1988) and are currently being used in UK computerised prescribing systems. These may offer advantages for persons who are not keyboard literate, though the speed of data entry may be a limitation.
Other methods for collection of data in the health care environment have been described, including optical character recognition, optical mark reading and optical image scanning (Emberton and Meredith 1993). Optical character recognition is a process by which text can be scanned into an ASCII file, however prescriptions are seldom, if ever, in printed form and the technique is error prone; should systems be developed which allow accurate scanning of hand writing they may be of use for pharmacy departments. Related technology is available in the form of write-on screens (such as the Apple Newton hand-held computer), however accuracy in character recognition has not yet been optimised and keyboard entry by the experienced user may be quicker. Optical mark reading technology has been widely used for automated marking of multiple choice examinations and analysis of questionnaires and involves computer recognition of areas marked in pencil in a specified area. Optical image scanning is an updated version of optical mark reading which utilises the increased processing speed of modern computers, allowing greater flexibility and data processing ability. These systems are suitable where there are limited permutations of the data e.g. anaesthetic data collection, some forms of audit data and patient satisfaction questionnaires. With a typical hospital pharmacy holding around 3,000 different drug lines, some with a number of different possible dosing regimens, their potential for use in this field is limited.

A major incentive for the further development of pharmacy computer systems was provided by the Resource Management Initiative (RMI), a DHSS pilot project carried out at six hospitals (DHSS 1986). The aim of the RMI was:

‘to enable the National Health Service to give a better service to its patients by helping clinicians and other managers to make better informed judgements about how the resources they control can be used to the maximum effect.’
In brief, the implementation of resource management (RM) necessitated major cultural and organisational changes (Buxton et al 1991), most significantly the active involvement of service providers (doctors, nurses and professions allied to medicine) in the management of resources and the arrangement of these providers into sub-units (the now familiar clinical directorate structure). In the RM process clinical staff make decisions about the deployment of resources and take responsibility for the consequences.

In order that services can be planned and the use of resources monitored, accurate information relating expenditure to activity is an essential requirement of RM. This was achieved by the creation of RM databases (also known as case-mix databases) which were designed to provide cost per case; operational systems for wards and departments fed data into the RM database. Of the six pilot sites, four were developing computerised prescribing systems, to collect patient specific drug data and hence costs (Anon 1990). However only two of the sites, Arrowe Park Hospital and the Royal Hampshire County Hospital have actually implemented computerised prescribing (Bould 1993, Farrar 1995). Both prescribing systems are part of a larger hospital information support system (HISS), consisting of a number of interdependent modules for departments (e.g. pathology, radiology) or for administrative functions (e.g. admissions). The system provides operational support by allowing electronic ordering of services and viewing of patient records and clinical information. Both HISS systems are supplied by the same US vendor (Technicon Data Systems), and both have been modified to suit the purposes of each site.

The HISS systems were essentially implemented to perform two functions, feeding costs into the RM database and providing operational support. An independent evaluation of
the RM process was undertaken by the Health Economics Research Group, Brunel University, though the health reforms initiated the dissemination of RM throughout the NHS before the end of the evaluation (Packwood et al 1991). Furthermore, the implementation of RM at the pilot sites was much slower than had been anticipated and the evaluators concluded that it was not possible to provide a definitive assessment of the process within the time available (Buxton et al 1991).

Evaluation of the operational benefits of computer systems was not an aim of the RMI and as a consequence there was little published relating to these aspects. With specific reference to the computerised prescribing modules, only a small amount of research has been published by pharmacists at Arrowe Park (Hughes and Farrar 1993, Anon 1994). However, the NHS Information Management and Technology Strategy (NHS ME 1992) incorporated plans to create an NHS wide, person-based information system. The continuing strategy to create the electronic patient record has included the procurement of a national telecommunications network and the commissioning of several ‘demonstrator projects’. In the hospital environment these projects included the further development of HISS systems (NHS ME 1992) and the design of integrated clinical workstations (NHS ME 1994). In the private sector, the creation of an electronic patient record has been achieved at the Health Care International Hospital, a private hospital near Glasgow (Anon 1995), where a completely paper-less HISS has been implemented, though to date only a small fraction of the hospital’s beds have been occupied at any one time.

Hospital pharmacy managers are showing a great deal of interest in computerised prescribing systems, though the emphasis is on operational support rather than costing drug treatments. However, in an environment where contracts are the basis of the
economic functioning of health care services, should case specific contracting, rather than block contracting, become the standard method, NHS managers will still require detailed costing data. But, most patients' drug costs per admission are very low, suggesting that indiscriminate collection of this data for financial purposes may not be the most appropriate way forward (Jenkins et al 1995); selective data collection or screening for high cost patients may be better.

If computerised prescribing systems are to be adopted throughout the UK, whether stand-alone or as part of a HISS, purchasers (pharmacy managers, hospital managers or IT managers) will need evidence to support the choice of system, particularly in view of their expense and potential impact on the critical process of drug distribution.

2.2.2 Computer applications in drug distribution systems in the USA

The adoption of the unit dose system in many hospitals in the US offered a large incentive to computerise the process. Manual systems which needed to create pharmacy, nursing and accounting records were very inefficient, often requiring several transcription stages. Computer systems were introduced to create patient medication profiles to support the unit dose process and reduce or eliminate the need for transcription steps. However, even with computerised support, the unit dose system remains complex, labour intensive and error prone. With economic constraints being applied more firmly to US health-care, measures are being taken to further computerise or automate the drug distribution process. A recent review of automated 'medication management systems' (Perini and Vermeulen 1994) categorised available devices as: medication distribution devices based in the patient care unit (i.e. the ward), centrally located medication-distribution devices (i.e. in the pharmacy) and point-of-care information systems (i.e. used at the patient's
A further recent development is the application of decision support software to the order entry component of these systems. These applications are discussed further below.

**Patient medication profiles**

Computerisation was first considered in the early 60's; Barker et al (1963a) used an IBM punch card system for processing patient prescription data allowing data sorting to support the unit dose process. By 1987 a survey of hospital pharmacy services revealed that nearly three quarters of American acute hospitals operated the unit dose system, most of them supported by computerised patient medication profiles. Entry of data onto the computer system is normally by pharmacist, though some systems allow direct entry of data on the wards by doctors, nurses or clerks (Schroeder and Pierpaoli 1986, Larson and Blake 1988, Kawahara and Jordan 1989). Verification of the order by a pharmacist normally occurs before the order becomes active.

**Medication distribution devices based on the ward**

Medication distribution devices based on the ward are designed to either replace the system of delivering unit doses to the ward in carts (Access and Meditrol) or to allow easier, more controlled access to floor stock and/or controlled drugs (Lionville CD module, Argus, Pyxis Medstation and Medstation Rx, Sure-Med and SelecTrac-Rx). These devices allow rapid access to drugs, either as unit dose or as bulk packs. A problem with traditional unit dose systems has been the capture of drug administration data (and hence costs for billing purposes) of controlled drugs and the relatively small quantities of floor stock; automated systems create records of drugs obtained and the patients they are administered to. The controlled drug recording and reconciliation
procedures required by nurses are eliminated, resulting in a substantial time saving (there is a wider range of controlled drugs in the USA than in the UK), though an additional workload is incurred by the pharmacy department in stocking the devices (especially for those which dispense individual doses) and reconciling stocks against dispensing records. A further advantage is the secure nature of the automated cabinet (though less so for systems which hold bulk items); in the USA the price paid by patients for prescription drugs is often much higher than in the UK and so there is a greater incentive for pilferage.

Pharmacy based medication-distribution systems

Currently three pharmacy based medication-distribution systems are available (Automated Pharmacy Station, Baxter ATC 212 and Medispense). These systems are designed to improve accuracy and efficiency of unit dose systems. The Automated Pharmacy Station is a robotic arm which originates from technology used in the knitwear industry. It relies on unit doses being packed into bar-coded sachets and maintains these within the system. It facilitates cart-filling, dose verification, automated restocking of returned doses, removal of outdated unit doses and stock control. The Baxter ATC 212 is a unit dose packing system which packs on demand for specific patients for direct transfer into unit dose carts.

Point of care information systems

Point of care information systems allow entry and retrieval of patient specific data at the patient’s bedside. The MedTake clinical information system consists of terminals at each patient’s bedside, allowing verification and documentation of drug administration as well as the documentation and storage of other clinical information (for example, pathology and radiology). CliniCare is a similar system which has the advantage of using portable...
devices which enable wireless retrieval and entry of data at the patients bedside. The Automated Medication Administration Tracking System is dedicated to drug administration, is wireless and utilises a bar-code scanning system for verification and documentation of drug administration. MedLynk is a similar system, again wireless and bar-code driven which uses specially designed medication carts. Bar-code verification of drug administration (by checking the patient identification and the dose administered against the patient’s medication profile) could play a significant role in reducing drug administration errors, however this has yet to be demonstrated.

Decision support systems

A future trend towards using computerised decision support for prescribing using expert systems is likely (Morrell 1994) and vendors currently offer databases to screen prescription entries for drug interactions, contra-indications and therapeutic duplication. Several benefits of computerised decision support or patient monitoring have been demonstrated, including improved antibiotic selection (Kawahara and Jordan 1989) and a significant reduction in the occurrence of drug-induced renal damage (Rind et al 1994).

2.3 An overview of health technology assessment

In the previous sections the development of drug distribution systems on both sides of the Atlantic and the role of automation in this process have been described. Having provided a background to the technologies being considered by this thesis, this section now considers the influence of technology on the delivery of health care, the philosophy of health technology assessment as described in the literature and the process adopted by the NHS in the UK.
2.3.1 The influence of technology on the delivery of health care

It is widely accepted that technology has had a profound impact on the effectiveness of healthcare in terms of intervention success rates, patient survival, quality of life and other clinical outcomes. These outcomes have mostly been beneficial, however some technologies have been associated with unacceptable morbidity or mortality, resulting in the withdrawal of the technology. It is also accepted that some form of financial outlay is usually associated with the implementation and maintenance of a new technology. This cost is balanced against the impact of the intervention in monetary or other terms. However, the wider impacts of technology on the processes by which healthcare is provided, the structure of the organisations providing this care and on society in general are less often considered.

In his book entitled ‘Medicine and the reign of technology’, Reiser (1978) described the influence of technology throughout the history of medicine. Reiser’s findings are summarised in table 2.1. In the seventeenth century, the examination of the patient was restricted to a verbal and visual techniques and as such it was not always necessary for the doctor to be present to make a diagnosis; the patient’s narrative could be relayed to the physician by messenger or letter. In the eighteenth century however, the technique of physical examination began to emerge in the form of percussion and palpitation of the body for evidence of disease, requiring that the physician be in direct contact with the patient in order to make a diagnosis. At the same time the post-mortem dissection became an important means of further exploring the physical changes associated with disease.
### Table 2.1 The impact of technology on the medical profession since the invention of the stethoscope - a summary of the findings of Reiser (1978)

<table>
<thead>
<tr>
<th>Date</th>
<th>Technology</th>
<th>Impact on medical profession</th>
</tr>
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<tbody>
<tr>
<td>1820-1850</td>
<td>Stethoscope</td>
<td>• Acceptance of the importance of physical examination (rather than visual or verbal)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Doctors needed direct contact with patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Diagnosis based less on patient-centred signs of illness</td>
</tr>
<tr>
<td>1850-1900</td>
<td>Visual technology and X-rays</td>
<td></td>
</tr>
<tr>
<td>1860-1900</td>
<td>The microscope</td>
<td>• Specialisation</td>
</tr>
<tr>
<td>1860-1920</td>
<td>The measurement of physiological processes using machines</td>
<td>• Centralisation</td>
</tr>
<tr>
<td>1880-1930</td>
<td>Chemical pathology and the diagnostic laboratory</td>
<td>• Less direct contact with patient needed to diagnose illness</td>
</tr>
<tr>
<td>1880-</td>
<td>Telecommunications</td>
<td>• Less need for centralisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduced need for direct contact with patient</td>
</tr>
<tr>
<td>1960-</td>
<td>Computerisation</td>
<td>• Centralisation</td>
</tr>
</tbody>
</table>

In the first half of the nineteenth century the introduction of the stethoscope allowed the physician to use his sense of hearing to examine the patient. This compounded the need for the doctor to have direct physical contact with the patient. Significantly, for some time after the introduction of the stethoscope, now a ‘tool of the trade’, the opinion of the medical profession on its usefulness was divided. The introduction of tools which allowed visual examination of internal anatomy, such as the ophthalmoscope, further expanded the doctor’s use of sight in the diagnostic process. However, with the advent of x-rays, machines which measure physiological processes (for example the electrocardiogram) and the medical laboratory, the diagnosis itself was increasingly being made remote to the patient. These techniques produced permanent, objective records (as opposed to one person’s subjective account) which could demonstrate trends in the patient’s condition and more readily allowed group discussion. The need for patients to be in close proximity
to specialist equipment meant that the treatment of patients became increasingly centralised. As a result of rapidly increasing knowledge within the medical profession, specialisation was occurring; the convenience of being able to consult with a range of specialists under one roof exacerbated the trend towards centralised health care.

In the 1880's, the use of the telephone meant that doctors were more accessible to patients than ever before. The convenience of the telephone meant that doctors could provide advice to patients, could make a diagnosis and could send prescriptions by telegram. Furthermore the ability to consult with specialists in other hospitals diminished the need for the centralisation of health care. More recently the use of telecommunications has allowed the transmission of video pictures and other information, such as ECG traces and digitalised x-rays, to medical specialists remote to the patient so that they can contribute to the management of the patient.

Reiser predicted that computerisation would lead to a further centralisation because doctors would need to be in close proximity to the machines that would allow the processing of vast amounts of information. This may have been true in some cases in the 70's and 80's, though diffusion of computer technology in health care has been fairly slow and the use of technology which enables the networking of computer systems is now established; the tendency to centralise is probably less significant than Reiser predicted.

Reiser's account demonstrates the impact that technology has had on the processes and structure of health care and the doctor-patient relationship. The technologies he considered were not confined to specific medical technologies but included those which have diffused through society as a whole, such as telecommunication and
computerisation. The effect of basic technologies on fundamental issues emphasises the importance of a thorough assessment of the wider impacts of the introduction of new technologies, whether they are aimed at specific treatment goals or are more generic in nature.

2.3.2 The origins of health technology assessment

Health technology assessment (HTA) has its origins with technology assessment (TA), a process which has been practised in various forms since the 1930’s (Morgall 1991). Early TA focused on industrial policy; was ad-hoc and confined to safety, efficacy and cost-benefit; and was isolated either in industry as option appraisal exercises or in special interest and pressure groups. In the late 60’s and early 70’s TA became broader based and a matter of public policy and interest. This was largely a response to technological and environmental disasters and the resultant public protest which occurred. In the 70’s the modern concept of TA was conceived with the formation of the US Office of Technology Assessment (OTA), resulting mainly from the campaigning of Congressman Emilio Daddario, who had sensed a growing public mistrust in science and perceived a need to tackle urgent public health and welfare problems. In particular, Daddario emphasised the need to consider social, economic and legal considerations of technology as well as purely technical merits (Goodman 1992). He further emphasised that TA was a class of policy studies and that emphasis should be placed on unintended, indirect or delayed consequences. These features are still key to the process of TA (and HTA) today.
2.3.3 The HTA process

Definitions

Various definitions of ‘health technology’ and ‘health technology assessment’ have been stated and a number of interpretations and emphases are evident in the literature.

Goodman (1992) expressed concern over the equivocal nature of HTA, both in terms of definitions and its relationship to other processes such as quality assurance, health services research, effectiveness research and medical informatics. A detailed debate on the subtleties of the definition and process of HTA is beyond the scope of this thesis. One interpretation of the HTA process is provided, with particular influence taken from the current NHS strategy.

Health technology was described by the Advisory Group on Health Technology Assessment (1992) as:

‘The variety of methods used by health professionals to promote health, to prevent and treat disease, and to foster improved rehabilitation and long-term care.’

The US OTA describes health technology as:

‘The drugs, devices and medical and surgical procedures, used in medical care, and the organisational and supportive systems within which such care is provided’ (US Congress Office of Technology Assessment 1982).

The broad nature of these definitions reflects the wide variety of health technologies and also allows for a flexible interpretation. Emphasis is placed on the inclusion of ‘low-tech’ products such as syringes and dressings as well as ‘high-tech’ products such as imaging devices or lasers. The definitions also include health policies and the time and skills of health professionals. Littenberg (1992) stated that hospitals and the doctor-patient relationship should also be classified as health technologies. The broad nature of the
definitions contrast with a popular perception (by many health workers as well as the general public) that ‘health technology’ refers to the hard-ware used in health care.

An advisory panel to the Department of Health Central Research and Development Committee (Advisory Group on Health Technology Assessment 1992) stated that:

‘Rigorous assessment of new technologies is essential to evaluate their effectiveness and safety, their cost-effectiveness, and their social, ethical and organisational impacts’.

The US Institute of Medicine (1985) defines HTA as:

‘any process examining and reporting properties of a medical technology used in health care, such as safety, efficacy, feasibility, and indications for use, cost, cost-effectiveness, as well as social, economic, and ethical consequences, whether intended or unintended.’

The OTA defines HTA as:

‘a structured analysis of health care technology or related techniques, or technology related issues, that is performed for the purpose of providing input to a policy related decision’ (Irving 1995).

These definitions imply that a range of outcomes should be used in HTA, which may be used to assess clinical, economic, social, legal and ethical impact, depending on the technology. The philosophy is that the whole is greater than the sum of the parts. The measurement of a range of outcomes also implies a multidisciplinary approach to HTA. This does not necessarily mean that every assessment must be an examination of all outcomes possible; early assessments may provide information on the potential of a technology and offer guidance to the future development of the product and the methods used to evaluate it (Sculpher et al 1995). In this way, the HTA process can be regarded as iterative, each step providing more information. It should also be stressed that HTA is a process which supports policy making.
The emphasis on the early work of the US OTA was to formulate policies to protect society from dangerous technologies. This still remains true for HTA, particularly as the introduction of many technologies remains outside of the control of any formal regulatory systems. The introduction of a new drug into the UK market requires years of carefully documented research and development and detailed submissions to the Medicines Control Agency. In contrast, there is no comprehensive regulation of medical devices (except a system for alerting health workers to dangerous or faulty technology), surgical techniques or computerised clinical support systems. For example, laparoscopic surgical techniques have been widely practised in the UK since the start of the decade despite there being little evidence to demonstrate safety or cost effectiveness. Assessment of this type of surgery has now been prioritised by the NHS (Spiby 1994).

Assessment of performance

The traditional assessment of health care includes measurement of both safety and performance. A range of qualitative and quantitative methods have been used to either measure these factors or obtain relevant opinion. These include randomised controlled trials (RCTs), performance analysis, case series, case studies, meta-analysis, consensus development conferences and opinion surveys (Hendee 1991). The RCT for assessing health technologies is considered to be the gold standard by many workers (for example, Laupacis et al 1992). While RCTs provide information concerning the potential for new technologies, they are limited in that they are usually conducted under ideal conditions (and so provide a measure of efficacy); performance under normal conditions (effectiveness) may be an equally useful measure to decision makers (Goodman 1992, Banta et al 1981). A comprehensive HTA may therefore include an assessment of effectiveness following diffusion of the technology into practice (Jennett 1993, Tugwell et
The medical audit processes should provide the final practice-based measurements of effectiveness. Following widespread diffusion of a technology, epidemiological methods may provide information concerning the effectiveness of the technology on a macro level when set against a baseline, pre-intervention measurement (Tugwell et al. 1986). Such techniques are also useful for prioritising the development and assessment of new technologies, based on potential for reducing the incidence of treatable diseases or events.

Outcomes used to measure performance include survival rates, quality of life measures and other, intermediate or proxy outcomes such as reduction in blood pressure or tumour shrinkage. While the latter parameters are easier to measure in the short-term, they offer less meaning than true outcomes. Nevertheless intermediate outcomes have been deemed useful in early HTA research to assess the potential of a technology (Goodman 1992, Littenberg 1992, Sculpher et al. 1995) and can eliminate the need for studies requiring patient follow-up over long periods. Moreover intermediate outcomes such as reduction in blood pressure have been validated by studies which confirm associations with reduced morbidity and mortality. This approach, however, carries the risk that other effects such as adverse drug reactions are not detected.

Economic factors

A feature of every health care system in the world is the availability of limited resources with which to satisfy an unlimited demand. It is generally accepted that even if all harmful health technologies or those with no benefit were eliminated, there would still be an excess demand for resources (Buxton 1988). This fact makes rationing of health care inevitable. In the UK various forms of rationing, mostly implicit, have been operated
(Buxton 1993, Sheldon and Maynard 1993), for example waiting lists have been a consequence of this. With the acceptance that some form of rationing is inevitable, it is desirable to prioritise the funding of (safe and effective) health technologies by objective means. Chris Ham (1993) emphasised the difficulty in prioritising different types of health care by describing the process as being like 'comparing apples, oranges and kiwi fruit'. A measure of the value for money provided by technologies may provide some direction.

Economic methods of assessing value for money are well established (Adang et al 1995, Drummond et al 1987) and include cost-benefit analysis (CBA, where costs and benefits are expressed in monetary terms), cost-effectiveness analysis (CEA, where treatments can be compared in terms of cost per unit of outcome) and cost-utility analysis (CUA, where, for example, treatments can be compared in terms of cost per quality-adjusted life year gained). CBA is useful for comparing technologies which have different impacts, though does rely on the ability to place a financial value on costs and outcomes, which is not always possible; willingness to pay is a commonly used approach. CEA is suitable for comparing technologies in the same clinical area, for example reduction in blood pressure or, less specifically, life years gained. CUA is useful for assessing technologies which have a multi-dimensional impact on both quality of life and survival.

**Wider issues**

Evaluation of efficacy, effectiveness and value for money may not provide a complete assessment of the technology in question. Wider issues should also be taken into account. The patient’s satisfaction with the health technology is increasingly being sought, for example Murphy et al (1996) carried out a RCT of GPs versus hospital doctors providing accident and emergency care which included a ‘consultation satisfaction questionnaire’.
Similarly the views of relatives and carers may be useful. Staff attitudes may play an important role, particularly in the evaluation of clinical support systems (Aydin 1994, Kaplan and Maxwell 1994). Qualitative and quantitative techniques may be useful to provide information on organisational changes and to assess the wider 'knock-on' effects of the technology. Some technologies may require an assessment of the ethical and legal implications.

Decision making

HTA research should provide answers to research questions. It is beyond the scope of an evaluative project to provide decision makers with definitive answers on whether a technology should be adopted or not. In some instances, the decision will be easy; for example when a technology costs more than or the same as the established alternative and performs less well. For other scenarios the decision is more difficult, such as when an intervention costs more than the established technology but performs better, or when it costs less but performs worse. In these cases, the wider social and ethical issues may provide an important influence. Some workers have provided guidelines for decision making (Laupacis et al 1992) based on clinical and economic impacts, though other workers have emphasised that decisions are often ultimately value-based (Deber 1992). Bos (1988) describes an explicit criteria based process for ranking technologies based on the nature of the target patient population. On a local level, Reiser (1992) describes a goal-orientated approach, considering civic, institutional, organisational and practice goals and other decision makers use a combination of criteria-based assessment and expert panel, GP and public preference (Watson et al 1996). Another approach has been to use consensus development techniques, such as Delphi studies (Gallagher et al 1996) or consensus development conferences (Stocking et al 1991, Perry and Wilkinson 1992).
2.3.4 Health technology assessment in the UK health service.

The HTA programme in the NHS is a major part of the Research and Development (R&D) strategy. This was launched, following the publication of the House of Lords Report on priorities in medical Research (House of Lords Committee on Science and Technology, 1988), which criticised the mechanisms by which the NHS could identify and articulate its research needs and translate the findings of research into practice. A senior post of Director of R&D was created to head the NHS R&D Division and a strategy was launched in 1991 (Department of Health 1991a). In the same year the Patient’s Charter (Department of Health 1991b) emphasised the need for objective decision making in the provision of appropriate care. The aim of the R&D strategy is to secure a knowledge-based health service in which clinical, managerial and policy decisions are based on sound and pertinent information about research findings and scientific developments (Stocking 1996). The director of R&D sits on the NHS ME in order to ensure that the outputs of HTA and research and development in general are considered fully during the policy making process. He is supported by a central research and development committee (CRDC) which reviews R&D relevant to the NHS and identifies areas where further work is required. The CRDC is supported by advisory groups which consider specific topics and are temporary in nature. Much of the needs assessment and commissioning of projects is carried out by regional R&D directorates with support from the CRDC, thus facilitating a two-way link between local and central policy makers.

Early on in the implementation of the strategy, it was evident that there was a lack of controls on medical technology and the role of technology assessment became apparent (Spiby 1994). An expert group was set up to prepare a report on the methods by which health technologies should be assessed (Advisory Group on Technology Assessment
1992). The report contained recommendations concerning the outcomes for evaluating the effects of health technologies, research design, the use of evidence about the effects of health technologies and the fostering of the HTA approach in the NHS. A strong message in the report was that unevaluated forms of care should only paid for if properly designed research is conducted to assess their impacts after implementation.

The recommendations of the Advisory Group on Technology Assessment provided practical direction for the further development of R&D within the NHS whilst adhering to the philosophy of HTA. These were firmly grasped by the R&D directorate and in February 1993 a Standing Group on Health Technology was established. Six advisory panels were established by the group (Irving 1995). These were to consider i) acute care, ii) primary and community care, iii) pharmaceuticals, iv) diagnostic and imaging techniques, v) population screening and vi) R&D methods. The key tasks of the group are to identify and rank technologies in need of assessment, to identify the need for R&D of HTA methods (especially where the diffusion of a technology is being held up due to the lack of suitable methodology) and to identify emerging technologies likely to have a profound impact on the NHS. The recommendations of the Standing Group are approved by the CRDC and are then passed to a commissioning group. Projects can be commissioned directly or, if more appropriate, research needs are discussed with other funding groups such as the Medical Research Council or the Economic and Social Research Council.

To meet information requirements of the end users in the process, two centres were commissioned (Sheldon and Chalmers 1994). Firstly, the Cochrane Centre in Oxford, was established to undertake systematic analysis of clinical trials and now provides a
regularly updated database of systematic reviews is now available on electronic media for clinicians and decision makers (Hyde 1995). Secondly, the NHS Centre for Reviews and Dissemination was opened in York in 1993 (Hyde 1995). This centre selects topics of relevance to the NHS and has produced a number of ‘Effective Health Care Bulletins’ and epidemiologically-based needs assessments.

The final stages of the R&D strategy are to translate the information generated by HTA into clinical practice and to monitor the effects. This provides ‘evidence’ used to foster the practice of evidence-based medicine (or more accurately evidence-based health care) in the NHS and provides a more objective mechanism for determining resource allocation. At a practice level, clinicians are increasingly using clinical guidelines; the NHS ME is collaborating with the professions to promote this process and to ensure that guidelines are based on sound evidence (Department of Health 1995). Emphasis is also being placed on the assessment of the implementation of guidelines as a health technology per se (Russell and Grimshaw 1995). Purchasers are increasingly considering research evidence in contract negotiations (for example Warson et al 1996); the trend is to only pay for new technologies if benefits have been demonstrated by evaluation (Szepura and Cooke 1993).

Significant resources have been allocated to HTA for funding of commissioned assessments, the maintenance of the information dissemination centres and the funding of the local and central R&D directorates. Having adopted a philosophy of knowledge-based health care provision, the HTA process itself should be assessed to establish whether it provides value for money. Specific projects have been studied in detail to calculate payback from the R&D strategy (Buxton and Hannay 1996).
The steps in the HTA process in the UK NHS are summarised in table 2.2. Emphasis should be placed on the fact that the process can start at any stage. For example, research commissioned by industry will not be governed by the CRDC prioritisation process, yet may generate information which supports decision making. Similarly, systematic reviews of the existing literature may be disseminated or decision makers (for example health authority purchasers) may carry out their own literature reviews. In summary, HTA is an important, though immature, mainstream process in the NHS.

2.3.5 Summary

HTA is a relatively new discipline and as a result, definitions are still equivocal. This is compounded by the multi-disciplinary nature of the research and the involvement of different parties at different stages in the process who have different expectations of HTA. Nevertheless, fundamental features can be drawn out of the HTA literature. These are:

1. HTA should support policy making.

2. HTA research is multi-disciplinary and should include the measurement of clinical, economic, social, ethical and legal impacts where appropriate, using explicitly stated outcomes.
3. Research should be designed to identify unexpected impacts as well as those expected and should therefore focus on all parties involved.

4. The nature of the research will depend both on the nature of the technology and on the degree of diffusion. It should be iterative in nature, early work identifying the potential for the technology and aiding with the design of subsequent methodology, later work providing information on performance in normal practice; emphasis should be placed on effectiveness as well as efficacy.

5. HTA research should provide information in a form readily understandable by end users. These may be managers, clinicians, politicians, industry representatives or patients.

6. HTA research provides information which can support decision making. It does not automatically answer questions about the choice between technologies. If evaluation does not show one technology to be more beneficial in all respects, some form of value-based or criteria-based decision is required.

2.4 A review of the literature on the evaluation of drug distribution systems

The definitions of HTA described in the previous section encompass a wide range of equipment, techniques and systems of health care delivery. According to these broad definitions, drug distribution system can clearly be regarded as health technologies and should therefore be evaluated systematically using HTA methods. This section critically examines work carried out in the past and in particular, to what extent this research satisfies the requirements of HTA.
The last major changes to drug distribution systems on both sides of the Atlantic were made in the 1960's and early 1970's. Work carried out in the UK may offer the most useful direction to present day evaluations as the setting for this research remains essentially the same as the systems in operation today. The work carried out in the USA however, was more comprehensive and although the systems examined were of a different nature (i.e. the unit dose system of drug distribution), the overall principles, getting the right drug to the right patient at the right time, remain the same. Moreover, many of the systems being considered for use in the UK are American in origin, some incorporating components of the unit dose approach.

2.4.1 UK evaluations

Following the publication of studies demonstrating unacceptably high error rates, health care professionals in the UK were faced with the challenge of re-designing drug control systems. Most publications regarding new systems in the 1960's were concerned with descriptions of redesigned drug distribution systems, including the introduction of dedicated charts and the ward pharmacist’s role, though some publications included brief descriptions of developmental research carried out to support these changes. For example, Sykes and Oakes (1968) described a small activity sampling study of ward pharmacy, Walsh (1969) described a direct timing method for comparing dispensing times before and after the implementation of stock/non-stock system and Calder (1967) described a questionnaire administered to gauge the impact of the Aberdeen system. However, the approach was to design new systems based on prescription data and workload rather than comprehensive evaluations of these systems. This may in part have been due to the general approach adopted by the DHSS to improving drug distribution
systems. Expert panels produced reports and their recommendations were translated into policy; little emphasis was placed on evaluation of new systems to establish their strengths and weaknesses.

2.4.2 North American evaluations

The majority of evaluations carried out in the USA were those examining the unit dose system in the 60's and 70's. Some of these were fairly comprehensive (in comparison with the UK work), and were funded by large R&D grants from the US Public Health Service. Table 2.3 summarises the nature of the North American evaluations and shows the parameters which were measured. Most of the studies considered unit dose systems either operated from centralised or decentralised ('satellite') pharmacies. Most studies examined systems in hospitals, though some were conducted in nursing homes and others in long-stay facilities for the mentally handicapped. A before and after design was the most common, though several workers studied only the new system ('measured') and others used parallel controls. Most of the early studies examined a small scale implementation of an experimental system (usually on a small number of wards), some of these including an extrapolation of the results to predict the impact on the organisation with complete implementation. The outputs measured included drug administration errors, staff activity and attitudes. Other studies included calculating the costs of providing the new services, calculation of response times and estimates of drug losses. Each of the major areas is considered below.
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Key:
- **Syst** - System description
  - U - Unit dose
  - DU - Decentralised unit dose
  - C - Computerisation
  - A - Automation
  - P - Private hospital
  - N - Nursing home
  - D - Doctors
  - E - Small scale, extrapolation

- **Act** - Activity studies
  - DT - Direct timing
  - A - Activity sampling
  - S - Self reporting
  - P - Pharmacy staff
  - N - Nursing staff
  - I - Interview
  - Q - Questionnaire
  - P - Pharmacy staff
  - N - Nursing staff
  - D - Doctors
  - A - Administrative staff
  - L - Drug losses

- **Econ** - Economic studies
  - S - Staff costs
  - P - Packaging
  - C - Charge capture
  - D - Drug costs or consumption
  - S - Staff costs

- **Des** - Study design & context
  - B - Before and after
  - P - Parallel controls
  - M - Measured
  - S - Small scale
  - E - Small scale, extrapolation

- **Other studies**
  - UD - Unit dose costs
  - F - Floor space
  - In - Installation
  - P - Private hospital
  - N - Nursing home
  - D - Doctors
  - S - Staff report

Table 2.3 Summary of North American evaluations of drug distribution systems
### Drug administration error rate measurement

An examination of the potential of the unit dose system to reduce drug administration errors (DAEs) was first made by Schwartau and Sturdavant (1961), though this was limited to the perception of pharmacists and nurses of the potential to reduce the DAE rate using a list of causes of errors previously published by Safren and Chapanis (1960).
An observation method of determining DAE rate was developed by Barker and McConnell (1962). This method, usually covert, used an observer who recorded all drug administration to patients. This record was retrospectively compared with the original drug order and any discrepancies assessed and classified according to error type. The retrospective determination of errors meant that the observer was not aware of an error occurring and so the ethical dilemma of intervening to prevent the error was not encountered. An alternative to observer methods where nurses voluntarily reported DAEs was considered by Barker and McConnell, however the observer method was found to detect 1422 times more errors than the reporting method, even when the latter was kept anonymous. Following the publication of this method and its application in evaluating a unit dose system (Barker and Heller 1963a-b, 1964a-b, Heller et al 1964, Barker et al 1964), it was employed in all of the studies after 1964. Today the Health Care and Financing Administration and the Joint Commission for the Accreditation of Healthcare Organisations, bodies responsible for Medicare and Medicaid reimbursement to healthcare organisations, require DAE rate monitoring (using this method) to be incorporated in quality assurance programmes as part of their accreditation requirements.

Analysis of staff time
A variety of techniques have been used to quantify staff time required to operate drug distribution systems, including direct timing, self timing and activity sampling. Some studies focused on nursing staff, some pharmacy staff and some on both. One study considered medical staff time (though did not differentiate this from ancillary staff time). A variety of parameters have been calculated including time per dose, time per patient, total time comparisons and the translation of these parameters into costs. Some studies considered all nursing activities allowing examination of how nursing time saved could be utilised, others examined only those activities directly related to medication preparation, administration ordering and maintenance of the associated records. Despite this apparent lack of consensus on methodology and choice of parameters, the overall conclusion with respect to changes in staffing requirements was undoubtedly that the unit dose system

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saves on nursing time with a resultant major increase in pharmacy time. This reflected the fact that the adoption of the unit dose system was a major change in practice, with very significant implications for the deployment of staff. In order to measure more subtle changes, as may be the case with the future adoption of new systems in the UK, the more sensitive methods may be required, such as activity analysis and calculation of standard times, rather than measurement of gross changes in staffing levels.

Attitudinal studies
A component of several evaluations of American systems has been some form of assessment of staff attitudes. Some studies included the analysis of reports on system performance written by nurses and pharmacists from which a list of perceived advantages and disadvantages of the unit dose system was compiled. Others used questionnaires either of the yes/no design or with the use of Likert scales, while other workers used one to one interviews with varying degrees of structure. The attitudinal studies all examined the views of staff or managers, though none examined the patient’s views. These studies mainly examined staff perception of the advantages and disadvantages of the system, its usability and the level of job satisfaction.

Economic analysis
American workers have calculated a variety of parameters to analyse the cost of operating drug distribution systems. Some publications contain extrapolations from small scale implementations to predict the financial impact of implementation throughout a whole hospital site, others include the calculation of costs to operate a system in part of a hospital and others have include calculations based on a fully implemented service.

A variety of costs, both measured and calculated, have been used including the cost of unit doses, the cost of equipment, structural alterations, floor space and staff costs. Cost savings such as those due to increased charge capture, reduction in drug losses and minimisation of ward inventories have been included in some studies. There is however a
striking variation between studies in the range of costs used (see table 2.3), making comparison between studies difficult, if not inappropriate. The parameters calculated by combining costs also varies, some studies quoting cost per dose, others cost per patient and others comparative costs to operate a service over a specified time frame. The problem of interpreting economic parameters was demonstrated by Schnell (1976) who, for one hospital, calculated that the unit dose system resulted in a cost saving of 12% when cost per dose was examined but resulted in a cost increase of 8% when cost per patient day was calculated.

Probably the most significant economic analysis of the unit dose method was conducted in 1972 by the US General accounting Office in the form of a survey of 30 hospitals (19 with traditional systems and 11 with unit dose systems). A cost analysis was performed which included costs of staff, equipment, floor space and drugs. The conclusion was that the unit dose system was more economical in hospitals with a higher workload in terms of annual prescription dispensing rates and less economical than the traditional systems for hospitals with low prescription dispensing rates. The relationship between cost effectiveness and the size of hospital further complicates the interpretation of economic analyses.

Some of the benefits identified by American studies (and hence the parameters measured) are likely to be specific to the USA. This probably applies to clinical and staffing impacts, though is probably most significant when economic impacts are considered. The benefit of improved charge capture which resulted in increased revenue to the hospital cannot be translated to the UK health system, though this may be valid in the future. Similarly the importance of drug losses due to theft is probably far greater in the USA than in the UK due to differences in prescription charges.
Summary

The descriptions of the North American evaluations demonstrate both the range of inputs studied and the range of methodologies which have been used in the past (see table 2.3). Much of the research considered was conducted before the conception of the HTA process. Some of the studies examined a wide range of impacts which would have satisfied the criteria stated in modern HTA definitions; others considered only a narrow range of impacts. Whilst each of these studies supported local decisions at the time, and bearing in mind that there may have been a publication bias affecting what we see, further progress may have been made with the development of the unit dose system had a consistent approach been adopted on evaluation scope and the choice of parameters measured. This provides a lesson for the design of future evaluative work in the UK in an environment where decision makers will want to make direct comparisons between different proprietary systems and between different systems of service delivery.

Before embarking on the first stage of an evaluation of drug distribution system, a strong foundation is needed on which to build a research strategy. Previous UK research does not provide this foundation; the USA experiences provide guidance on the general approach and some of the methodologies used may be applicable to UK research.
3 Background to the Meditrol trial

3.1 An overview of the Meditrol System

The Meditrol Automated Medication Distribution System® (Meditrol Management Inc.) was first described in 1970 by Bombinski and Millar. The most recent version provides secure storage for drugs on wards, facilitates ordering and stock control, automates dispensing of drugs to individual patients on the ward, and compiles electronic medication profiles and records of drugs issued to inpatients on the ward. It is American in origin and was designed to improve the unit dose system of drug distribution by eliminating the need to supply unit doses to the ward just prior to the time of administration.
Plate 3.2 The Meditrol cabinet with doors open showing coils loaded with unit doses

On each ward is a computer keyboard, a visual display unit and a secure cabinet (access being available to pharmacy staff only) which stores and dispenses tablets, liquids, injections and other suitable formulations as individual doses. Some preparations such as ampoules, nebules and suppositories are suitable for storage in the cabinet with no or little re-packing. Other preparations require packing into single doses, tablets being packed into sealed sachets and liquids into small, sealed pots. These individual doses are packed
into coil-like components similar to those found in vending machines; a twist of the coil delivers a dose. The cabinet has the capacity to hold 5120 doses of up to 200 different drugs. Drugs which are not suitable for storage inside the cabinet, either because of their size, the need to be refrigerated or the drug not being available as a unit dose, are stored on shelves, in cupboards or in a refrigerator in the normal way. On each ward and in the pharmacy department the system is driven by a local processor, co-ordinated from a central processor.

The cost of the system in the USA has been quoted in a recent review article as $1.3 to $1.5 million for a system consisting of 20 cabinets (Perini and Vermeulen 1994). Usually there is one cabinet per ward and so this would probably be sufficient for a ‘district general’ size hospital. However, the likely cost of the system in the UK, had not been disclosed when this research was being conducted.

The functions of the Meditrol system can be divided into; data entry; order, supply and storage; and drug administration.

**Data entry**

All information entry and access to the system is by keyboard with password security. When patients are admitted onto a ward a variety of details are entered by nursing staff, including patient name, date of birth and hospital number. There is the capacity to enter drug allergies at this stage or at a later time. In the US hospitals operating Meditrol, pharmacists maintain the medication profiles on the system by transcribing details from orders written by doctors. The medication profile includes the drug preparation, route, dose and exact time when it should be given.
Order, supply and storage

When prescription details for a drug are first entered and the drug is not available on the ward, an order is sent electronically to a terminal in the pharmacy dispensary. From a printed order, a small contingency supply, known as a 'baggy', is dispensed in unit dose form if possible (or in the traditional manner if not) and sent by porter. Subsequent supplies of drugs are provided daily at fixed times; assistants or technicians generate a picking list (for products stored inside and outside of the cabinet) and assemble the order. Unit doses are packed into the coils, taken to the ward in a specially designed trolley and then loaded into the cabinet. Drugs not stored inside the cabinet are delivered at the same time. Ad-hoc orders are generated by the system if there is insufficient supply on the ward to last to the next re-stock.

Drug administration

The system visually signals when a dose is due and lists for the nurse the patients requiring drugs at this time. By password entry, the nurse can then access the system for each patient in turn, the system delivering the patient's medication into a compartment on the top of the cabinet. A printout can be generated simultaneously which list drugs due for each patient. If a drug is not given she enters a code to explain why. If a drug that is due for administration is not available on the ward and the pharmacy department is closed, the system will list other wards holding the drug. The nurse can then obtain it from the machine at the alternative location. A drug trolley containing labelled drawers for each patient on the ward can be used to transport doses from the machine to the patient and to store suitably sized items not loaded into the cabinet as unit doses.
3.2 The trial site

3.2.1 The hospital

The Luton and Dunstable Hospital NHS Trust consists of 27 wards with 625 beds. There is a typical mix of 'district general' specialities with two regional specialities (ophthalmology and neonatology). In 1993/4 the hospital handled over 41,000 patient episodes. Appendix 1 contains a summary of the ward configuration in the Trust and appendix 2 contains a summary of the number of consultant episodes per annum by directorate.

3.2.2 The pharmacy department

Before the implementation of the trial system, the pharmacy department at Luton and Dunstable Hospital employed 40 staff (37.65 FTE), providing a typical range of services (Appendix 3 contains department staffing levels before and after implementation of the trial system). A dispensing service (the supply of medicines to specific patients according to a doctor's prescription) was provided to outpatients, inpatients and patients being discharged. Wards and departments obtained the majority of drugs used (those on their 'stock-list') by sending an order to the pharmacy distribution section. The wards also received a ward pharmacy service (see section 2.1.1 for a description of ward pharmacy). The clinical services department, in addition to co-ordinating the ward pharmacy service, provided services to the clinical directors in the form of policy review and financial reporting. Some senior pharmacists also attended some consultant ward rounds. The drug information section, equipped with a range of standard texts and on-line searching facilities, provided a query answering service to health-care professionals in the Trust. A part-time senior pharmacist was employed to compile the hospital formulary, carry out
drug use review work and was a member of the hospital drugs and therapeutics committee.

The production unit carried out both sterile and non-sterile manufacturing. The sterile manufacturing facility was atypical in that it operated as business, providing intravenous nutrition for other hospitals. Reconstitution of cytotoxic drugs was performed, though a centralised service for preparation of intravenous medication (provided with great success by a small number of hospitals in the UK) was not offered. Non-sterile production was limited to small scale re-packaging of medicines and some extemporaneous dispensing.

3.2.3 The original drug distribution system

A drug distribution system starts with the doctor making a decision to treat a patient with drugs and writing a drug order or prescription. The system includes the monitoring of drug treatment by the pharmacist (and other professionals), the ordering, preparation and supply of drugs to the ward, the storage of drugs on the ward, their administration to the patient and the documentation of these processes (either using paper-based methods or computer systems). A detailed account of the systems commonly in use in the UK and their evolution has been provided in section 2.1.1. The system in operation at Luton and Dunstable before implementation of the trial system is summarised in figure 3.1; the description below refers to this flow-chart representation. The processes of ordering and supplying of drugs needed on the hospital wards were dependent on the drug product or more specifically, whether it was designated as a 'stock drug' or as a 'non-stock drug' for a specific ward. Stock drugs were routinely kept on the ward as they were commonly used or may be needed in an emergency. Non-stock drugs were not commonly used (or
required particular caution in their use) and so were not routinely kept on the ward. This concept is common to most hospitals in the UK.

(a) **Prescribing (all drugs)** Doctors prescribed most drugs on the patient's drug chart, a dedicated pro-forma on which drug orders and drug administration records are written. The drug chart in use at Luton and Dunstable was typical of those used throughout the UK (appendix 4 contains a copy of the drug chart). Different categories of prescription could be written on specific sections of the chart. These were regular medication, drugs administered when required, drugs given once only, intermittent intravenous drugs and intravenous fluids or infusions. For patients undergoing surgical procedures, some premedication and other drugs given during or immediately after the operation were prescribed on an anaesthetic record sheet. When the drugs prescribed on this sheet had been administered, it was filed in the patient's case notes. Discharge medication was prescribed onto the patient's discharge summary. This consisted of an original and two carbon-less copies, one went into the patient's case notes and the other two were sent to the GP, one via the patient and the other by courier. Once the patient was discharged, the drug chart was archived in the patient’s case notes.

(b) **Prescription monitoring (all drugs)** All wards were visited by a pharmacist once daily (Monday to Friday) except the maternity and some care of the elderly wards which were visited at least once per week. Most pharmacists within the department were allocated wards to visit, and so in this capacity were referred to as 'ward pharmacists'. The ward pharmacist was expected to see each patient's drug chart every day, to monitoring patients' progress and advise other health care professionals, e.g. doctors and nurses, on improvements to patients’ drug therapy. At the same time supply of drugs not
All drugs
(a) Prescribing* ‘order’ for
drug treatment is written on the
patient’s drug chart

(b) Prescription monitoring*
- check that drug treatment is
appropriate for the patient

Doctor

Non-stock drugs
(c) Transcription* - Details
of any non-stock items are
written onto the ward
pharmacy sheet

Pharmacist

(d) Computer transaction#
- Required drugs are ‘booked
out’ and a label is produced
for the container

Technician

(e) Dispensing# - Required
drug is selected and the
appropriate quantity placed
in a suitable container and
label attached

Technician

(f) Checking# - The
dispensed item is checked to
ensure the required drug is
supplied correctly

Pharmacist

Stock drugs
(g) Ordering* - The quantity
of stock drugs on the ward is
assessed. If this fall below
the pre-determined level, a
card specific to the drug
product is filled out

Nurse

(h) Order processing# -
Bar-codes are scanned on the
cards to produce a computer
generated ‘picking list’. Items
on list are selected, packed
into a box and ‘booked out’ on
the computer system

Assistant

(i) Delivery - The item is
transported to the ward in a
locked box

Porter

(j) Storage* - Drugs are
stored in an appropriate
location on the ward

Nurse

(k) Administration* - Drug
is administered to the patient
at the appropriate time

Nurse

Location key:
* Ward
# Pharmacy

Figure 3.1 Flow chart representation of the original drug distribution system
normally stocked on the ward was initiated by the pharmacist (see section (c) below).
This arrangement was typical of that operating in most hospitals within the UK today.

Luton & Dunstable hospital was unusual in that it was experimenting with providing a consultant-based clinical pharmacy service to the general medical teams, rather than the usual service in which each ward was allocated a pharmacist. Four senior pharmacists were assigned to deal with one or two particular consultant’s patients rather than being allocated to specific wards; patients were usually cared for on one subset of wards although, they could be on any ward in the hospital. The pharmacists organised in this way could visit several wards each day. The pharmacist also contributed to the prescribing policy of their allocated consultant and attended a medical ward round each week to reinforce this role. Each of these pharmacists was also designated as liaison pharmacist to a particular ward to deal with any general problems that the ward staff may have with drug therapy.

(c) **Transcription (non-stock drugs)** When a doctor prescribed a medicine which was not routinely kept on the ward, an order was written by the ward pharmacist by transcribing the prescription details onto a dedicated pro-forma. On returning to the pharmacy department this order was then processed by the dispensary. Alternatively, if a non-stock medicine was needed urgently, a nurse could take the drug chart to the pharmacy to wait for the drug to be dispensed. The pharmacist authorising the supply of the drug (the ward pharmacist or a dispensary-based pharmacist) initialled and annotated the drug chart with the amount supplied. Supplies of non-stock medicines were replenished by the dispensary on instructions from the ward pharmacist at weekly intervals on a specified day for each ward and so the quantity of drug supplied when the
prescription was first written needed to be sufficient to last until the next convenient re-
supply day. If the drug was required when the pharmacy was closed the nurse could
either borrow the drug from another ward or contact the on call pharmacy service.

(d) **Computer transaction (non-stock drugs)** After the ward pharmacist deposited the
ward pharmacy sheet in the dispensary, a pharmacy technician, using the appropriate
program on the pharmacy computer system, produced a label for the drug, which stated
the drug name, the quantity supplied, the destination ward and the name of the patient.
The same transaction adjusted the computer stock levels for the drug product being
supplied. No patient specific data was stored on the pharmacy computer system in order
to avoid the need to register the system in accordance with the Data Protection Act and
so the only patient specific record of drugs prescribed was in the patients case notes.
However, for non-stock drugs the computerised record of dispensing included the
destination of the drug product, entered as a code during the transaction procedure (see
below for a more detailed description of information management in the department).
This process was essentially the same if a drug chart was presented directly to the
dispensary by a nurse.

(e) **Dispensing (non-stock drugs)** Once the drug required had been ‘booked out’ on the
pharmacy computer system and a label had been produced, the drugs were located and the
quantity required was dispensed into a suitable container and the label attached. The
dispensed drug, the original container and the ward pharmacy sheet (or drug chart) were
then arranged in readiness for a final check.
(f) **Checking (non-stock drugs)** Technicians’ dispensing was checked against the ward pharmacy sheet (or drug chart) for accuracy by a pharmacist or senior pharmacy technician. Ward pharmacy sheets were then filed in the dispensary until the end of the month when they were destroyed.

(g) **Ordering (stock drugs)** A stock-list for each ward defined the range and quantity of drugs which could be routinely kept on the ward and supplied by the pharmacy department without the need for a pharmacist to see a prescription. The contents of the stock-list and the quantities of each drug were decided by discussions between pharmacy and nursing staff. In this respect the system was typical of most UK hospitals, however the ordering of stock drugs was facilitated using a system known as ‘Shotley Bridge’, originally developed in the 1960s (at Shotley Bridge Hospital) and nowadays more popular in long-stay hospitals than in acute hospitals. For each stock drug on the ward was a card with the drug name in type and in bar-code, minimum and maximum stock levels and a grid for entering the amount of drug needed, the date and the nurse’s initials. These cards were sent to the pharmacy department in the ward’s pharmacy box (a lockable box large enough to contain a delivery of stock drugs). Nursing staff ordered stock medicines according to a regular schedule, to ensure that the quantity of each stock drug kept on the ward remained at the level stated on the stock list, returning excess quantities to the pharmacy department when necessary. The ward pharmacist inspected the drug cupboards on an ad hoc basis to remove items considered exceeding the maximum stock level or items no longer needed on the ward. If a stock drug was needed urgently, ward staff could take the card for that drug to the pharmacy department in order to obtain an ‘ad-hoc’ supply.
For medicines classed as Controlled Drugs (CDs) the system for their distribution was governed by the need for strict legal control and ordering was not performed using the Shotley Bridge cards. CDs were ordered by nursing staff in a dedicated requisition book and a running balance and details of each dose used were recorded in a dedicated CD register. Reconciliation of the quantity of each CD kept on the ward took place daily and involved two qualified nurses.

(h) **Order processing (stock drugs)** When an order for stock drugs had been compiled by nursing staff, the pharmacy box was delivered to the pharmacy distribution area. The cards were taken out of the box by a pharmacy assistant, who then processed them with a data capture terminal (DCT) (a hand held unit which could capture data by keyboard entry or bar code scanning with a light pen). A code for the ward was entered, a bar code on each card was scanned with the light pen and the quantity of each item required was typed into the unit. Once all cards for a particular ward had been processed in this way, the information in the DCT was down-loaded into the pharmacy computer and a ‘picking list’ was produced. The assistant then used the picking list to retrieve the required drugs from the shelves. As this process was carried out, the assistant scanned bar codes (on the shelves) for the drugs being picked. This created a new record of the order, taking into account unavailable stock. Alternatively, discrepancies could be noted on the picking list and the initial information amended on the computer screen. This information was then printed on a packing note which added on any items which were owing from previous orders and stated items which were ‘to follow’ and items which were ‘owing’. All medicines were supplied in bulk packages as either the manufacturers original pack or ward packs, for example a pack of fifty tablets.
(i) **Delivery (all drugs)** Both stock and non-stock medicines were delivered to the ward in the locked pharmacy box by a hospital porter assigned to the pharmacy department. Stock drugs and non-stock drugs were normally delivered to the wards at different times of the day, though essentially the process was the same.

(j) **Storage (all drugs)** When drugs were delivered to the wards by the porter, nursing staff transferred them to lockable cupboards on the ward. It was the nurse's responsibility to ensure the safe and correct storage of drugs on the ward. Drugs were stored in two locations, lockable drug cupboards, mainly used to store stock drugs and a lockable drug trolley containing stock drugs currently in use and non-stock drugs. The security of drugs at ward level was provided by the lockable medicines cupboards and trolleys and by nursing staff's compliance with local hospital policy for the safekeeping of medicines. Generally each ward kept one set of keys for all cupboards for which the nurse in charge was responsible; anybody needing the keys needed that nurse's permission.

(k) **Administration (all drugs)** Medication administration took place during four main drug rounds per day at 8am, 2pm, 6pm, 10pm. The 2pm drug round consisted of drugs prescribed for administration at 12 noon as well as 2pm. Single nurse administration rounds were introduced several months before the implementation of Meditrol, prior to which drug rounds had been carried out by two qualified nurses. The drug chart was the reference document for drug administration. Drug administration information could only be written on the drug chart by medical staff, though pharmacists could clarify the prescription, add further information or directions to aid nursing staff or under certain circumstances could amend prescription details with the prescriber's consent. During a
drug round the trolley would be wheeled from bed to bed (see figure 3.2). Drugs due were located, selected, the appropriate dose dispensed from the trolley, and administered to the patient according to the directions on the drug chart which was usually kept with other charts at the end of each patient’s bed. The drug chart was then signed by the nurse as a record of drug administration. If a drug was not available the nurse put a code number on the chart which indicated that the drug was not administered due to non-availability.

The pharmacy computer system

The computer system in operation in the pharmacy department (Horis®, Lennon Computers) provided support for stock control, purchasing from wholesalers and manufacturers, dispensing and labelling. When drugs were issued on the computer, they could be allocated to a consultant or a clinical location for costing purposes. The allocation of cost occurred during the ‘Order processing’ or the ‘Computer transaction’ stages, when a code was entered corresponding to either a ward or consultant and the nature of the prescription (outpatient, inpatient or discharge prescriptions). These codes were referred to as ‘cost-centres’. Outpatient cost centres were specific to the patient’s consultant though inpatient and discharge medication cost centres were specific to the ward. Consultant and ward cost centres were grouped into directorates. Reports could be produced which summarised the volume and cost of drugs issued to cost centres or cost centre groups (for example, the cost centres in a clinical directorate). The detail produced in the reports could be specified by the user; drug usage could be displayed by individual drugs or by groups of drugs, arranged according to the system’s own therapeutic drug classification system. These included use in a calendar month, the
Figure 3.2 Flow chart representation of the original drug administration round
average cost per month of the current financial year, total cost for the current financial year, projected cost for the entire year and the amount spent in the previous year. These reports were used to prepare financial summaries for clinical directorates and were sent to the service managers of most clinical directorates, though pharmacists provided them directly to two clinical directors.

'Inventory logs' were a record of all transactions (orders created, drugs received and drugs issued) and could be produced on a daily basis. They could be produced for the pharmacy stores and the dispensary. Information was displayed as drug catalogue number. (a unique number for each preparation specific to drug, formulation, strength and pack size) and cost centre (for drugs issued) or supplier code (for drugs received). Similarly, 'searches' displayed all transactions for a particular catalogue number and could be produced for specified days. Searches could be carried out for dispensary and stores issues.

3.3 History of the Meditrol trial

In 1991, during a visit to the USA, staff from The Boots Company viewed a demonstration of Meditrol, an automated, ward based unit dose dispensing system. Meditrol was being marketed in the USA against claims to reduce medication administration errors, to reduce the amount of drugs wasted on wards (primarily due to pilferage) and to reduce the amount of staff time required to facilitate drug distribution. Because of these claims, which were supported by anecdotal evidence in hospitals in the USA (at the time Meditrol was installed in two American hospitals), the Boots Company
perceived the unit dose method of supplying drugs in conjunction with Meditrol system as a means of improving drug distribution in the UK.

During that year approaches were made to senior managers of several hospitals in the UK by a company of management consultants, on Boots behalf. Reports of these approaches, allegedly bypassing pharmacy managers (Anon. 1991a) were met with extreme resistance and suspicion, in particular from the Guild of Hospital Pharmacists (a section of the Managerial, Scientific and Financial Union), who perceived a 'take-over attempt' and considered a boycott of branches of Boots the Chemists (Anon. 1991b). Early in 1992, the chief executive of the Luton and Dunstable NHS Trust granted The Boots Company access to the Luton and Dunstable site to carry out a trial of the Meditrol system.

In mid 1992, the Boots Company asked Professor Peter Noyce (the Boots Professor of Pharmacy Practice, University of Manchester) to consider Meditrol's evaluation. Professor Noyce then approached Dr Nick Barber, (then Senior Lecturer in Clinical Pharmacy at the School of Pharmacy, University of London and Director of Clinical Pharmacy Development in North West Thames Regional Health Authority) with a view to carrying out the work in collaboration. Dr Barber had visited the USA in 1992 as part of a fact finding group looking at automated dispensing. As a result, 'The Joint Universities Evaluation Team' were commissioned to carry out a comprehensive evaluation of the system. Two PhD students were recruited to carry out the Meditrol evaluation under the joint supervision of Professor Noyce and Dr Barber. One of these students was to develop methods to assess performance and efficiency of existing drug distribution systems, with an emphasis on the existing system. The second student (the author) had previously conducted research at MSc level assessing the potential benefits of
computerised prescribing which provided a starting point for some for several of the methods to used in the evaluation of Meditrol. Collaboration occurred with data collection and piloting of the methodology, though academic application of the findings occurred strictly in isolation. The author was to concentrate on applying methods to assess the impacts of new technology using a HTA framework.

The stance taken by the evaluation team was to remain strictly independent and, by contractual agreement, the evaluators maintained the right to publish any findings of the evaluation. No advice was to be given regarding implementation, though close contact was maintained with the progress of the trial, the agreement being that the evaluation team would intervene if they considered that the implementers were about to fall into an ‘elephant trap’ that would put the viability of the whole project in peril. Evaluators attended meetings, though only contributed when actions of the implementation team were likely to affect the evaluative research. Further evaluation of skill mix and economic analyses were commissioned by Boots from a group of management consultants. The Boots Company established a base in the hospital in mid 1992. The hospital seconded the dispensary manager and a ward sister to work as full time members of the evaluation team. In addition, a newly appointed care of the elderly consultant occasionally contributed to this group. Groups of potential users were also set up to establish likely problems in specific areas (such as intensive care). A national ‘Meditrol development group’, consisting of recognised experts in hospital pharmacy practice, hospital

1 These findings were not seen by the evaluation team.
consultants, a hospital manager, an authority on pharmacy law and a representative from
the Royal Pharmaceutical Society of Great Britain was set up to offer Boots advice on the
development of Meditrol and its niche in the UK health service.

At the onset of the trial The Boots Company were instructed by hospital managers that
professional practices, and in particular those relating to drug administration, should not
be altered. Doctors were to enter prescription data onto the system (ie computerised
prescribing) rather than pharmacists as this was seen as the most efficient method,
avoiding a duplication of effort if pharmacists entered doctors written orders. With this
brief the implementation team tailored Meditrol to the systems of work already in place
and any changes in practice were to be planned and agreed by hospital staff. This proved
to be a problematic area; the hospital members of the implementation team had a limited
influence throughout the hospital and felt they were not offered sufficient guidance by
senior professional staff or hospital management. The pharmacy manager made little
contribution to the progress of the trial and there was little in the way of strategy, such as
information requirements, coming from the hospital management. In summary there
seemed to be a lack of ownership and authority for the project.

In October 1992 two research pharmacists from the Joint Universities Evaluation Team
established a base in the trial hospital. A research protocol was submitted to the hospital
ethics committee, though the study was deemed to be an ‘audit’ and so approval was not
considered necessary. Pilot research was carried out in November and December and
research examining the established drug distribution system started in January 1993 and
continued through to June. Initially the Meditrol system was to be implemented in early
to mid 1993, however a number of problems contributed to a delay in implementation.
Most significantly it was realised that the system was not suitable for use by medical staff for entering prescription data; a knowledge of the pack sizes of drug products was needed and the screen designs were not deemed suitable. The solution was to use pharmacists to transcribe prescription data from doctors' original prescriptions on the drug chart, which would remain the definitive document for both prescribing and drug administration recording. This was the method used to operate the system in the USA and the fact that there were fewer pharmacists to train than doctors made this option more attractive, though extra pharmacists needed to be employed.

The implementation team were also experiencing several technical problems. Firstly, the Meditrol software (written in the Fortran language), required the correction of 'bugs' in the system and some re-design to suit use in a UK hospital. Secondly, difficulty was experienced with the packing of unit doses. This operation was carried out in a dedicated unit (commissioned for the trial) within the pharmacy production department using specialist equipment; the unreliability of this equipment caused delay which was further compounded by the resignation of the production pharmacist. Thirdly, due to the weight of the Meditrol cabinets, floors on some of the wards needed to be strengthened.

Installation of the working system on hospital wards eventually started in January 1994, around one year later than planned. Just prior to this the pharmacy manager had resigned and the chief executive brought in an external consultant (the chief pharmacist from a teaching hospital) to direct the project from the hospital’s side. A few months later a newly appointed service manager (responsible for pharmacy, pathology and imaging) had taken the lead from the hospital side which gave the project much needed direction. In May 1994 the new pharmacy manager was appointed, who had been involved with the
unsuccessful implementation of a ward based computer system at Guy’s Hospital and was able to inject further experience and authority into the project. Due to pressures on pharmacy staff and the need to support nursing staff on Meditrol equipped wards, the implementation was stopped after the eleventh ward, about half-way through the schedule which had included all of the wards in the hospital.

In March 1994 the post implementation evaluation commenced and continued through to mid August. During this time the Chief Executive of the trust resigned amidst controversy over allegations that she was bugging a consultant radiologist’s phone-line and a resultant vote of no confidence by hospital consultants.

The finished report of the evaluation findings was submitted to The Boots Company in early November 1994. A presentation was made to the Managing Director of the Boots Company later in the month and to the Meditrol Development Group at the end of November. As a result of the research findings, the Boots Company made the decision not to carry on with the Meditrol system, though the hospital had already made the decision to remove the system before seeing the evaluation report.

3.4 The Meditrol drug distribution system

Figure 3.3 shows a flow-chart representation of the Meditrol drug distribution system implemented at Luton and Dunstable and the description below refers to this. It should be noted that whilst there was no longer a differentiation between stock and non-stock drugs, parameters could be set on the computer system which meant that specific drugs would always remain on the ward (the equivalent of a stock drug). For other drugs,
Figure 3.3 Flow chart representation of The Meditrol drug distribution system
where retention on the ward was not desirable, the computer system could be set so that when a specified time period had elapsed without the drug being used, the system instructed its removal. All drugs were supplied in the same way, except for when an order was entered onto the system for a drug which was not on the ward.

(a) **Prescribing (all drugs)** - The drug chart was retained with the Meditrol system; doctors still wrote prescriptions onto it in the normal way.

(b) **Order entry (all drugs) & (c) Prescription monitoring (all drugs)** - The implementation of Meditrol onto 11 of the 27 wards in the hospital changed the function and structure of the ward-based pharmacy service. The ‘transcription’ of prescription data from the drug chart to the Meditrol computer system was carried out by ‘order entry pharmacists’. Seven out of the fourteen pharmacists who visited the wards (9 pharmacists visited wards before Meditrol implementation), were order entry pharmacists. The remaining pharmacists who visited wards only carried out the ward pharmacy function of the service. Ward pharmacy is differentiated from order entry below. The order entry pharmacists worked a shift pattern covering 9 am to 9.30 p.m. Monday to Friday and 9 am to 6.30 p.m. Saturday and Sunday. Typically, in any week the order entry pharmacists worked the following shifts:

- Conventional day shifts (9.00 a.m. to 5.30 p.m.) on Monday to Friday (3 pharmacists)
- Conventional day shifts (6.30 finish on Saturday and Sunday) on all 7 days (1 pharmacist)
- ‘Late’ shifts (1.00 p.m. to 9.30 p.m.) Monday to Friday (1 pharmacist)
• 2 days off (after working a weekend) and 3 working days without order entry duties (1 pharmacist).

• Conventional day shifts Monday to Friday without order entry duties (1 pharmacist).

Each of the 11 Meditrol wards received the following visits on each weekday:

• One ‘full’ visit by an order entry pharmacist where all charts were scrutinised and any new or amended prescription details were checked for safety and ‘transcribed’ onto the computer system. In addition to the keyboard and VDU positioned on the Meditrol cabinet, each ward was provided with another keyboard and VDU for use by the order-entry pharmacists.

• One visit by the ward pharmacist where all charts were scrutinised as for ‘prescription monitoring’ with the original system, though the with the implementation of the Meditrol system, ward pharmacists became less involved with the supply of medicines. The transcription process was no longer necessary and they were able to devote their time on the wards to prescription monitoring and providing advice to medical and nursing staff. A more in-depth clinical check was performed at this stage than at the order entry stage. On some of the wards, the order entry pharmacist may also have been the ward pharmacist and so this visit may have been combined with the ‘full’ order entry visit. Typically each order entry pharmacist was ward pharmacist for one of the Meditrol wards. The consultant based part of the clinical service was retained.

• One ‘walk on’ visit by the order entry pharmacist to ‘transcribe’ any new or amended prescription details from charts put to one side by nursing staff.
• One further ‘walk on’ visit in the evening by the late shift pharmacist.

On Saturdays and Sundays, only ‘walk on’ visits were made.

(d) ‘Baggy order’ (initial supply) - If an order was placed for a product which was not available on the ward the system sent a message electronically to the dispensary for a small quantity of the drug, referred to as a ‘baggy’ (an expression used in a hospital in the US where Meditrol was installed), pharmacy staff being alerted by the a print-out of an order. Each baggy provided enough drug to last until the next scheduled restock when an order for a larger quantity was generated (as for step (j) onwards).

(e) Computer transaction (initial supply) - The pharmacy technician ‘issued’ the required drug and produced a label. This process was identical to the carried out for non-stock drugs with the original system, except that the required details were obtained from the print-out rather than from the ward pharmacy sheet.

(f) Dispensing (initial supply) - The required drug was dispensed by a pharmacy technician in the same way in which non-stock drugs were dispensed in the original system.

(g) Checking (initial supply) - The dispensed ‘baggy’ was then checked for accuracy by a pharmacist.

(h) Delivery (initial supply) - The pharmacy porter took ‘baggies’ to the ward in a locked box.
(i) **Storage (initial supply)** - When the drugs arrived on the ward a nurse placed each item in a drawer labelled with the patient's name, in the drug trolley.

(j) **Order processing (inventory drugs)** - An order for the ward was generated at a specified time each day in the pharmacy distribution area by a pharmacy assistant using an option of the Meditrol programme called scheduled restocking. The system automatically ordered more stock if a specified minimum level had been reached. Drugs destined for the Meditrol cabinet on the ward needed to be available in individual dose units. At the trial site, these were called 'unit doses', though unlike the true unit dose philosophy adopted in the USA, doses were not manipulated to provide the exact dose prescribed (for example half a tablet or 7.5ml of liquid) and so will be termed 'individual dose units'. If drug products were available in individual dose units (a small minority of products) or were suitable for storage in the Meditrol system in the form produced by the manufacturer (for example, most injection ampoules) then no further packing by the pharmacy department was required. If this was not the case, drugs were packed into sachets or, in the case of liquids, into small pots. This process occurred in the production department and so no further packing was required in the distribution area.

The individual dose units required were then loaded into the coil-like components. These coils were available in various sizes to accommodate different sizes of packages. Under the direction of the computer, these coils were placed in specific alphanumerically labelled locations in a trolley specially designed for transporting the ordered drugs.
The system was also capable of predicting if the minimum level would be reached before the next stock delivery, based on the current orders (prescriptions) for the drug, and hence generating an additional order for more stock in advance.

(k) **Restocking (inventory drugs)** - On arriving on the ward, the assistant accessed another program on the Meditrol computer. The system systematically instructed which coils were to be removed from the cabinet and where the newly prepared coils were to be placed, again by referring to alphanumerically labelled locations in the cabinet and the trolley. For drugs stored outside of the cabinet, the system indicated the appropriate location, for example ‘Medicine cupboard 1’. Access to the inside of the cabinet was restricted to pharmacy staff, though nursing staff retained keys for the drug cupboards and refrigerators as before.

Initially procedures were written which allowed the storage of controlled drugs (CDs) in the Meditrol cabinet. This would have relieved nurses of the need for daily CD reconciliation, however poor compliance with the system operation in its early stages, together with software faults, necessitated that CDs were stored as before. Some adaptation of procedures was still necessary so that CDs could be ordered automatically by the Meditrol system whilst still complying with legal requirements.

(l) **Administration (all drugs)** - Figure 3.4 is a flow chart representation of the drug administration round with the Meditrol system. This shows the most common way in which the drug round was conducted, though there were several variations on this approach. For example, on some wards it was common for two nurses to be each allocated with half of the patients and simultaneously perform a shortened drug round.
Nurses could access the computer system to issue drugs thirty minutes before the time they were due for administration when they were prompted by the illumination of a light on the wall. There was then a 90 minute window during which time the nurse could access the system. The nurse logged onto the system with a personal identification number (PIN) and instructed the machine to dispense the drugs which, according to the computerised records, were due for each patient on the system. The machine issued individual dose units for one patient at a time. For items not in the cabinet the nurse was directed to the drug's location. Medicines were transferred into a drug trolley containing labelled drawers, one for each patient on the ward. This created an electronic record of the time the drug was issued, who it was issued to, and the name of the person whose PIN was used to issue the item.

Having transferred doses from the Meditrol cabinet (or from the drug cupboard) into the trolley, the nurse wheeled the trolley from bed to bed, locating the drug chart, confirmed that a drug was due for administration, selected the appropriate patient's drawer, and administered the drugs prescribed from it. If a drug was due which was not issued by the cabinet, the nurse usually dispensed it from a storage space in the drug trolley. After administration of the drugs the drug chart was signed and the trolley moved to the next patient. As the drug chart remained the definitive document for prescribing and guiding the administration of drugs, the nurses still checked each chart on the drug round; the opportunity to shorten the drug round by only visiting patients with drugs due could not be exploited.
When prompted by system individual dose units issued from cabinet and placed in trolley drawers

→ Non-cabinet drugs assembled as directed

→ Wheel trolley to 1st patient

→ Locate drug chart

→ Scan drug chart for drugs due to be given

→ Is order entered onto the system?
  Yes → Access Meditrol Computer
  No → Obtain drug from cabinet or locate on shelf

→ Is drug on ward?
  Yes → Is Pharmacy open?
    Yes → Is drug needed urgently?
      Yes → Take drug chart to pharmacy for further supplies
      No → Go to other ward and issue drug on Meditrol system
    No → Wait for order entry pharmacist
  No → Does the system locate drug on another ward?
    Yes → Wait until pharmacy open
    No → Is drug needed urgently?
      Yes → Contact emergency pharmacy service
      No → Supply brought to ward by on-call pharmacist

→ Select and dispense correct dose(s) for patient

→ Administer drugs to patient

→ Sign drug chart to confirm administration

→ Wheel trolley to next patient

Figure 3.4. Flow chart representation of the Meditrol drug administration round
If, during the drug round, the nurse found that a new prescription had been added but not entered onto the Meditrol system, a facility existed on the Meditrol system that allowed the nurse access to any drug stored within the system. In these circumstances the nurse had to return to the Meditrol cabinet and request the drug. If it was available it was issued to the nurse as units from the cabinet or she was directed to its location. The issue was logged to the patient prescribed the drug. If the drug was not available on the ward and the pharmacy department was open then the nurse contacted pharmacy for supplies. If the pharmacy was closed the system searched each ward location for the item. If found, it then informed the nurse of the ward from where the items could be obtained. The nurse could then go to that ward, issue the drug to his/her patient, and take the drug back to the patient for administration. If the drug was not available on another Meditrol ward the nurse would normally try to locate the drug by telephoning other wards. If the drug still could not be located then the nurse could contact the emergency pharmacy service. A pharmacist would advise the nurse accordingly. At the end of the drug round any unused medication needed to be ‘returned’ to the system to ensure the correct stock levels and the correct patient drug administration records. The system also allowed the nurse to repeat the dispensing of a dose if it was accidentally wasted.

**Meditrol generated information**

The Meditrol system had the potential to document every drug dispensed to patients on drug rounds, offering significant advantages over the pre-existing pharmacy computer system. Reports could be generated which provided drug histories for specified patients and the nature and number of doses which had been issued to them. Furthermore, the implementation team had developed a way of downloading data onto IBM PC
spreadsheets for further manipulation. The ultimate plan was for the Meditrol system to act as a feeder into the case-mix database, where costs would be allocated to patients’ drug consumption records to allow cost per episode calculation. This initiative, however, was never realised.

In practice, the utility of Meditrol’s information management capability was largely confined to operational aspects, such as locating expired doses. This was particularly useful as the unit doses packed on-site were allocated much shorter expiry dates by quality control than those originally allocated by the manufacturers (due to the lack of stability data relating to the repackaged products and the storage conditions within the Meditrol cabinet). Some pharmacists also used the system for locating patients receiving specific drugs for audit and drug usage review. The usefulness for this purpose was limited by the system being restricted to a portion of the wards and that issues were often not patient specific but to ward cost centres. Nurse managers also used the system to monitor nursing performance; information could be generated which compared the time doses were obtained from the system with when the doses were due to be administered to the patient.
4. Research strategy for the Meditrol evaluation

This section describes the research strategy employed for evaluating the Meditrol system, incorporating the HTA principles discussed in chapter 2. The first section describes how the potential impacts of the system were identified. The second section describes how a suitable framework was developed for the measurement of these impacts. Emphasis was placed on producing a framework which would accommodate not only the work described in this thesis but also evaluative research assessing the product at subsequent stages of development and dissemination. It was also intended that this framework would be suitable for the evaluation of other automated drug distribution systems. The third section describes the design of the research described in later sections of the thesis where specific outputs and outcome measures are described.

4.1 Identification of potential impacts of the Meditrol system

Meditrol was originally designed to solve known problems in the USA (in particular the high drug administration error rate) and the system was promoted to hospital managers at the trial site on the basis of the claims made by the Manufacturers (see table 4.1). However, very little research had been published (only in brief abstract form) which demonstrated the benefits claimed by the manufacturers. Furthermore, the drug distribution systems commonly operating in the USA are fundamentally different to those operating in the UK (descriptions of both systems are included in section 2.1) and so a direct extrapolation of these potential benefits was not considered to be appropriate without further consideration. Therefore, to postulate the potential benefits specific to
the UK, features of the Meditrol system were set against the perceived weaknesses in the UK drug distribution system discussed in section 2.1.1 (see table 4.2).

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient safety</td>
<td>A reduction in the incidence of drug administration errors</td>
</tr>
<tr>
<td>Reduced staff time</td>
<td>Reduction in staff time required to operate the drug distribution system</td>
</tr>
<tr>
<td>Inventory management</td>
<td>Reduction in the quantity of drugs held on the ward</td>
</tr>
<tr>
<td></td>
<td>Provision of ward inventory reports</td>
</tr>
<tr>
<td></td>
<td>Secure storage to reduce the quantity of medicines pilfered</td>
</tr>
<tr>
<td>Information management</td>
<td>Provision of detailed reports based on drug issues to individual patients</td>
</tr>
</tbody>
</table>

Table 4.1 Summary of the potential benefits of the Meditrol system stated in promotional literature.

A comparison of the perceived benefits to the UK drug distribution system with those claimed by the manufacturers demonstrated that the basic issues were the same; patient safety, staff time, inventory management and information management. However, differences were evident when the source and nature of benefits were examined in more detail. For example, when considering inventory management, improved security and the resultant reduction in staff pilfering were benefits claimed by the manufacturers (pilfering of drugs is a recognised problem in hospitals in the USA), though pilfering had not been perceived as a problem in the UK. However, the critical appraisal of the current UK system was based only on perceptions; it was not known whether the theft of drugs from wards was a problem or not. This uncertainty of the performance of the current system meant that the potential benefits based on the manufacturer’s claims could not be dismissed purely because they did not tackle perceived weaknesses in the UK system.

The evaluation, therefore, considered both the manufacturer’s claims from the US and the potential to rectify perceived weaknesses in the UK system.
<table>
<thead>
<tr>
<th>Current feature</th>
<th>Weakness</th>
<th>Meditrol feature</th>
<th>Potential impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-written prescriptions</td>
<td>Risk of misinterpretation, inconsistent presentation of information.</td>
<td>Prescriptions details on computer screen or print-outs</td>
<td>Improved patient safety</td>
</tr>
<tr>
<td></td>
<td>Doctors are remote to all but most basic paper-based information sources</td>
<td>On-line alerts for drug interactions and therapeutic duplication¹</td>
<td></td>
</tr>
<tr>
<td>Pharmacist transcription of prescription details</td>
<td>Duplication of effort</td>
<td>Direct relay of drug orders to pharmacy department²</td>
<td>Saving in staff time</td>
</tr>
<tr>
<td></td>
<td>Additional opportunity for errors to occur</td>
<td></td>
<td>Improved patient safety</td>
</tr>
<tr>
<td>Manual ward-based stock control</td>
<td>‘Stock’ drugs not tailored to demand, no information relating to ward inventories</td>
<td>Computerised stock control</td>
<td>Improved inventory management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Saving in staff time (nursing or pharmacy)</td>
</tr>
<tr>
<td>Paper-based drug orders</td>
<td>Nurse needs to visit each patient to determine if drugs are due</td>
<td>Computerised scheduling - system directs nurse to patients requiring drugs³</td>
<td>Saving in staff time (nursing)</td>
</tr>
<tr>
<td>Paper-based archiving</td>
<td>Inefficient retrieval of patient drug histories</td>
<td>Computerised drug histories</td>
<td>Improved information management</td>
</tr>
<tr>
<td></td>
<td>Limited capability to produce prescribing information</td>
<td>Computerised report producing facilities</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2. Weaknesses of the current UK drug distribution systems and features of the Meditrol system which have the potential to rectify them

NB this table relates to features of system as it was intended to be implemented. The system actually implemented differed in the following respects:

1. Doctors order entry was not implemented and so decision support facilities were not developed.
2. Order-entry pharmacists were still required to enter prescription data onto the system and so the potential to save pharmacists time be eliminating the ‘transcription’ stage was not realised.
3. The drug chart remained the definitive drug prescribing and administration record and so the nurse was still required to visit every patient on each drug round rather than being directed only to those with drugs due.
In addition to the potential impacts described above, an assessment of staff views was considered to be an essential component of HTA research. Such research was a prominent component of evaluations of (mainly manual) drug distribution systems carried out in the USA in the 1960's and 1970's. This type of evaluation was particularly relevant to a computerised system as it is recognised that computers in the workplace can have psychological and social influences on workers (Bradley 1989). Also, society in general is still learning how best to interface computers with their users, an issue which was recognised as a key requirement for successful implementation; exploration of staff views and attitudes may help to elucidate issues with interface design. For these reasons, an assessment of staff attitudes towards the system was included in the areas of study. It was also anticipated that this work would yield further, more contextual information to support research into the areas described previously in this section.

In summary, the formulation of research questions was carried out in an atmosphere of uncertainty, mainly due to the lack of information relating to the deficiencies of the current UK system. Areas of potential impact were identified from the manufacturer's promotional literature and by setting the planned Meditrol system against the perceived weaknesses of the UK system established by a critical review. This method was considered to be 'real-world' rather than ideal, though examination of the current system as part of the HTA process would provide valuable direction for future work, both in the long-term evaluation of Meditrol and of other systems. The potential impacts examined were patient safety, staff time, inventory management, information management and staff attitudes. The generation of more specific research questions is described in following chapters.
4.2 Development of a HTA framework for the evaluation of the Meditrol system

HTA frameworks described in the literature were examined to determine their suitability for the evaluation of drug distribution systems. Some of the descriptions of HTA frameworks consider broad concepts, often in the context of national strategy, for example Hailey and Crowe (1991), Kankaanpa (1991) and Spiby (1994). These provide insight into the context of HTA, though offer a limited direction to the researcher planning an evaluation project. Other frameworks described by Littenberg (1992) and Jennett (1983, 1993) define the HTA process which occurs in parallel with the conception, development and dissemination of the technology in question.

Littenberg (1992) describes 5 levels of technology assessment (see table 4.3). The first stage is to establish biological plausibility: Is the expected clinical impact in line with current understanding of biology and pathology? The second level is to establish technical feasibility: Determination of whether the technology does what it is supposed to do. Level 3 considers the performance of the technology by measuring intermediate outcomes, such as reduction in serum cholesterol or reduction in tumour size. Level 4 considers patient outcomes, with emphasis on factors such as long term adverse effects, survival and quality of life. Lastly, level 5 considers societal outcomes, which Littenberg describes as 'the ethical and fiscal interests of [society’s] members'.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Biological plausibility</td>
</tr>
<tr>
<td>Level 2</td>
<td>Technical feasibility</td>
</tr>
<tr>
<td>Level 3</td>
<td>Performance - intermediate outcomes</td>
</tr>
<tr>
<td>Level 4</td>
<td>Patient outcomes - long term adverse effects, survival, quality of life</td>
</tr>
<tr>
<td>Level 5</td>
<td>Societal outcomes - social and fiscal interests of society</td>
</tr>
</tbody>
</table>

Table 4.3 HTA framework - Littenberg (1992).
Littenberg’s framework is more relevant to the evaluation of interventional, diagnostic or health screening technologies than to systems which support the delivery of care.

Biological feasibility (level 1) is not relevant to drug distribution systems and the technical feasibility (level 2) of computer technology and automation applied to drug distribution systems is proven, though this kind of evaluation may be applicable to innovative technologies in the future. The assessment of intermediate outcomes (level 3) in the context of this framework relates to physiological and anatomical measurements, though parallels can be drawn with respect to drug distribution systems, for example drug administration error rate is an intermediate outcome used as an indication of the safety of drug distribution systems. Consideration of long term effects on patient survival, adverse effects and quality of life (level 4) is not relevant to the assessment of drug distribution systems; other, more short term patient outcomes such as morbidity, mortality and length of stay will provide a measure of the impact of drug distribution systems on the quality of care (the consequences of reduced error rates and more streamlined drug distribution).

The examination of wider ‘societal’ outcomes is an essential component of HTA, though in the context of computer technologies (and other health technologies), the attitudes and perceptions of staff and patients as well as the ‘ethical and fiscal’ aspects are a key element of a comprehensive evaluation.

Jennett (1983, 1993) described a framework consisting of 4 components (see table 4.4): 1. Technical feasibility and safety; 2. Efficacy in selected patients and places, usually formalised trials; 3. Effectiveness - a significant degree of improvement in outcome in a significant number of patients under average conditions; 4. Economic appraisal - comparison with other means of achieving the same end.
Jennett’s framework is similar to Littenberg’s, though places emphasis on the assessment of efficacy followed by effectiveness and there is no reference to measurement of social impacts, a key component of HTA. This approach to HTA had previously been promoted by other workers (Wall 1991, Tugwell et al. 1986) and is a standard technique used in the assessment of drugs by the pharmaceutical industry and, with the current R&D strategies and the emphasis on evidence-base medicine, is likely to be adopted for the assessment and development of other technologies. When assessing the efficacy of a drug, it is relatively easy to specify and to create ‘ideal’ conditions. However, with a computer system, designed to support a system of work, rather than a particular treatment or technique, ‘ideal’ conditions are less easily defined. Most computer systems need to be adapted to suit local needs; a strong technical team, responsive to user requirements would be desirable. Likewise, a high standard of training and technical support should be provided for system users and, in more general terms, the implementation team should be well resourced and sensitive to clinical, managerial and organisational issues.

Consideration should be given to the patient population being studied; patients receiving very specialised or complex drug treatments, such as cancer chemotherapy, may offer an unnecessary challenge to a prototype system and will provide findings which cannot be generalised to many hospitals. Having established efficacy under these conditions,
effectiveness can be measured under ‘average’ conditions with respect to implementation and training resources and more varied patient populations.

Certain aspects of both of the frameworks discussed above were incorporated into the synthesis of the framework used in this thesis, summarised in table 4.5. This framework incorporates the potential impacts of automation in the drug distribution system described in the previous sections. Level 1 considers the technical feasibility of the technology and, unlike other, more ‘conventional’, medical technologies was considered to be only appropriate for innovative technologies. Level 2 considers performance under the ideal conditions described above and, as such, is comparable with Jennett’s level 2 which considers efficacy and, with emphasis place on the measurement of intermediate outcomes, is comparable with Littenberg’s level 3. Performance under average conditions (measurement of effectiveness) is considered in Level 3 and is comparable with Jennett’s level 3. The emphasis on the measurement of true patient outcomes parallels level 4 of Littenberg’s model. The final level of the framework follows further dissemination and involves standard quality assurance and audit of the performance of the established system. As has occurred with current, pharmacy-based systems, this work is likely to be co-ordinated by local and national (or even international) user groups.

The evaluation of the Meditrol system described in this thesis was conducted at level 2 of the framework. Meditrol was a product developed for use in the US where it had been installed and was operating in 2 hospitals. However, there was little evidence in the literature of a formal evaluation of the system in this setting; the perceived benefits of the system were based on manufacturer’s claims and the experiences recounted by staff using the system in the US hospitals. The system had undergone extensive modification by the
implementation team in order to allow easier integration with current pharmacy, nursing
and medical practices at the UK trial site. The implementation was being carried out by a
relatively large team of staff, including seconded hospital staff and a high level of technical
support was available to users while operating the system. In this respect, although the
setting was regarded as ‘normal’ (rather than a specialist research institution), the
implementation was being carried out under near ideal conditions. Therefore, the
evaluation was considered to be focusing on the efficacy of the system rather than the
effectiveness.

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Technical feasibility (innovative technologies)</th>
</tr>
</thead>
</table>
| Level 2 | Performance under ideal implementation conditions on small scale
|        | - Impact on patient safety measured using intermediate patient outcomes |
|        | - Assessment of implications for staff time |
|        | - Assessment of impact on inventory management |
|        | - Exploration of staff attitudes |
|        | - Exploration of potential impacts on information management |
|        | - Basic economic analysis |
|        | - Emphasis on assessing potential |
| Level 3 | Performance under average implementation conditions on a larger scale in a wider range of settings |
|        | - Impact on Patient safety measured using true patient outcomes (morbidity, mortality, length of stay) or validation of intermediate outcomes |
|        | - Further assessment of impacts on staff time and inventory management in a variety of settings |
|        | - Comprehensive assessment of staff attitudes |
|        | - Quantitative assessment of the impact of information management |
|        | - Comprehensive economic analysis using all relevant parameters |
| Level 4 | Local audit and monitoring of system performance, co-ordinated through local and national user groups |

Table 4.5 HTA framework for evaluation of the Meditrol system.

It was acknowledged that initial research would provide information on the potential of
the product. Should sufficient potential be demonstrated by the initial evaluation, further,
more in-depth work would be required to demonstrate the true value of the product for at
least some of the impacts considered. In other words, the complete evaluation of the product would involve an iterative process, with each iteration providing more detailed answers to the questions being asked. According to this philosophy, leaving economic, social and ethical analyses to the final stages of HTA, as is implied by both Jennett’s and Littenberg’s frameworks, was considered inappropriate. Basic economic factors (in particular staff costs), and an exploration of staff attitudes as well as an assessment of performance were considered to be essential components of an early evaluation of a drug distribution system.

In summary, a framework was developed from existing, generic frameworks described in the literature. This framework was specific for drug distribution systems and incorporates the potential impacts identified from setting the Meditrol system specification against perceived and known deficiencies in the current drug distribution system and from Meditrol promotional literature. The evaluation was aimed at assessing the potential of the product and, should sufficient potential be demonstrated, more in-depth research would be required in parallel with further dissemination of the technology.

4.3 Evaluation design

The evaluation team became involved in the Meditrol project after the trial site had been selected and preparation for the implementation of the system had started. This restricted the options for evaluation design. A randomised controlled trial, considered by many workers in the field of HTA, to be the gold standard, was not possible. Instead a ‘before and after’ design was used. This involved using the wards in the trial hospital as their own control, conducting the research in a longitudinal manner. The drawbacks of this
design are that variations in patient population and staff characteristics as well as seasonal changes occurring during the course of the study may weaken the validity of the control achieved. This was however, considered to be the best achievable within the restraints imposed by the implementation plans. An alternative option considered was the use of a second hospital site as an external control. This option was dismissed as it was felt that, even with a carefully matched site, there would be more variation in patient, staff, operational and organisational characteristics between the two sites than would occur with a single site, longitudinal study.

The areas included in the evaluation were patient safety, staff time, inventory management, information management and staff attitudes. Outcomes and outputs measured are shown in table 4.6, together with the methods used and the corresponding subjects or areas of the hospital. The impacts associated with the commissioning of a small unit for the packing units of dose in the pharmacy department and the packing process itself were not considered during the evaluation. With further diffusion of the Meditrol system it was anticipated that individually packaged doses would have been obtained from the manufacturers at no extra cost (as occurs in the USA); the small scale packaging of unit doses was therefore viewed as a temporary measure and so was not studied by the evaluation team. The short term implications were being considered by management consultants, however this work was not seen by the evaluation team.

The ward based research was conducted either hospital wide or on 6 'core wards'. These were 2 medical, 2 care of the elderly and 2 surgical wards. These were considered to represent typical specialities provided at most hospitals. Individual wards were selected at
<table>
<thead>
<tr>
<th>Potential Impact</th>
<th>Measures</th>
<th>Method</th>
<th>Subjects/setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient safety</td>
<td>Drug administration error rate</td>
<td>Direct observation</td>
<td>Drug rounds on 6 core wards</td>
</tr>
<tr>
<td></td>
<td>Quality of prescription writing</td>
<td>Criteria based audit</td>
<td>6 core wards + selection of more specialised wards</td>
</tr>
<tr>
<td></td>
<td>Pharmacist intervention patterns</td>
<td>Analysis of pharmacist intervention records</td>
<td>All pharmacists' ward based work on all wards</td>
</tr>
<tr>
<td>Staff time</td>
<td>Staff time required to conduct drug rounds</td>
<td>Activity sampling using an observer</td>
<td>Drug rounds on 6 core wards</td>
</tr>
<tr>
<td></td>
<td>Staff time required for ordering drugs</td>
<td>Self recording</td>
<td>6 core wards</td>
</tr>
<tr>
<td></td>
<td>Pharmacists' ward based time</td>
<td>Activity sampling - self recording</td>
<td>All pharmacists' ward based work on all wards</td>
</tr>
<tr>
<td></td>
<td>Net changes in pharmacy staff levels</td>
<td>Observation</td>
<td>Pharmacy department</td>
</tr>
<tr>
<td>Inventory management</td>
<td>Volume and cost of drugs on the ward</td>
<td>Manual counts</td>
<td>6 core wards</td>
</tr>
<tr>
<td></td>
<td>Drug consumption not accounted for</td>
<td>Comparison of actual consumption with drug chart records</td>
<td>6 core wards</td>
</tr>
<tr>
<td></td>
<td>Computer inventory accuracy</td>
<td>Comparison of manual counts with computer reports</td>
<td>6 core wards</td>
</tr>
<tr>
<td>Information management</td>
<td>Descriptive accounts of cost savings</td>
<td>Observational case study</td>
<td>Hospital wide</td>
</tr>
<tr>
<td></td>
<td>Descriptive accounts of improved quality of care</td>
<td>Observational case study</td>
<td>Hospital wide</td>
</tr>
<tr>
<td></td>
<td>User perception of potential value</td>
<td>Semi-structured interviews</td>
<td>Key hospital staff</td>
</tr>
<tr>
<td>Staff attitudes</td>
<td>User perception</td>
<td>Structured interview</td>
<td>Random sample of nursing and medical staff, all pharmacy staff involved with drug distribution</td>
</tr>
</tbody>
</table>

Table 4.6 Summary of research evaluating the Meditrol system
random by drawing numbers from a hat. The rationale behind the selection of each measure and the methods used is explained in the appropriate chapter.
5 The impact of Meditrol on patient safety

In section 4.1, an improvement in patient safety was identified as a potential benefit of the Meditrol system, both according to manufacturer’s claims and by comparing Meditrol specifications with perceived weaknesses in the UK drug distribution system. This section considers the safety of the current UK system, the changes following the implementation of Meditrol which were identified as having the potential to facilitate improvements in patient safety and describes the research conducted to measure the impact of these changes.

Patient safety can be compromised by misjudgements or the introduction of errors at several stages in the current UK drug distribution process summarised in table 5.1 and described in detail below. At the start of the process doctors may prescribe inappropriate drug treatment, either as an oversight, or due to a lack of knowledge of either the drug being prescribed or the patient’s clinical status and history. These types of error include wrong doses, drug-drug interactions, drug-disease interactions, and therapeutic duplications. Illegible or unclear prescriptions may be misread by nursing staff (or pharmacists) and the wrong drug or dose may be administered. Practices such as using abbreviations for drug names, or units of drug weight or quantity (for example using ‘μg’ for ‘micrograms’ or using ‘u’ for ‘units’) may further compound the risk of drug administration errors occurring.
Prescriptions are monitored for safety and appropriateness to the patient by the ward pharmacist. This involves performing a systematic check of the doses prescribed, the

<table>
<thead>
<tr>
<th>Process</th>
<th>Worker</th>
<th>Nature of errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prescribing decision</td>
<td>Doctor</td>
<td>Wrong drug&lt;br&gt;Wrong dose&lt;br&gt;Wrong frequency&lt;br&gt;Drug-drug interaction&lt;br&gt;Drug-disease interaction&lt;br&gt;Therapeutic duplication&lt;br&gt;Patient allergy&lt;br&gt;Inappropriate route&lt;br&gt;Inappropriate method of administration.</td>
</tr>
<tr>
<td>2. Prescription writing</td>
<td>Doctor</td>
<td>Unclear prescription may be misread by nurses or pharmacists (see transcription and drug administration)</td>
</tr>
<tr>
<td>3. Prescription monitoring</td>
<td>Pharmacist</td>
<td>Inappropriate annotations&lt;br&gt;Prescribing error not detected</td>
</tr>
<tr>
<td>4. Transcription</td>
<td>Pharmacist</td>
<td>Wrong patient name&lt;br&gt;Drug&lt;br&gt;Strength&lt;br&gt;Formulation&lt;br&gt;Unclear writing may be misread by other pharmacy staff (see below)</td>
</tr>
<tr>
<td>5. Computer transaction</td>
<td>Technician</td>
<td>Label with wrong patient name, drug, strength or formulation.</td>
</tr>
<tr>
<td>6. Dispensing</td>
<td>Technician</td>
<td>Wrong patient name&lt;br&gt;Wrong drug ) +/-&lt;br&gt;Wrong strength ) drug-label&lt;br&gt;Wrong formulation ) mismatch&lt;br&gt;Wrong preparation</td>
</tr>
<tr>
<td>7. Checking</td>
<td>Pharmacist or technician</td>
<td>Labelling or dispensing errors not detected</td>
</tr>
<tr>
<td>8. Storage</td>
<td>Nurse¹</td>
<td>Integrity of drug product is compromised by incorrect storage</td>
</tr>
<tr>
<td>9. Drug administration</td>
<td>Nurse</td>
<td>Wrong dose&lt;br&gt;Omission&lt;br&gt;Commission&lt;br&gt;Wrong dosage form&lt;br&gt;Administration of an unprescribed drug&lt;br&gt;Wrong preparation of dose&lt;br&gt;Administration of expired drug&lt;br&gt;Wrong route</td>
</tr>
</tbody>
</table>

Table 5.1 Stages in the drug distribution system where errors can occur.

Notes: ¹In some hospitals pharmacy staff may be responsible for the storage of drugs on the ward.
combination of drugs used and a review of their suitability with respect to the patient’s clinical status and their response to drug treatment. The pharmacist contacts the prescriber to discuss any prescriptions considered to be inappropriate and to clarify any prescriptions which are unclear or ambiguous. Ward pharmacists annotate the drug chart with approved names, clarify doses written with abbreviated units and add additional directions to guide nursing staff when drugs are being administered to the patient (for example how to prepare drug products or whether the drug needs to be given with or after food). The pharmacist may annotate the prescription chart with inappropriate information, either inadvertently or due to misreading the doctor’s prescription. This may lead to the drug being administered incorrectly by the nurse or the wrong drug being given. The ward pharmacist may also make errors when transcribing information relating to non-stock drugs onto the pro-forma which is processed by dispensary staff. This may lead to the dispensing of the wrong drug product or to the drug being dispensed with the wrong patient name on the container.

In the dispensary, where non-stock drug requests are processed, errors can be introduced at the labelling (‘computer transaction’) stage or when the product is dispensed (the selection of the product from dispensary storage area, transfer of the appropriate quantity of the drug product from a bulk container to a smaller container, where necessary, and the attachment of a label with the drug product name, quantity and patient name). The final check is made by a pharmacist or technician (the latter usually deemed qualified to check by internal accreditation). Errors not detected by this final check may reach the ward where, if not detected by nursing staff, may reach the patient. In the distribution area of the pharmacy, the erroneous supply of drugs not included on the ward’s stock list could lead to products being available on the ward which are unfamiliar to the nursing staff or
which are deemed too dangerous for universal availability. For example it is recommended by the Royal Pharmaceutical Society of Great Britain that potassium chloride injection, which is potentially lethal if administered incorrectly, is not routinely made available to hospital wards.

Once the drug arrives on the ward, nursing staff (in most hospitals) are responsible for storing the drug in an appropriate place. Some drugs need to be stored in a refrigerator in order for the drug product to retain its potency. Failure to do so may mean that the patient does not receive an adequate dose of the active constituent. The final stage at which errors can be made is during the drug administration process. The nurse is responsible for selecting the correct drug and administering the correct dose to the patient, in the correct manner. The drugs are selected from the drug trolley or the drug cupboard shelf, from bulk containers (stock drugs) or from containers labelled for individual patients (non-stock drugs). Errors occurring during the drug administration include wrong dose, omitted doses, additional doses being administered (commission errors), wrong preparation of the drug administered (for example using the wrong diluent for an intravenous drug), administration of a drug which has not been prescribed, administration of a drug by the wrong route, administration of an expired drug and the administration of the wrong dosage form. At this stage the nurse may contact the prescriber or a pharmacist if there is doubt over the appropriateness of a prescription or for further guidance on how to administer a drug. The nurse may also detect errors which have occurred in the dispensing of drugs in the pharmacy department.

In summary, in the current UK drug distribution system, there are a number of stages where errors can be made. These are stages where a decision or judgement is made,
where information is transferred from one medium to another (for example from a drug chart onto a ward pharmacy order form) or where drugs are selected for transfer from one container to another, are labelled or are selected and prepared for administration to the patient. There are several stages where checks are carried out for appropriateness and to validate the contents and labelling of drug products. However, there has been very little research into the safety of the drug distribution system in the UK since the 1960’s, when several studies were published which examined the drug administration error rate.

In contrast to the UK, in the USA there has been a continuous focus on the safety of drug distribution systems since the 1960’s. The unit dose system was successful in reducing drug administration errors in the USA, though the labour intensity of the system often lead to deviations from the true unit dose philosophy (for example supplying unit doses for a 24 hour period rather than just before each drug round) and as a result the very low drug administration error rates (as low as 2%) were often compromised. Automated systems such as Meditrol aim to provide doses according to unit dose philosophy, but be less labour intensive for pharmacy staff than the conventional unit dose systems. The manufacturers of Meditrol claim that the system reduces the incidence of drug administration errors, though this is not substantiated with any research.

Although, the original raison d’être of the Meditrol system was to reduce the drug administration error rate, there were several additional features of the Meditrol system which were identified as having the potential to improve the safety of the UK drug distribution system. Firstly the display of prescription details on computer screen or printouts, rather than a hand-written prescription on a drug chart has the potential to improve the clarity, consistency and completeness of prescriptions. This in turn may have
an impact on the number of errors due to misinterpretation of prescriptions. Secondly, the provision of decision support for the prescriber that was planned for the trial (though in the USA, pharmacists enter prescription data onto the system) was viewed as a means of improving the quality of prescribing. Other features which were identified as contributing towards an improved safety of the system included the elimination of the wards pharmacist’s transcription process and the individual packaging of the majority of dose units under manufacturing conditions, with less dispensing in the dispensary. However, the number of errors made in transcription and dispensing with the conventional system were considered to be very low; for example Spencer and Smith (1993) determined a mean dispensing error rate of 18.1 errors leaving the department per 100,000 items dispensed. The influence of the Meditrol system in this area was considered to be more concerned with efficiency rather than safety and so transcription and dispensing errors were not examined in this study.

This study focused on the impact of the Meditrol system on drug administration errors, pharmacists’ clinical interventions and the quality of written prescription. The implementation of a system with pharmacist order entry rather than the intended doctor order entry had several consequences for this part of the research. Firstly, as the drug chart remained the definitive document which guided drug administration, the examination of the quality of written prescription was restricted to the original system. This research is described in appendix 5. Secondly, the examination of ward pharmacists’ interventions was originally aimed at assessing the impact of decision support software, the hypothesis being that the software would take care of some of the basic issues with prescribing, such as drug interactions. The emphasis of this research changed to that of assessing the impact of pharmacists entering orders onto the system; the new hypothesis being that this
process would increase the number of interventions made by pharmacists due to more intense scrutiny.

5.1 Drug administration errors

Methods

Several methods for quantifying drug administration errors have been described in the literature. Corak and Hartigan (1978) used tablet counts before and after drug rounds to determine if errors had been made. This method, however, cannot take into account for accidental wastage, administration to the wrong patient or incorrect preparation of the medication and so was dismissed as being unsuitable. The early work of Barker and McConnell (1962) established that the optimum method of determining the DAE rate was to observe the administration process; this method detected in excess of 1400 times more errors than the established scheme which relied on staff reporting their own errors. For this reason, a direct observation method was used which was developed by a co-worker in the evaluation team (Ridge et al 1995).

The study was carried out for one week on each of 2 medical wards, 2 surgical wards and 2 care of the elderly wards. These 3 specialities were chosen because they were considered to be typical of a 'district general hospital' and as such would be generalisable to other sites. The individual wards were selected at random by drawing numbers from a hat. Each ward was studied at least 4 weeks before the implementation, and at 10 and 20 weeks after the implementation of Meditrol in each location. Permission had been gained by the respective directorate lead nurses, with the agreement that no comments on an individual nurse’s performance would be fed back to nursing or hospital management.
Before each study week started the nurse in charge of each ward was informed that studies involving the recording of nurses' time involvement in the drug administration process would soon be starting. A general notice was also issued to all ward nursing staff.

The observation periods included all the scheduled drug rounds; 8am, 12 noon, 2pm, 6pm and 10pm. With the original system, drugs prescribed to be given on the 12 noon and 2pm drug rounds were combined into one round which usually commenced around 1-45pm (the 'lunch time' round). On most study wards after Meditrol implementation, this combined round was split into the two separate rounds. At least 12 drug rounds with the original system were observed on each ward and 14 drug rounds in each phase with the Meditrol system (two extra rounds were included to allow for the increase in the number of drug rounds per day), including at least two rounds for each time of day. One of two researchers (the author and a second PhD student) observed drug rounds with the original system, though on some rounds with the Meditrol system, where 2 nurses performed the drug round (each covering half of the patients), both observers were used. The administration of drugs not obtained from the trolley, but given as part of the same drug round was included in the observation period. Intravenous drug administration was usually carried out separately, at the end of the round and was not included in this analysis. On some drug rounds, intravenous drugs were given during the main round and, in these cases, were included in the observation. Immediately before nurses started their first observed drug round of the study the observer explained that this was a work sampling study and that all drugs due at that time would be noted to give an indication of workload. A work sampling study was carried out simultaneously (described in a later chapter) which provided a 'disguise' for the error study.
Barker's method of DAE rate determination was adapted for use in the UK by Ridge et al (1995). The use of this method in the UK raised ethical issues not experienced in the USA. With the American method of drug administration, the original medication order is remote from the patient and so the occurrence of most errors is established retrospective to the administration of the medication by comparing records made by the observer with the original doctor's order. In the UK the nurse administers medication according to the original order on the medication chart and so the observer was able to concurrently check the drug against the prescription and witness errors as they were occurring. Allowing errors to occur was deemed to be unethical and so a standard method of intervention was developed where, if a nurse was about to make an error, the observer could prevent it. The timing and method of intervention was standardised to give consistency between observers and was made as late as possible in order to allow the nurse sufficient time to correct the error, though without distressing the patient. Anonymity of nurses was maintained throughout due to the sensitive nature of DAEs within the nursing profession. Post implementation, due to the size and uniform nature of unit doses, it was not always possible for the observer to identify the drug being administered. Therefore, during this phase of the study, the contents of each patient's drawer in the drug trolley was recorded (after the transfer of unit doses from the Meditrol cabinet but before the drug round started), allowing reconciliation at the end of the drug round if necessary. In order to maintain the covert nature of the study, nurses were told that the observers needed to do this in order to assess the range and proportions of doses which were obtained from the cabinet.

DAE definitions were adapted from those of Allan and Barker (1990) and were: wrong dose, omission (in which the nurse did not see that a dose was due or could not find the
drug in the drug trolley despite it being present), commission (where the nurse intended to
give an extra dose of a prescribed drug), unprescribed drug (this included drugs not
actually prescribed but about to be intentionally administered and those due to wrong
selection or misreading of the drug name on the prescription), wrong dosage form, wrong
route, expired/unsuitable drug, incorrect dose preparation (where the drug product is not
prepared according to the manufacturer's or local guidelines, for example, using the
incorrect diluent for an injection) and error due to non-availability of medication (where
supplies of the drug are either exhausted or have not arrived from the pharmacy). During
pilot work a series of scenarios was produced and the two observers independently
allocated error categories to each. Any disagreements were discussed in detail to ensure
consistency of classification during the study proper. 'Wrong time' errors were
determined by comparing the time that the drug was administered (recorded for each
administration) with the time indicated on the drug chart. The data was analysed to show
the percentage of drugs which were administered within 1 hr and within 2 hours of the
prescribed time.

The DAE rate for each error category and the total DAE rate were expressed as
percentages, the denominator being the number of doses administered (including the
omissions where the observer needed to intervene) and 95% confidence intervals (CI)
were calculated using the method described by Altman (1991). A significant difference at
5% level was concluded if CIs for a comparable pair of DAE rates did not overlap. DAE
rates were calculated for each ward and these results expressed as a range. As is standard
practice in the USA, wrong time errors were expressed separately with CIs calculated as
described above
Results

During the pre-implementation phase of the research, 37 nurses were observed over 74 drug rounds. There were 115 errors during 3312 drug administrations. The number and type of errors observed are shown in tables 5.2 and 5.3. The total DAE rate was 3.5% (CI = 2.9% - 4.1%). The observed DAE rate excluding errors due to non-availability of medication was 1.9%¹ (CI = 1.4% - 2.4%). The observed rate of errors due to non availability of medication was 1.5%¹ (CI = 1.1% - 1.9%). The dose was given within one hour of the time indicated by the prescriber in 80.7% (CI = 79.4% - 82.0%) of cases and within two hours in 97.9% (CI = 97.4% - 98.4%) of cases (see Table 5.4).

<table>
<thead>
<tr>
<th></th>
<th>Number of nurses observed</th>
<th>Number of drug rounds</th>
<th>Total administrations observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original system</td>
<td>37</td>
<td>74</td>
<td>3312</td>
</tr>
<tr>
<td>Meditrol (10 wks)</td>
<td>47</td>
<td>83</td>
<td>2436</td>
</tr>
<tr>
<td>Meditrol (20 wks)</td>
<td>49</td>
<td>82</td>
<td>2585</td>
</tr>
<tr>
<td><strong>DAE Rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original system</td>
<td>3.5%</td>
<td>± 0.6%</td>
<td>1.5 - 5.4%</td>
</tr>
<tr>
<td>Meditrol (10 wks)</td>
<td>3.7%</td>
<td>± 0.7%</td>
<td>2.4 - 5.4%</td>
</tr>
<tr>
<td>Meditrol (20 wks)</td>
<td>3.5%</td>
<td>± 0.7%</td>
<td>2.1 - 5.8%</td>
</tr>
</tbody>
</table>

Table 5.2 - Drug administration error rate.

¹ The sum of the error rates for non-availability and errors excluding not availability do not add up to the total DAE rate due to rounding of values to 1 decimal place.
<table>
<thead>
<tr>
<th></th>
<th>Total DAE</th>
<th>NA</th>
<th>OM</th>
<th>WD</th>
<th>WF</th>
<th>UP</th>
<th>CE</th>
<th>WP</th>
<th>ED</th>
<th>WR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original system</td>
<td>115</td>
<td>51</td>
<td>27</td>
<td>17</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>% of total admins</td>
<td>3.5*</td>
<td>1.5</td>
<td>0.8</td>
<td>0.5</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>95% CI</td>
<td>±0.6</td>
<td>±0.4</td>
<td>±0.3</td>
<td>±0.2</td>
<td>±0.1</td>
<td>±0.1</td>
<td>±0.1</td>
<td>±0.1</td>
<td>±0.1</td>
<td>±0.1</td>
</tr>
<tr>
<td>Meditrol (10 wks)</td>
<td>90</td>
<td>31</td>
<td>34</td>
<td>11</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>% of total admins</td>
<td>3.7*</td>
<td>1.3</td>
<td>1.4</td>
<td>0.5</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>95% CI</td>
<td>±0.7</td>
<td>±0.4</td>
<td>±0.5</td>
<td>±0.3</td>
<td>±0.1</td>
<td>±0.2</td>
<td>±0.2</td>
<td>±0.1</td>
<td>±0.0</td>
<td>±0.0</td>
</tr>
<tr>
<td>Meditrol (20 wks)</td>
<td>90</td>
<td>37</td>
<td>29</td>
<td>11</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>% of total admins</td>
<td>3.5*</td>
<td>1.4</td>
<td>1.1</td>
<td>0.4</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>95% CI</td>
<td>±0.7</td>
<td>±0.5</td>
<td>±0.4</td>
<td>±0.3</td>
<td>±0.1</td>
<td>±0.2</td>
<td>±0.1</td>
<td>±0.1</td>
<td>±0.0</td>
<td>±0.0</td>
</tr>
</tbody>
</table>

Table 5.3 Types of drug administration error
NA - Non-Availability of Medication, OM - Omission, WD - Wrong dose, WF - Wrong dosage form, UP - Unprescribed drug, CE - Commission, WP - Wrong preparation of dose, ED - Expired/Unusable drug, WR - Wrong Route. *Sum of values does not add up to the total DAE rate due to rounding to 1 decimal place.

<table>
<thead>
<tr>
<th></th>
<th>Within 1 hour of prescribed time (% ± CI)</th>
<th>Within 2 hours of prescribed time (% ± CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original system</td>
<td>80.7 ± 1.3</td>
<td>97.9 ± 0.5</td>
</tr>
<tr>
<td>Meditrol (10 weeks)</td>
<td>79.6 ± 1.6</td>
<td>94.7 ± 0.9</td>
</tr>
<tr>
<td>Meditrol (20 weeks)</td>
<td>85.5 ± 1.4</td>
<td>97.7 ± 0.6</td>
</tr>
</tbody>
</table>

Table 5.4 Timing of drug administration
At 10 weeks after the implementation, 47 nurses were observed during 83 drug rounds. There were 90 errors observed during 2436 drug administrations. The number and type of errors are shown in tables 5.2 and 5.3. The total DAE rate was 3.7% (CI = 3.0 - 4.2%), not significantly different to that observed with the original system. The DAE rate excluding errors due to non-availability of medication was 2.4% (CI = 1.8 - 3.0%). The rate due to non-availability of medication was 1.3% (CI = 0.9 - 1.7%). The time of administration compared to that indicated on the prescription is shown in table 5.4. The dose was given within one hour of the time indicated in 79.6% (CI = 78.0% - 81.2%) of cases (not significantly different to that achieved with the original system) and within 2 hours in 94.7% (CI = 93.8% - 95.6%) of cases, (3% lower than that achieved with the original system, significant at 5% level).

At 20 weeks after implementation, 49 nurses were observed during 82 drug rounds. There were 90 errors during 2585 drug administrations. The number and type of errors observed are shown in tables 5.2 and 5.3. The total DAE rate was 3.5% (CI = 2.8% - 4.2%), not significantly different to that observed with the original system. The observed DAE rate excluding errors due to non-availability of medication was 2.0%¹ (CI = 1.5 - 2.5%). The observed error rate due to non-availability of medication was 1.4%¹ (95% CI = 0.9 - 1.9%). Forty two percent of errors were associated with pharmacist order entry, the majority of these being non-availability of doses for which orders which had not been entered. The dose was given within one hour of the time indicated by the prescriber in 85.5% (CI = 84.1% - 86.9%) of cases (5% higher than that for the original system,

¹ The sum of the error rates for non-availability and errors excluding not availability do not add up to the total DAE rate due to rounding of values to 1 decimal place.
significant at 5% level) and within two hours in 97.7% (CI = 97.1% - 98.3%) of cases, not significantly different to that achieved with the original system (see table 5.4).

Discussion

In the USA, DAE rate determination has been used to evaluate drug distribution systems since the 1960's (Barker & McConell 1962, Allan & Barker 1990) and its measurement is obligatory for hospitals to gain approval from the Joint Commission on Accreditation of Healthcare Organisations. In contrast, little work has been published in the UK since the work of Vere (1965), Crookes et al (1965,1967) and Hill and Wigmore (1967). The work presented here was the first UK study to examine drug administration errors in detail since these studies were published. The error rate of 3.5% achieved with the original system is similar to that measured after the introduction of the common prescription and drug administration record charts (3.1%) in the UK in the 1960's (Hill and Wigmore 1967) and that measured in US studies since the introduction of the unit dose system (a median error rate of 3.7% for observation studies, Allan and Barker, 1990). The incidences of DAEs determined before implementation and at 10 and 20 weeks after Meditrol implementation were similar as were the patterns of different types of error. A similar proportion of drug administrations were administered within 1 and 2 hours of the prescribed time in the three phases of the study.

Following implementation of the Meditrol system, no changes in the DAE rate were observed at either 10 or 20 weeks, though at 10 weeks after implementation there were slightly less administrations within 2 hours of the prescribed time compared with the original system and, at 20 weeks, there were slightly more administrations within 1 hour of prescribed time. The system was examined at 10 and 20 weeks after implementation in
order to investigate the relationship between time elapsed after implementation and the
error rate or, in other words, to establish if there was a 'bedding-in' period required in
order for workers to get used to using the system. These results suggest that the only
improvement in performance witnessed during the 10 to 20 week time-frame related to
timing of drug administration and not to the DAE rate itself. It is possible that
improvements in the DAE rate would occur over a much longer time-scale than that
studied; this hypothesis requires further research.

The Meditrol system did not reduce the drug administration error rate. However, the
Meditrol system was not implemented according to original intentions which may have
adversely affected performance for several reasons. The use of pharmacists for entering
orders meant there was an inherent delay between a doctor prescribing and the pharmacy
department receiving an order. Approximately 40% of DAEs were related to operating
requirements of the system (the majority being due to orders not entered and subsequent
non-availability of the drug), suggesting that if doctors had been entering orders, the
efficiency of the system may have improved, with an overall lower error rate due to non-
availability. A further implication of the use of pharmacist order entry in preference to
computerised prescribing was the retention of the drug chart as well as computerised
records, which resulted in the need for all prescriptions to be 'transcribed' onto the
system and so providing a greater potential for error. Wrongly entered prescription
details contributing to DAEs were witnessed during the study and were a source of
repeated (systematic) errors. The use of only the computerised record (compiled by
direct prescribing onto the computer system) may, therefore have resulted in a lower error
rate. In the US arm of a transatlantic study of DAEs a higher incidence of systematic
errors were associated with automated dispensing systems (with profiles entered and
maintained by the pharmacy department) than with unit dose cart systems or floor stock (Dean et al. 1995). This sort of error, due to the computerised medication record being incorrect, is repeated each time the drug is administered and is therefore potentially more harmful than one-off errors. This issue has been raised by several workers (Barker 1995, Neuenschwander 1996) and is a priority for future implementation and design of automated systems.

A further factor which may have accounted for Meditrol’s failure to reduce the DAE rate was the deviation from unit dose philosophy. Barker and Pearson (1986) describe a unit dose as:

‘A physical quantity of a drug product ordered by a prescriber to be administered to a specified patient at one time, in ready-to-administer form with no further physical or chemical alterations required.’

The ‘units of dose’ packed for the Meditrol system did not always comply with this definition as packages containing a pre-determined quantity for each drug product were loaded into the machine. For solid dosage forms this was always one unit i.e. one tablet, one capsule etc. This meant that if the dose prescribed was, for example, equal to a half tablet, the nurse would need to perform a further ‘alteration’ to the ‘unit of dose’ i.e. break the tablet in half. Also liquids were packed in variable volumes ranging form 5ml to 30ml, depending on the product. Errors were observed for drugs where a further ‘alteration’ to the machine-dispensed, packaged drug was required. Furthermore, drugs not stored within the cabinet (about 50% of doses) were never presented to the nurse in ‘unit dose’ form. Barker et al. (1986a-c) concluded that, although the unit dose system was capable of achieving DAE rates of less that 2%, deviation from unit dose philosophy, either by supplying multiple dose packs or not delivering unit doses just before they are due (for example, by supplying unit doses for a whole day, rather than for each drug
round), results in a higher error rate. This evidence suggests that unit dose systems are only safer if the original philosophy is complied with rigidly.

Three other recent UK studies have measured the DAE rate using the same methodology as described here. In a study at a UK teaching hospital, the DAE rate was found to be 3.1% (95% confidence interval 2.5 - 3.7%) (Dean et al 1995). A similar pattern of types of error was found, though there was a lower incidence (1.1%) of errors due to non-availability. This may have been because the UK hospital where this study was carried out provided a 24 hour pharmacy residential on-call service. The second study using identical methodology demonstrated a DAE rate of 3.15% (Gethins 1996). The third study examined DAEs on care of the elderly wards in a 'district general hospital' and measured a DAE rate of 5.5% (95% confidence interval, 4.5% - 6.4%) (Ho et al 1997). These error rates, measured in different settings, are similar to that found in the pre Meditrol phase of this study, demonstrating that a DAE rate of 3.5% is of the same magnitude as that occurring in other UK hospitals.

The DAE rate is an intermediate or proxy outcome, and provides only an insight into the clinical and economic consequences of system errors. There are several drawbacks to the use of this outcome. Firstly, although there were no changes in the DAE rate or the distribution of errors by category as a result of implementation, it was tempting to conclude that there was no change in the overall safety of the drug administration process. However, this would have to assume that there was no change in the severity of the errors detected. As stated above, automated systems have been associated with a higher incidence of repeated errors, which are potentially more serious than one-off errors. This means that, although the error rate may remain the same, the consequences to the patient
may be more serious. With a cross-sectional study, such as this one, there is little indication of the exposure of individual patients to DAEs. Secondly, without knowing the impact of DAEs in terms of patient morbidity and mortality and hence being able to estimate the ultimate cost to the health care organisation, the true benefit of systems which successfully reduce the DAE rate cannot be established.

Several workers have studied error severity (Barker et al 1966, Hynniman et al 1970, Schnell 1976, Rippe and Hurley 1988), though assessment was either simplistic, classifying errors as 'serious' or 'less serious', according to the pharmacologic class of the drug or were subjective and not very well explained. Considering actual clinical outcomes, Barker et al (1966) failed to identify any documented consequences in patients' case notes which could be attributed to errors detected, though this does not mean that there were no adverse effects. Other workers have assessed the clinical and economic outcomes of DAEs by case-note review of patients known to have had clinical consequences from an error (Schneider et al 1995), though this methodology is biased towards more severe events. Such an assessment of outcomes would not have been an option in this study as errors were prevented by the observers.

In conclusion, the Meditrol system failed to make an impact on the DAE rate achieved with the original system. However, the DAE rate associated with the original system was lower than that anticipated by the implementation team. The implementation of a system which complied with the unit dose philosophy may have reduced the error rate to less than 2%, though this would have made the system more labour intensive. Similarly, prescriber order entry may have eliminated errors due to pharmacist order entry and would have eliminated the need for two prescription records, the computer version and
the drug chart. Further work is required to assess the clinical and economic implications of DAEs in order to assess the return on an investment in staff and technology aimed at improving system safety.

5.2 Pharmacists' clinical interventions

Methods

The aim of this study was to examine changes in the quantity and nature of ward pharmacists' interventions following the implementation of Meditrol. Originally this information was to be used to assess the impact of decision support software; intervention rate was to be used as a proxy measure of the quality of prescribing. The original hypothesis was that with the application of decision support software there would be fewer interventions concerning drug interactions and wrong doses. However, without the implementation of computerised prescribing, the emphasis of the study changed to that of examining the impact of the change in system on pharmacists' intervention rate. The new hypothesis was that the additional scrutiny of prescriptions in order to enter orders would result in a higher intervention rate.

In the UK 4 methods for analysing interventions have been described in the literature. Firstly, Hawkey et al (1990) classified interventions by the nature of the problem (for example 'prescription inappropriate', 'wrong dose' and 'inappropriate choice of drug or route') and by outcome. Secondly, Cousins and Hatoum (1991) described a method of intervention analysis supported by a computerised data base (QARx, American Society of Hospital Pharmacists) where interventions were categorised by the stage in the drug use process which they impact. Thirdly, Eadon (1992) described interventions only by their
perceived impact. The final method has been used throughout the North West Thames Region to examine the extent and nature of the pharmacists role in the drug treatment of individual patients (Batty and Barber 1992). This method was selected as both evaluators and ward pharmacists at the research site were familiar with its use. Also, interventions are categorised by the nature of the problem rather than the stage in the drug use process and so was deemed to be more suited to the purpose of the study; for example it was desirable to know how many interventions concerned unclear prescriptions, wrong doses or drug interactions.

The study was conducted over a period of 4 weeks, both before and after the implementation of Meditrol. The first phase was completed at least four weeks before the Meditrol implementation was commenced and the second phase was started 8 weeks after Meditrol has been installed on the eleventh ward. All ward pharmacists (9 before and 14 after implementation) covering 22 wards of the hospital (day surgery, labour ward and 3 maternity wards were excluded because of the absence or very low profile of the ward pharmacy service) participated in the study. In the second phase of the study, this included pharmacists carrying out order entry duties on the 11 wards equipped with the Meditrol system. Before each phase of the study started, ward pharmacists attended a short tutorial, explaining the aims and objectives of the study, and the definitions and method of classifying interventions. Written examples of interventions and how they should be categorised, together with answers to common questions, were provided at the same time.

Ward pharmacists recorded details of interventions whenever a prescriber was contacted with a view to changing drug therapy or to clarifying a prescription and when information
was obtained from patient case notes or records (other than at the end of the patient's bed). Also recorded were occasions when a pharmacist gave advice to ward staff or

<table>
<thead>
<tr>
<th>Prescription incomplete</th>
<th>Further information was required from the prescriber before the drug could be supplied or administered. This included omission of information or clarification of ambiguous prescriptions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulary</td>
<td>The drug prescribed was either not listed in the hospital formulary or was subject to restrictions</td>
</tr>
<tr>
<td>Administration</td>
<td>Concerned techniques for preparing, administering drugs, advice on the availability of alternative formulations (for example, liquid formulations for dysphagic patients) or the choice of route by which the drug was administered.</td>
</tr>
<tr>
<td>Dose/frequency</td>
<td>Concerned the dose of the drug prescribed and how often it was administered.</td>
</tr>
<tr>
<td>Duration</td>
<td>Usually concerned with courses of antibiotics or electrolyte supplements and involved the length of the treatment course.</td>
</tr>
<tr>
<td>Adverse drug reactions</td>
<td>The pharmacist suspected that a patient was suffering from the adverse affects of a drug treatment or warned the prescriber of the possibility of a patient suffering from an adverse effect or was asked for information relating to adverse effects.</td>
</tr>
<tr>
<td>Interaction</td>
<td>A drug combination was identified which could produce harmful effects or compromise the effectiveness of the medication. Also information requested (usually by a doctor) regarding the potential for drugs to interact.</td>
</tr>
<tr>
<td>Choice of treatment</td>
<td>Advice was offered (or requested) on the optimal choice of drug treatment for a specific patient.</td>
</tr>
<tr>
<td>Pharmacokinetics</td>
<td>The dosing regimen of a drug was modelled or checked using pharmacokinetic equations.</td>
</tr>
<tr>
<td>Pharmacology</td>
<td>Usually background information requested on the properties of a drug which had been prescribed for a specific patient.</td>
</tr>
<tr>
<td>Discharge medication</td>
<td>Clarification of prescriptions for patients to take home. Usually concerned differences between the discharge prescription and the inpatient prescription.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Those interventions which could not be readily allocated into one of the above categories.</td>
</tr>
</tbody>
</table>

Table 5.5 - Intervention categories according to the nature of the problem.
patients. All interventions made during ward pharmacy and order entry visits were included, but not interventions made in the pharmacy department or while pharmacists were on-call. The interventions were recorded on a pro-forma (see appendix 6) and a summary of the ward visit, including the time of day, the number of beds occupied on the ward and the number of interventions made were recorded on a second form (see appendix 6). Interventions were categorised by ward pharmacists according to the nature of the problem which prompted the intervention (see table 5.5), the outcome of the intervention (see table 5.6) and the prime reason for making the intervention. The categories according to prime reason for intervention were safety, efficacy, value for money, quality of life and controlled drug (CD) legislation. Pharmacists could allocate only one category for outcome and prime reason, though could allocate any number of categories according to the nature of the problem. At the end of each week the completed forms were collected from the ward pharmacists by one of the evaluation team.

| Prescription altered | Prescriber accepted the pharmacist’s advice and changed or initiated the prescription accordingly. |
| Prescription unchanged, advice accepted | The prescriber accepted the pharmacist’s advice but decided that a change in treatment was not merited (for example when the benefits of treatment were considered to outweigh the risks). Also when the pharmacist advised action which did not involve changing the prescription (for example advice to monitor specific patient parameters). |
| Advice not accepted | The prescriber disagreed with pharmacist’s advice and the prescription remained unchanged. |
| Resolved without doctor | The pharmacist identified a potential problem, but after scrutinising case notes, laboratory results or other information was satisfied that the prescription was appropriate. |
| Information only | Background information was provided to another healthcare professional which was related to a specific patient’s drug treatment but did not prompt any modification. |

Table 5.6 Intervention categories according to outcome.
Data was entered onto a Microsoft Excel® spreadsheet and sorted and summarised using a macro (copyright North West Thames Clinical Pharmacy Unit). The total number of interventions was calculated for each ward pre- and post-implementation. To adjust these for different frequencies of ward pharmacy visits and different bed occupancies, the results were expressed as interventions per week per 100 occupied beds using a mean bed occupancy value calculated for each ward from figures recorded by ward pharmacists on each visit. The data was then stratified by ward type (Meditrol and non-Meditrol wards) and a mean intervention rate was calculated for each group of wards pre and post implementation. Statistical analysis was performed by calculating the mean change in intervention rate with 95% confidence intervals for each group of wards using the method described by Altman (1991).

Data was analysed according to intervention category for all wards pre and post implementation. Percentage occurrences were calculated for each nature of problem, outcome, and prime reason category and 95% confidence intervals calculated using the method described by Altman (1991). A significant difference at 5% level was concluded if the confidence intervals for a pre and post implementation pair of values did not overlap.

Results

After implementation, the mean intervention rate for wards equipped with Meditrol had increased from 46 to 73 interventions per week per 100 beds occupied, an increase of 28 (± 10) interventions per week per 100 beds occupied. For wards which were not equipped with Meditrol, the intervention rate decreased from 89 to 55 interventions per
week per 100 beds occupied, though this difference was not statistically different at 5% level. Mean intervention rates pre and post Meditrol implementation are shown in table 5.7.

<table>
<thead>
<tr>
<th></th>
<th>Mean intervention rate (Interventions/week/100 beds occupied)</th>
<th>Mean change in intervention rate (±95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Meditrol</td>
<td>Post Meditrol</td>
</tr>
<tr>
<td>Meditrol wards</td>
<td>46</td>
<td>73</td>
</tr>
<tr>
<td>Non Meditrol wards</td>
<td>89</td>
<td>55</td>
</tr>
</tbody>
</table>

Table 5.7 Pharmacist intervention rates

Examining interventions according to the ‘nature of problem’, the percentage of problems relating to incomplete prescriptions increased from 4.7% (±1.4%) before implementation to 10.0% (±2.0%) after implementation (significant difference at 5% level). Other significant differences were a decrease in interventions related to adverse drug reactions from 21.4% (±2.7%) to 15.8% (±2.5%), and a decrease in interventions relating to pharmacokinetics from 11.3% (±2.1%) to 6.4% (±1.7%). Table 5.8 shows the analysis of interventions according to the nature of the problem.

Analysis of interventions according to ‘outcome’ showed that following the implementation of Meditrol, the percentage of interventions resulting in a change of prescription increased from 47.1% (±3.3%) to 55.7% (±3.4%). Pre implementation, significantly more problems were resolved without contacting the prescribing doctor (26.6 ± 2.9%) compared with post implementation (19.7 ± 2.7%). The outcome of pharmacists’ clinical interventions are shown in table 5.9.
Analysis of interventions according to the 'prime reason' for the interventions showed that there were no significant differences between the two phases (see table 5.10).

<table>
<thead>
<tr>
<th>Nature of problem</th>
<th>Pre Meditrol (all wards)</th>
<th>Post Meditrol (all wards)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%2 ± 95% CI</td>
</tr>
<tr>
<td>Prescription incomplete</td>
<td>41</td>
<td>4.7 ± 1.4*</td>
</tr>
<tr>
<td>Formulary</td>
<td>28</td>
<td>3.2 ± 1.2</td>
</tr>
<tr>
<td>Administration</td>
<td>101</td>
<td>11.7 ± 2.1</td>
</tr>
<tr>
<td>Dose/frequency</td>
<td>261</td>
<td>30.2 ± 3.1</td>
</tr>
<tr>
<td>Duration</td>
<td>40</td>
<td>4.6 ± 1.4</td>
</tr>
<tr>
<td>Adverse drug reactions</td>
<td>185</td>
<td>21.4 ± 2.7*</td>
</tr>
<tr>
<td>Interaction</td>
<td>60</td>
<td>6.9 ± 1.7</td>
</tr>
<tr>
<td>Choice of therapy</td>
<td>260</td>
<td>30.1 ± 3.1</td>
</tr>
<tr>
<td>Pharmacokinetics</td>
<td>98</td>
<td>11.3 ± 2.1*</td>
</tr>
<tr>
<td>Pharmacology</td>
<td>6</td>
<td>0.7 ± 0.6</td>
</tr>
<tr>
<td>Discharge medication</td>
<td>7</td>
<td>0.8 ± 0.6</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>33</td>
<td>3.8 ± 1.3</td>
</tr>
<tr>
<td></td>
<td>865</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.8 Nature of pharmacists' clinical interventions

Notes: 1. Eleven out of 26 wards were equipped with Meditrol.
2. The percentages do not add up to 100 as more than one nature of problem category could be allocated to each intervention.
* Denotes a significant difference at 5% level.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pre Meditrol</th>
<th>Post Meditrol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>% ± 95% CI</td>
</tr>
<tr>
<td>Prescription altered</td>
<td>407</td>
<td>47.1 ± 3.3*</td>
</tr>
<tr>
<td>Prescription unchanged, advice accepted</td>
<td>144</td>
<td>16.6 ± 2.5</td>
</tr>
<tr>
<td>Advice not accepted</td>
<td>21</td>
<td>2.4 ± 1.0</td>
</tr>
<tr>
<td>Resolved without doctor</td>
<td>230</td>
<td>26.6 ± 2.9*</td>
</tr>
<tr>
<td>Information only</td>
<td>50</td>
<td>5.8 ± 1.6</td>
</tr>
<tr>
<td>Unresolved at end of study</td>
<td>13</td>
<td>1.5 ± 0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>865</strong></td>
<td>**</td>
</tr>
</tbody>
</table>

Table 5.9 Outcome of pharmacists' clinical interventions.* Denotes a significant difference at 5% level.
Table 5.10 Prime reason for pharmacists' clinical interventions.

<table>
<thead>
<tr>
<th>Prime reason</th>
<th>Pre Meditrol</th>
<th>Post Meditrol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>% ± 95% CI</td>
</tr>
<tr>
<td>Safety</td>
<td>457</td>
<td>52.8 ± 3.3</td>
</tr>
<tr>
<td>Efficacy</td>
<td>258</td>
<td>29.8 ± 3.0</td>
</tr>
<tr>
<td>Value for money</td>
<td>84</td>
<td>9.7 ± 2.0</td>
</tr>
<tr>
<td>Quality of life</td>
<td>65</td>
<td>7.5 ± 1.7</td>
</tr>
<tr>
<td>CD legislation</td>
<td>1</td>
<td>0.1 ± 0.2</td>
</tr>
<tr>
<td>Total</td>
<td>865</td>
<td></td>
</tr>
</tbody>
</table>

Discussion

This is the first study to examine the effects of automation on pharmacists' intervention rates. After the implementation of Meditrol on 11 of the 27 wards of the trial hospital, the mean intervention rate on wards using the Meditrol system increased by 28 ± 10 interventions per 100 beds per week. This increase in interventions on Meditrol wards may have been because of the more frequent ward pharmacist visits to these wards and because of the more intense scrutiny required when entering orders compared with conventional prescription monitoring. The order entry pharmacist may also have seen prescriptions sooner after they had been written and so detected problems that would otherwise have been resolved by nursing staff on the drug round. Approximately one third of interventions on Meditrol equipped wards were made on order entry visits where the pharmacist only viewed newly written prescriptions.

There were some notable differences in the intervention patterns seen with the two phases. Following Meditrol implementation there was an increase in the number of interventions due to incomplete prescription. This supports the theory that when pharmacists perform order entry they pick up more problems sooner; incomplete prescriptions would prevent the pharmacist from entering the order. All interventions for
incomplete prescriptions would result in the prescription being changed and so the increase in ‘prescription altered’ outcome was not unexpected. There were reductions in the number of interventions made concerning adverse drug reactions and pharmacokinetics. This change in intervention patterns may reflect a decline in the performance of ward pharmacists. According to a model described by Campagna (1995), interventions which only involve clarification of a prescription have been described as submissive and are the least advanced with respect to the level of performance required. Interventions where a pharmacist questions a doctor’s decision after the prescription has been written have been described as corrective and require a higher level of performance; those where recommendations are made at the time of prescribing are described as consultative and require a still higher level of performance. The highest level of performance is associated with prescriptive interventions where the pharmacist makes the final decision. An increase in interventions due to ‘prescription incomplete’ (submissive interventions) and decreases in interventions involving ‘adverse drug reactions’ and ‘pharmacokinetics’ (corrective or consultative interventions) are, according to this model, associated with an overall decline in the level of performance of the ward pharmacy service.

Considering the outcome of interventions, more interventions were resolved without the doctor before Meditrol implementation. This provides further evidence that pharmacists were performing at a higher level before the implementation of the Meditrol system, with more potential problems being investigated by scrutinising case notes and other records and proportionally less being purely to clarify and correct prescribing (which would usually result in a prescription change).
A further difference between the two phases was the number of categories allocated to each intervention according to the nature of the problem. Pre implementation, an average of 1.29 categories were allocated per prescription compared with 1.16 categories per prescription post implementation. This inconsistency further complicates interpretation, though may be due to pharmacists categorising interventions differently or may suggest that interventions were more straightforward following implementation of the Meditrol system.

It is tempting to conclude that the introduction of Meditrol was responsible for the changes discussed above. However, the intervention rates and patterns may be quite sensitive to changes in staff, patient type or a change in doctors. During the post implementation phase the absence of a senior clinical pharmacist, performing ward pharmacy duties mainly on non-Meditrol wards, for some of the study period may have contributed towards the difference in the intervention patterns between the two phases. Also, more pharmacists were employed in the post implementation phase to carry out order entry duties on Meditrol wards. These pharmacists were relatively junior and may have diluted out the clinical expertise of the pharmacists working on the wards, which may explain the trend towards a lower level of performance (as interpreted using Campagna’s model) despite an increase in the intervention rate due to the additional prescription scrutiny associated with order entry.

The method used to document interventions before Meditrol was implemented involved recording the number of interventions made on each ward visit and a separate record of the intervention details and category allocations. Unfortunately, due to the way in which pharmacists recorded intervention details, the intervention records could not be matched
up with the wards on which they occurred, and so it was impossible to compare intervention patterns for Meditrol and non Meditrol wards. During the first phase of the study this was not perceived as a problem because the system was expected to be implemented on all wards in the hospital. As a result, the usefulness of the data summarising intervention patterns after implementation is limited due to its heterogeneous nature.

The original reason for studying interventions was to examine the impact of a basic decision support database which was to be used in conjunction with computerised prescribing. With the intended database, decision support would have been limited to drug interaction and therapeutic duplication alerts. More extensive decision support may include adverse drug reaction and contra-indication screening and may even provide information on the most appropriate choice of therapy. The use of a method of intervention analysis which categorises interventions by the nature of the problem (as opposed to the stage in the drug use process) is, therefore suitable for use in future evaluations assessing the impact of decision support databases. However, as discussed above, there may be a variety of factors which influence the intervention rate other than decision support.

In summary, it is difficult to draw solid conclusions from this study due to the heterogeneous nature of the data and due to a lack of control over the study. Intervention rates and patterns are likely to be influenced by a range of factors including staff changes (pharmacy and medical), time pressures and inconsistent classification of interventions. This method has been successfully utilised to describe the ward pharmacists’ role in the care of individual patients (Batty and Barber, 1992), to examine the influence of
workload on intervention rates (Barber et al 1993) and, more recently, to examine the
influence of factors such as pharmacist grade, ward type and time spent on the ward, on
pharmacists' intervention rates (Barber et al 1997). However, as a potential method for
assessing the impact of decision support software, it is too withdrawn from the
prescribing process; future work should focus on the development of alternative methods
which directly examine the prescribing process.
6 The Impact of Meditrol on staff time

The introduction of the unit dose system in the USA was associated with a reduction in nursing time and an increase in pharmacy time (Barker and Pearson, 1986). Automated systems were introduced to reduce the staff resources required to operate the unit dose system, whilst maintaining the low drug administration error rate associated with unit dose systems. In the UK the Meditrol system (incorporating computerised prescribing) was expected to provide the benefits of the unit dose system (including a saving in nursing time), though with a minimal impact on pharmacy staff resources.

The nursing involvement in the drug distribution process includes drug administration, controlled drug reconciliation and activities associated with stock control (such as the ordering and putting away of drugs). The Meditrol system was expected to eliminate nursing involvement in the ordering of drugs and the automation of dispensing on the ward, together with the application of a computerised patient drug profile, was expected to streamline the drug administration process, resulting in further savings in nursing time.

The main advantage to the pharmacy department, in terms of staff time, was perceived to be the direct relay of orders to the pharmacy department, achieved by computerised prescribing, which would have eliminated the need for pharmacists to transcribe orders onto forms for processing in the pharmacy department. This would have allowed the study of a ward pharmacy service where pharmacists had minimal involvement in the supply of drugs. The hypothesis was that this would have allowed ward pharmacists to
spend more time on clinical duties. However, when the decision was made to adopt pharmacist order entry, the emphasis changed; the expected outcome was an extension of the ward service to facilitate entry of drug orders by pharmacists.

With the original drug distribution system, stock drugs (about 80% of drugs administered) were supplied in bulk containers by pharmacy distribution. The remainder (non-stock drugs) were supplied in smaller quantities, labelled for individual patients, by the dispensary. With the Meditrol system, most drugs were supplied as individually packaged dose units loaded into coils. The consequences of this change in practice for the pharmacy workload and skill mix were uncertain.

This part of the research was carried out to assess the impact of the Meditrol system on nursing and pharmacy time. This section considers the impact of Meditrol on nurses' time consumed by drug stock control and drug administration and on ward pharmacists' time. The impact of the system on all pharmacy staff was examined on a macro level by observation of changes in staffing levels (these findings are shown in appendix 3 and their implications are considered at the end of the thesis).

**Overview of work study methodology**

Two different work study methods were considered for achieving the objectives of this part of the research. These were direct timing methods and activity sampling. Direct timing techniques involve using a stopwatch to time specific activities. They are best suited for activities which are performed in a predetermined or predictable order and which have an easily identifiable start and end point. For example, direct timing would be suitable for timing the individual manipulations executed during the reconstitution of
intravenous drugs in a pharmacy aseptic unit. This process is cyclical, performed in a predictable and predetermined order and the start and finish of each manipulation is easily predictable. A number of 'cycles' can be observed and the average time for each manipulation calculated. Alternatively, the time taken to perform each cycle can be measured by timing a period of activity, counting the number of cycles performed within the time period and calculating the average time per cycle. This approach has been used to analyse drug administration rounds (Cousins 1992, Johnson and Giles 1993, Counsell et al 1981), though the major disadvantage with this technique is that only a basic analysis can be performed (for example time per patient or time per drug administration). When the time taken to perform specific tasks within the drug round is required (for example dispensing drugs, reading the drug chart, administering the drugs to the patient), direct timing is unsuitable because the drug round is a complex activity consisting of a number of different tasks. Although the process is, generally speaking, cyclical in nature, the time spent on different tasks is highly variable, subject to frequent interruption and the transition between tasks is not easily anticipated. For this reason, when complex tasks are being studied, activity sampling methods are preferred (Roberts 1982).

Activity sampling involves dividing work into mutually exclusive activity categories. At specific times (either at set intervals or at random) the activity being performed by the subject is recorded or sampled. When a large number of samples are obtained, the proportion of the total number of samples for each activity approximates to the proportion of time spent on that activity. Activity sampling can be carried out with an observer or with the subject self recording. Activity sampling using an observer has been used to study ward pharmacy in the UK by Sykes & Oakes (1968) in their examination of 'The London system' with 'a team of work study officers' and, more recently, a
pharmacist observer was used in an exploratory study to investigate how ward pharmacists spend their time (Jenkins et al 1992). However, where a large proportion of the activities being studied are of a cognitive nature, as in the case of ward pharmacy, it is preferable to use self reporting as the subject is in the best position to allocate activity categories at the appropriate time (Nickman et al 1990). Also, self reporting methods do not consume as much researcher time as observer methods and data relating to the activities of many subjects can be collected simultaneously without the need for an equivalent number of observers. However, self reporting methods can be disruptive, particularly if the tasks being performed require intense concentration (for example during drug administration rounds) or the sampling interval is very short.

Activity 'samples' can be taken either systematically (at regular intervals) or at random. The disadvantage with systematic sampling is that the subjects may be able to anticipate the sampling time and so modify their behaviour. This is less of a problem if a short sampling interval, such as one minute, is used. In addition, bias towards specific activities may occur if the work being performed is cyclical in nature and the duration of the cycle is similar to the sampling interval. The random generation of signals is achieved using a signalling device. Signals are generated at random, though the mean rate can be altered.

A further advantage of activity sampling is that it can be used to analyse more than one aspect of the work process. For example, as well as the activity being performed, the location of the subject or the category of worker with whom the subject has contact with can be recorded (Yoon et al 1990, Rascati et al 1987). Using this method, termed multidimensional activity sampling, a more detailed picture of how time is spent can be created.
6.1 Nursing staff

Methods

The aim of this part of the study was to examine the impact of the Meditrol system on nursing time allocated to drug administration and drug stock control. Workers in the USA have examined the entire nurse's day (Schnell 1976, O'Brodovich and Rappaport 1991), the entire day excluding night shifts (Lee et al 1992, Barker et al 1964,) or have observed for 1 hour intervals selected at random (Simbourg and Derewicz 1975). These approaches were dismissed as the Meditrol system was expected to impact on discrete periods of activity rather than the whole day. Instead the study focused only on the time nurses spent ordering and putting away stock drugs (usually performed on an ad-hoc basis during quiet periods) and the drug administration round. The former was measured by a direct self timing method. This method was considered to be suitable as only a single activity was being performed at one time, in one location and with an obvious start and end.

Drug administration rounds were examined using an activity sampling method with one of two observers who were both members of the evaluation team. Pilot observations were made on 10 drug rounds on a selection of the study wards in order to divide the drug administration process into mutually exclusive activity categories; when the results were analysed these were aggregated to 8 or 9 categories (shown in table 6.1) in order to obtain narrower confidence intervals. A complete list of the activity categories used during the observation periods is shown on the data collection forms (see appendix 7). The two observers collaborated before data collection to ensure consistent classification of activities. A random sampling rate of 32 times per hour was used. The signal for sampling was generated by a silent, vibrating signalling device in the observer’s pocket.
(Random Reminder®, Divilbiss Electronics) which could be set for a variety of different random signalling rates using a series of switches inside the device. The signalling rate had been confirmed as accurate by other researchers who had use the devices to examine ward pharmacists’ activities (Beech and Barber 1993). Observers recorded activity categories on a specially designed form, together with the number of patients, number of drugs administered, and number of patients who received drugs. The use of standard times was adopted in preference to simple proportions for each activity category in order to take into account variations in workload. Several standard times were considered. Using time per drug administered or time per patient were considered unsuitable because of possible variations in the distribution of doses across the patient population. The denominator of the number of patients receiving drugs was used in order to allow for this variation. Ninety five percent Confidence intervals (CI) were calculated for standard times using the method described by Altman (1991).

Nurses were observed on 2 medical, 2 surgical and 2 care of the elderly wards. These specialities were selected as they were considered to be common to all hospitals; individual wards were selected at random by drawing numbers from a hat. The original system was studied at least 4 weeks before Meditrol was implemented and the Meditrol system was studied at 10 and 20 weeks after implementation. The observation periods included all the scheduled drug rounds with the drug trolley at 8am, 12 noon, 2pm, 6pm and 10pm. On all study wards pre Meditrol implementation, drugs prescribed to be given on the 12 noon and 2pm drug rounds were combined into one round which usually commenced around 1-45pm (the "lunch time" round). On most study wards after
'Dispensing medication' included selecting and preparing the dose for administration though not searching for the drug in places other than the drug trolley.

'Giving medication' included the tasks associated with actual drug administration the nurse performed at the bedside after dispensing the medication from the drug trolley.

'Travel' was all walking around the ward by the nurse except when moving from the drug trolley to the bedside.

'Patient assessment' or counselling included asking the patient if they require a particular drug, looking at patient observations (such as the pulse rate prior to digoxin administration) or counselling the patient with respect to drug therapy.

'Preparation' included manipulation performed on the medication before any drug administrations took place.

'Chart orientated activity' included looking for charts, picking them up, signing for drug administration and putting them back.

'Miscellaneous drug related activities' included looking for drugs in the medicine cupboard and checking patient identity prior to administration.

'Activities not related to drug administration' included any patient care or assessment carried out while on the drug round and any activities performed as a result of the nurse being called away from the round.

'Meditrol activities' included operating the Meditrol keyboard and cabinet in order to access or return medication.

Table 6.1 Aggregated activity categories used during the observation of drug administration rounds.

Meditrol implementation, this combined round was split into the two separate rounds. At least 12 drug rounds with the original system were observed on each ward and 14 drug rounds in each phase with the Meditrol system (two extra rounds were included to allow for the increase in the number of drug rounds per day), including at least two rounds for each time of day. On all drug rounds pre Meditrol and most post Meditrol a single observer was used. On some rounds post Meditrol where 2 nurses performed the drug round (each covering half of the patients), 2 observers were used. The observation period started as soon as preparation for the round commenced and finished when drug round...
administration and tidying up had been completed. The administration of drugs not obtained from the trolley, but given as part of the same drug round was included in the observation period. Intravenous drug administration was usually carried out separately, at the end of the round and was not included in this analysis. On some drug rounds, intravenous drugs were given during the main round and, in these cases, were included in the observation.

The mean drug round duration for each time of the day was calculated for each set of data. The difference between the mean drug round durations for both the Meditrol phases (10 weeks and 20 weeks after implementation) and the original system phase were assessed using Student's paired t test. For the purposes of the statistical analysis, the combined values for the 12 noon and 2pm drug rounds for each of the Meditrol phases were paired with the value for the single lunchtime round with the original system. It was considered appropriate to combine these values as the time taken to conduct the two drug rounds with the Meditrol system was equivalent to the time taken to perform the single lunch time round with the original system. Statistical significance was concluded with a p value of less than 0.05.

The time taken by nurses to order stock drugs and put them away when they had been delivered was recorded on a form by the nurse performing the activity.

Results

With the original system, 73 drug administration rounds were observed during which 2367 observations were made at random. The rounds comprised of 3073 drug administrations over a period of 77 hours, a mean time of 3.7 minutes per patient.
receiving drugs. The total time per day consumed by drug rounds was 262.5 minutes (4.4 hours) per day. On average 5.6 minutes per day were spent ordering stock and 4.8 minutes per day putting away stock. Table 6.2 shows a summary of the standard times for each activity category. Table 6.3 shows the average time per drug round time and the mean time taken for ordering of drugs from pharmacy.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Original system (mins ± CI)</th>
<th>Meditrol - 10 weeks (mins ± CI)</th>
<th>Meditrol - 20 weeks (mins ± CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispensing medicines</td>
<td>0.88 ± 0.06</td>
<td>0.77 ± 0.04*</td>
<td>0.82 ± 0.07</td>
</tr>
<tr>
<td>Administering medicines</td>
<td>0.78 ± 0.06</td>
<td>0.57 ± 0.04*</td>
<td>0.57 ± 0.06*</td>
</tr>
<tr>
<td>Travelling</td>
<td>0.20 ± 0.03</td>
<td>0.57 ± 0.04*</td>
<td>0.44 ± 0.05*</td>
</tr>
<tr>
<td>Chart-related activity</td>
<td>0.85 ± 0.06</td>
<td>0.85 ± 0.05</td>
<td>0.85 ± 0.07</td>
</tr>
<tr>
<td>Meditrol related activity</td>
<td>--</td>
<td>1.22 ± 0.05*</td>
<td>1.08 ± 0.08*</td>
</tr>
<tr>
<td>Preparation</td>
<td>0.25 ± 0.04</td>
<td>0.26 ± 0.03</td>
<td>0.26 ± 0.04</td>
</tr>
<tr>
<td>Assessment and counselling</td>
<td>0.15 ± 0.03</td>
<td>0.15 ± 0.02</td>
<td>0.15 ± 0.03</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.14 ± 0.03</td>
<td>0.19 ± 0.02</td>
<td>0.19 ± 0.03</td>
</tr>
<tr>
<td>Not related</td>
<td>0.41 ± 0.05</td>
<td>0.57 ± 0.04*</td>
<td>0.53 ± 0.06*</td>
</tr>
<tr>
<td>Total</td>
<td>3.7</td>
<td>5.0</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Table 6.2 Drug administration standard times (Minutes per patient receiving drugs)
* Denotes significant difference at 5% level from original system.

At 10 weeks after implementation of the Meditrol system, 73 drug rounds were observed during which 2535 observations were made. These rounds comprised of 2282 drug administrations over a period of 81 hours. On the drug rounds, the time per patient receiving drugs was found to be 5.0 minutes, compared to 3.7 minutes for the original system. The main reason for this increase was time spent on 'Meditrol related activities' (1.22 ± 0.05 minutes per patient receiving drugs). Compared with the original system, significantly more time was also spent 'travelling' (0.57 ± 0.04, compared with 0.20 ± 0.03 minutes per patient receiving drugs) and on 'not related' activities (0.57 ± 0.04, compared with 0.41 ± 0.05 minutes per patient receiving drugs), though significantly less
time was spent ‘administering medicines’ (0.77 ± 0.04, compared with 0.88 ± 0.06 minutes per patient receiving drugs) and ‘dispensing medicines’ (0.77 ± 0.04, compared with 0.78 ± 0.06 minutes per patient per day). The total time per day spent consumed by drug rounds was 359.9 minutes (6.0 hours) compared with 262.5 minutes (4.4 hours) consumed by drug rounds with the original system (p = 0.02).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Original system</th>
<th>Meditrol - 10 weeks</th>
<th>Meditrol - 20 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of drug rounds</td>
<td>73</td>
<td>73</td>
<td>86</td>
</tr>
<tr>
<td>Administrations</td>
<td>3073</td>
<td>2282</td>
<td>2529</td>
</tr>
<tr>
<td>8 am drug round</td>
<td>79.3</td>
<td>99.5</td>
<td>94.7</td>
</tr>
<tr>
<td>Lunch time/12 noon drug round</td>
<td>50.5</td>
<td>25.5</td>
<td>31.9</td>
</tr>
<tr>
<td>2pm drug round</td>
<td>--</td>
<td>45.4</td>
<td>45.9</td>
</tr>
<tr>
<td>6pm</td>
<td>57.3</td>
<td>73.7</td>
<td>76.6</td>
</tr>
<tr>
<td>10pm</td>
<td>75.4</td>
<td>115.8</td>
<td>81.2</td>
</tr>
<tr>
<td>Total drug round time</td>
<td>262.5</td>
<td>359.9*</td>
<td>330.3*</td>
</tr>
<tr>
<td>Ordering stock</td>
<td>5.6</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Putting away stock</td>
<td>4.8</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Daily total</td>
<td>272.9</td>
<td>359.9</td>
<td>330.3</td>
</tr>
</tbody>
</table>

Table 6.3 Total number of drug rounds, total number of drug administrations, duration of drug rounds and time taken to order and put away stock.

*Denotes a p value of < 0.05 when compared with original system.

Eighty six drug administration rounds were observed at 20 weeks after implementation during which 2509 observations were made. The rounds observed were comprised of 2529 drug administrations over a period of 87 hours. The total time per patient receiving drugs was 4.9 minutes, similar to that measured at 10 weeks. ‘Meditrol related activity’ consumed 1.08 ± 0.08 minutes per patient receiving drugs. Compared with the original system, more time was spent ‘travelling’ (0.44 ± 0.05, compared with 0.20 ± 0.03 minutes per patient receiving drugs) and on ‘not related’ activities (0.53 ± 0.06, compared with 0.41 ± 0.05 minutes per patient receiving drugs) and less time was spent ‘administering
medicines’ (0.57 ± 0.06, compared with 0.78 ± 0.06 minutes per patient receiving drugs).

However, unlike at 10 week after implementation, there was not significantly less time spent ‘dispensing medicines’. The total time per day consumed by drug administration rounds (330.3 minutes or 5.5 hours), was less than at 10 weeks, though still greater than the time consumed by medication related activities with the original system (p = 0.03).

Discussion

This is the first study in the UK to examine the impact of an automated drug distribution system on nursing time. The overall impact of the system was to increase the time involved in drug distribution (measured at 20 weeks after implementation) by just less than 1 hour per day (p = 0.03). The main reason for this increase was the time required to operate the Meditrol system; an additional 1.08 (± 0.08) minutes per patient receiving drugs was consumed by ‘Meditrol related activities’. There were some time savings due to the elimination of the need to order and put away stock drugs (an average of 10.4 minutes per ward per day) though this was insufficient to offset the additional time required to operate the system.

Fundamental changes in practice and the failure to implement computerised prescribing may have contributed to the Meditrol system being more time consuming. When Meditrol was being implemented, a review of practice associated with drug administration was carried out by hospital staff. This resulted in the decision to no longer merge the midday and the 2pm drug rounds into one lunch time round. This meant that instead of all of the drug charts being scrutinised once on the lunch time round they were now scrutinised at both midday and at 2pm. The main benefit in this practice was that drugs were being given nearer to the time of administration specified by the prescriber on the drug chart,
the trade off was that it was more time consuming. With respect to the failure to implement computerised prescribing, if doctors had been entering orders onto the system, the drug chart would no longer have been used. With an accurate computerised record, the system could have directed the nurse only to those patients who required drugs, eliminating the need to scrutinise every patient medication record. This may also have produced time savings on drug rounds at other times of the day, though it is uncertain whether this would have compensated for the additional time required to operate the Meditrol system.

A further consequence of pharmacists entering orders and the drug chart being retained as the definitive record of drug treatment was an inevitable lag between the drug being prescribed on the drug chart and the order being entered onto the system. When the nurse was carrying out the drug round it was common to find prescriptions written on the drug chart that had not been entered onto the system. In these cases the nurse needed to return to the cabinet and obtain the doses (if available) using a function which allowed a one-off dispensing of drugs not on the patient’s computerised record. This added further time onto the Meditrol drug round.

Although regular ordering and storing of stock drugs from pharmacy was eliminated with the Meditrol system, some nursing staff used the electronic message link to pharmacy to request drugs as required. Nurses were also required to enter new patients onto the system, update the patient’s location when they were transferred to another bed or another ward and to log patient discharges onto the system. These activities were not measured during the study. With hindsight, an activity sampling method capturing the entire nursing day would have captured any changes in the time required to operate the
system outside of the drug round; self recording techniques were considered to be unreliable. This approach, however, would have taken considerably more time and the method would have been sensitive to differences in patient dependence and nurse to patient ratios. During the evaluation the study hospital carried out a study using paid observers which compared a ward equipped with Meditrol and one without. For the reasons mentioned, the results of the study were difficult to interpret and inconclusive.

When the unit dose system was introduced in the USA, researchers were unanimous in their conclusions that a saving in nursing time resulted. Furthermore, an automated systems for dispensing controlled drugs was associated with a saving in nursing time (Lee et al 1992). These findings are in contrast to those presented from this study. This difference may be either due to the fact that the system operating in the UK is more efficient than both the unit dose system and the original (pre unit dose US) system or may be related to the nature of the Meditrol system as implemented in the UK. The original unit dose system involved the preparation of unit doses by pharmacy staff and the delivery to the ward, just prior to administration, in a ‘cart’. The nurse used the cart for the drug round, administering drugs from drawers labelled with each patient’s name. However, with the Meditrol system the nurse is required to load the trolley (cart) herself by accessing the computer system and initiating the automated dispensing process. If this step in the process was eliminated (by supplying the cart, already loaded, to the ward), the total time required to operate the system would be comparable to that of the original system (1.08 ± 0.08 minutes per patient were spent on ‘Meditrol related activities of a total of 4.9 minutes per patient, compared with a total time of 3.7 minutes per patient with the original system). Secondly, the use of parallel systems resulted in discrepancies between the drug chart record and the computerised record (due to the time lag between
prescribing and order entry) resulted in the nurse needing to return to the Meditrol cabinet during the drug round, doubling the time spent travelling (0.44 ± 0.05 minutes per patient with the Meditrol system compared with 0.20 ± 0.03 minutes per patient with the original system). The application of a unit dose system which provides the nurse with exactly what is required on the drug round (according to a medication record compiled by computerised prescribing), without the need to operate an automated dispensing system may have lead to a reduction in nursing time. The application of automated dispensing in the pharmacy department as opposed to on the ward could maximise the efficiency of the unit dose dispensing process (Jones et al 1989) and exploit economies of scale. Future research should be carried out to explore this option.

In summary, the Meditrol system, as it operated, failed to reduce nursing time involved with drug usage. The increase in the number of drug rounds carried out per day and the operating requirements of the system contributed to this increase. The failure to implement computerised prescribing may have further contributed to this by necessitating compliance with two systems. Furthermore, computerised prescribing would have eliminated the need for nurses to access the system to acquire doses not entered onto the system. The usability of the system may have further compounded the problem and the use of a static system (as opposed to a portable system) may have increased travel time. Not all activities related with the operation of the Meditrol system were captured during the study as they were not anticipated at the design stage. An analysis of the entire nursing day instead of or in addition to focusing on the drug round should be considered in the future.
6.2 Ward pharmacists

Methods

This study was designed to examine changes in ward pharmacists’ work patterns associated with the Meditrol system. The hypothesis was that there would be a reduction in time involved with supplying medicines (because of the automation of drug ordering from pharmacy) and there would be additional time required to enter prescription details onto the computer system.

An activity sampling method was considered to be the most suitable for this study because of the complex nature of the tasks being performed. Self reporting was used in order to capture cognitive activities and a reasonably long sampling interval was used to minimise the disruption for the subjects. Data was collected by bar code scanner (Datawand®, Symbol Technologies) using a method described by Beech and Barber (1993). The use of bar codes not only facilitated efficient data collection, but also rapid down-loading into a database. Two dimensions were examined; the activity being performed and the location of the pharmacist at the sampling time. Location was sampled as well as activity as it was anticipated that, when using the Meditrol system, pharmacists may spend less time at the patient’s bedside (arguably the optimum position for monitoring drug therapy) and more time at a computer terminal.

A two dimensional self recorded work sampling method was adapted from that of Beech & Barber (1993). Before both phases of the study, extensive pilot work was carried out, initially with researchers observing ward pharmacists, in order to test the suitability of the Beech and Barber activity and location categories and to develop new categories for work involving the Meditrol system. Categories and definitions are shown in tables 6.4 and 6.5.
The study examined the activities of all of the ward pharmacists (9 pre-implementation and 14 post implementation) for 25 wards in the hospital (labour and day surgery wards were not visited), including pharmacists entering orders onto the Meditrol system. Post-Implementation 11 of the wards were equipped with the Meditrol system. Twenty six days of ward pharmacy were examined before the implementation of the Meditrol system and 25 days after the implementation. The pre implementation phase was conducted at least one month before Meditrol was implemented on any of the wards and the post implementation phase, at least 2 months after the system was implemented on the last of the 11 wards. Before embarking on the study, definitions and examples of each of the categories were provided to ward pharmacists and they were thoroughly briefed on the principles of activity sampling and the use of the data collection tools. The sampling signal was generated by a Random Reminder® (Divilbiss Electronics) which could be set to emit an audible tone or a silent but detectable vibration at random intervals. The Reminder was set to generate a random signal at an average rate of 16 times per hour. Each pharmacist was issued with a pen- style bar code reader and a sheet of paper containing the activity and location categories printed as both text and bar codes, supplied by Symbol Technologies.

Unique bar-codes were used for data collected on Meditrol equipped ward in order to compare activities on Meditrol wards with those on non Meditrol wards. When prompted by the electronic reminder the pharmacist scanned an ‘activity’ category followed by a ‘location’ category (the bar code scanner was programmed only to accept data in this sequence). The bar code reader automatically dated and timed each scan sequence, and pharmacists also scanned ‘leave’ and ‘return’ bar codes on leaving and returning to the pharmacy department respectively so that the duration of each ward visit
could be calculated. Data was downloaded from the bar code scanners onto a personal computer every day. The data was then parsed onto a Microsoft Excel® spreadsheet for analysis. Results were expressed as standard times in minutes per ward per day with 95% confidence intervals (CI) calculated using the method described by Altman (1991). These parameters were calculated for all wards before implementation and for Meditrol and non-Meditrol (original system) after implementation.

<table>
<thead>
<tr>
<th>Activity Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescription monitoring</td>
<td>Included checking the prescription chart and monitoring for safety, efficacy and economy, including the identification of prescription monitoring incidents. This included both inpatient and TTA prescriptions.</td>
</tr>
<tr>
<td>Chart annotation</td>
<td>Annotation of the prescription chart with administration details, generic/approved name, dose and/or strength. This did not include supply details.</td>
</tr>
<tr>
<td>Information gathering</td>
<td>The gathering of information related to drug therapy and/or patient monitoring.</td>
</tr>
<tr>
<td>Change in drug treatment / patient monitoring</td>
<td>Action or attempted action taken to cause a change in drug treatment or patient monitoring.</td>
</tr>
<tr>
<td>Stock control</td>
<td>This included all activity, advice and information relating to the supply, storage and destruction of medicines.</td>
</tr>
<tr>
<td>Advice/ Information</td>
<td>The provision of advice and/or information on any topic with the exception of stock control and change in drug treatment/patient monitoring.</td>
</tr>
<tr>
<td>Travel</td>
<td>This included travel between the pharmacy and one or more wards, and travel between wards, but not travel whilst on the ward.</td>
</tr>
<tr>
<td>Waste/wait</td>
<td>Time wasted or time spent waiting on the ward.</td>
</tr>
<tr>
<td>Personal/PR</td>
<td>This included personal rest time, coffee breaks, social activities and public relations.</td>
</tr>
<tr>
<td>Order entry activities</td>
<td>Entering patient prescription details onto the Meditrol system.</td>
</tr>
<tr>
<td>Other</td>
<td>Any activity not described above, including data collection for this study.</td>
</tr>
</tbody>
</table>

Table 6.4 Ward pharmacy activity categories
Table 6.5  Ward pharmacy location categories.

<table>
<thead>
<tr>
<th>Location Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘End of bed’</td>
<td>Pharmacist is located at an occupied bed.</td>
</tr>
<tr>
<td>‘Nurses station’</td>
<td>Pharmacist is located at the area designated as that mainly occupied by nursing staff when they are not attending a patient.</td>
</tr>
<tr>
<td>‘Notes trolley’</td>
<td>Pharmacist is located at the central point for keeping patients’ notes.</td>
</tr>
<tr>
<td>‘Computer terminal’</td>
<td>Pharmacist is located at or near a computer terminal which is helping them perform their current activity.</td>
</tr>
<tr>
<td>‘On telephone’</td>
<td>Pharmacist is using a telephone which is helping them perform their current activity.</td>
</tr>
<tr>
<td>‘Between wards’</td>
<td>Pharmacist is located not on the ward but is between the pharmacy and the ward or between wards.</td>
</tr>
<tr>
<td>‘Doctors’ office’</td>
<td>Pharmacist is located in the area occupied mainly by medical staff when they are not attending a patient.</td>
</tr>
<tr>
<td>‘Other location’</td>
<td>Any other location not described in the above categories.</td>
</tr>
</tbody>
</table>

Results

Before the implementation of the Meditrol system, 9 pharmacists recorded data over a period of 26 days, during 243.2 hours of time spent out of the pharmacy department on ward visits. A total of 2972 work measurement samples were recorded. The proportion of time spent on all wards for individual categories and the standard times for each category are shown in table 6.6. The most time (9.7 ± 0.4 minutes per ward per day) was spent ‘prescription monitoring’, followed by ‘information gathering’ (5.6 ± 0.4 minutes per ward per day). By location, 11.4 ± 0.4 minutes per ward per day were spent at the ‘end of the bed’, 4.5 ± 0.3 minutes per ward per day at the ‘nursing station’ and 3.6 ± 0.3 minutes per ward per day at the ‘notes trolley’.
After the implementation of the Meditrol system on 11 wards, 4441 samples were collected. Of these, 75.5% were recorded on Meditrol wards during 247.4 hours and 24.5% were recorded on non Meditrol wards during 80.5 hours. The proportion of time spend performing individual activities and at different locations and the standard times for each category are shown in table 6.6.

After the implementation of Meditrol pharmacists spent significantly less time ‘prescription monitoring’ on both the wards operating the original system (5.9 ± 0.6 minutes per ward per day) and on those with the Meditrol system (6.7 ± 0.6 minutes per

<table>
<thead>
<tr>
<th>Ward pharmacy activities</th>
<th>Pre implementation (mins/ward/day ± CI)</th>
<th>Post implementation Original system (mins/ward/day ± CI)</th>
<th>Post implementation Meditrol system (mins/ward/day ± CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescription monitoring</td>
<td>9.7 ± 0.4</td>
<td>5.9 ± 0.6</td>
<td>6.7 ± 0.6</td>
</tr>
<tr>
<td>Chart annotation</td>
<td>1.3 ± 0.2</td>
<td>1.0 ± 0.3</td>
<td>1.4 ± 0.3</td>
</tr>
<tr>
<td>Information gathering</td>
<td>5.6 ± 0.4</td>
<td>4.7 ± 0.5</td>
<td>6.8 ± 0.6</td>
</tr>
<tr>
<td>Change in drug treatment/patient monitoring</td>
<td>1.2 ± 0.2</td>
<td>1.1 ± 0.3</td>
<td>0.9 ± 0.2</td>
</tr>
<tr>
<td>Stock control</td>
<td>0.6 ± 0.1</td>
<td>0.8 ± 0.2</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>Advice/information</td>
<td>1.9 ± 0.2</td>
<td>2.4 ± 0.4</td>
<td>2.8 ± 0.4</td>
</tr>
<tr>
<td>Travel</td>
<td>2.3 ± 0.3</td>
<td>2.6 ± 0.4</td>
<td>5.9 ± 0.6</td>
</tr>
<tr>
<td>Waiting/wasting time</td>
<td>0.2 ± 0.1</td>
<td>0.3 ± 0.1</td>
<td>0.9 ± 0.2</td>
</tr>
<tr>
<td>Public relations</td>
<td>0.6 ± 0.1</td>
<td>1.1 ± 0.3</td>
<td>1.0 ± 0.2</td>
</tr>
<tr>
<td>Other non Meditrol</td>
<td>0.8 ± 0.2</td>
<td>1.3 ± 0.3</td>
<td>1.6 ± 0.3</td>
</tr>
<tr>
<td>Order entry activities</td>
<td>—</td>
<td>—</td>
<td>25.6 ± 0.9</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>24.4</strong></td>
<td><strong>21.2</strong></td>
<td><strong>54.0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>End of bed</td>
<td>11.4 ± 0.4</td>
<td>8.6 ± 0.6</td>
<td>8.0 ± 0.6</td>
</tr>
<tr>
<td>Nurses station</td>
<td>4.5 ± 0.3</td>
<td>3.4 ± 0.5</td>
<td>6.2 ± 0.6</td>
</tr>
<tr>
<td>Notes trolley</td>
<td>3.6 ± 0.3</td>
<td>2.9 ± 0.4</td>
<td>3.7 ± 0.5</td>
</tr>
<tr>
<td>Computer terminal</td>
<td>—</td>
<td>&lt;0.1</td>
<td>23.9 ± 0.9</td>
</tr>
<tr>
<td>On telephone</td>
<td>0.2 ± 0.1</td>
<td>0.5 ± 0.2</td>
<td>1.3 ± 0.3</td>
</tr>
<tr>
<td>Between wards</td>
<td>2.4 ± 0.3</td>
<td>2.7 ± 0.4</td>
<td>5.9 ± 0.6</td>
</tr>
<tr>
<td>Doctors’ office</td>
<td>1.5 ± 0.2</td>
<td>1.9 ± 0.4</td>
<td>3.8 ± 0.5</td>
</tr>
<tr>
<td>Other</td>
<td>0.7 ± 0.2</td>
<td>1.1 ± 0.3</td>
<td>1.2 ± 0.3</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>24.4</strong></td>
<td><strong>21.2</strong></td>
<td><strong>54.0</strong></td>
</tr>
</tbody>
</table>

Table 6.6  Ward pharmacy activity analysis showing standard times for activities and locations.
ward per day) than during the pre implementation phase (9.7 ± 0.4 minutes per ward per day). Very little time was spent performing 'stock control activities' throughout the study, though significantly less time was spent on wards with the Meditrol system (0.2 ± 0.1 minutes per ward per day) compared with those operating the original system in both the pre-implementation phase (0.6 ± 0.1 minutes per ward per day) and the post implementation phase (0.8 ± 0.2 minutes per ward per day). Significantly more time was spent on waiting/waste on Meditrol equipped wards (0.9 ± 0.2 minutes per ward per day) compared with wards using the original system in both the pre implementation phase (0.2 ± 0.1 minutes per ward per day) and in the post implementation phase (0.3 ± 0.1 minutes per ward per day). The order entry activities on Meditrol wards accounted for an additional 25.6 ± 0.9 minutes per ward per day compared with the original system.

Over 40% of time was spent at the computer terminal on wards using the Meditrol system (23.9 ± 0.9 minutes per ward per day). Following implementation, significantly less time was spent at the end of the bed with both the Meditrol system (8.0 ± 0.6 minutes per ward per day) and the original system (8.6 ± 0.6 minutes per ward per day) than during the pre implementation phase (11.4 ± 0.4 minutes per ward per day). Significantly more time was spent 'between wards' when visiting Meditrol wards (5.9 ± 0.6 minutes per ward per day) than for the original system during both phases (2.4 ± 0.3 minutes per ward per day before implementation and 2.7 ± 0.4 minutes per ward per day after implementation).

Discussion

This is the first UK study to examine the impact of automated drug distribution systems on ward pharmacy activities. The results demonstrate that the implementation of the
Meditrol system resulted in more than a two-fold increase in the time pharmacists spend on the wards. This increase was mainly due to the activities associated with order entry, confirming the first study hypothesis. The second hypothesis, that less time would be spent on ‘stock control’, was also proven, though the time spent on this activity was very low throughout the entire study.

Following implementation of the new system, marginally more time was spent on ward pharmacy activities on Meditrol wards than on wards using the original system. This may be because of the nature of the wards which were equipped with the Meditrol system. The majority of general medical wards were equipped with Meditrol; general medical wards inherently carry a heavier prescription monitoring workload. However, there was a decrease in the time spent ‘prescription monitoring’ for both systems after implementation compared with that observed before. This may be due to the pressures placed on the ward pharmacy service to enter orders onto the system. It should also be noted that there was a change in patient population across the two evaluation periods pre and post Meditrol implementation; pre Meditrol was in winter and post Meditrol was in summer, affecting the patient mix and drugs used. During both phases of the study and on both types of wards, there was very little time spent on stock control (0.6 minutes per ward per day before implementation and 0.8 minutes per ward per day after implementation). This result was not expected as a previous study demonstrated that a larger proportion of ward pharmacy time (around 20%) can be spent on transcription of information and solving stock related problems (Jenkins et al 1992). This result suggests that the removal of drug supply responsibilities from the ward pharmacist (with computerised relay of orders direct to the pharmacy) will have a negligible effect on pharmacists’ ward-based time.
At certain times of the day, order entry pharmacists serving Meditrol wards needed to travel from ward to ward looking for prescription orders to be entered onto the Meditrol system. Therefore the amount of time spent travelling increased. Changes in location of activities can also be explained partly by the new needs of the Meditrol wards. Order entry was carried out at a computer terminal and so the pharmacists tended to spend less time at the end of the bed on Meditrol wards.

There was a decrease in time spent on wards with the original system after the implementation of Meditrol. However, when individual activities are examined, 'prescription monitoring' was the only activity and which consumed significantly less time and less time was spent at the 'end of bed' and at the 'nurses' station'. This is most likely to be due to the different nature of the wards in the 'post implementation, original system' group compared with the 'pre implementation, original group'. The latter group contained proportionally more medical and care of the elderly wards which are associated with a higher prescription monitoring work load (usually carried out at the end of the patient's bed or at the nursing station). The difficulties associated with unmatched groups are discussed in more detail below. Further difference may have been due to seasonal variations in the patient population, changes in staff and the increased pressure of running the Meditrol system on the pharmacy service as a whole. An increase in time consumed by 'public relations' was seen on the original wards after implementation. The reason for this could not be readily explained, though again may be due to the different nature of the wards.
The design of this study creates inherent difficulties with the interpretation of the results. It was anticipated that the system would be implemented on all wards in the hospital and so, for the pre implementation phase no measures were taken to separate the data for individual wards. When the Meditrol system was only implemented on 11 wards it was possible to use different bar-codes for the wards with each system. However, as a result, three sets of data have been obtained for activities carried out on 3 different groups of wards. This provides a lesson for future evaluation; measures should be taken at the research design stage to allow for incomplete implementation of new systems.

These findings demonstrate a significant increase in the pharmacists' ward-based time needed to operate the Meditrol system compared with the existing system. This activity analysis only considered ward based time and not time spent in the department, for example preparation for ward visits or slack time at weekends or during the evening. This significant time commitment required to operate a pharmacist order entry system (in this case only on 11 wards) renders this method non viable. The usability of the order entry screens was questioned; some processes such as the prescribing of a variable dose, variable route prescription to be given when required, could take up to 4 different entries, whereas this would only require one prescription on a drug chart. Although these issues must be resolved in the design of computerised prescribing systems, it is unlikely that optimising the interface design will reduce the time commitment needed to an acceptable level.
The introduction of the unit dose system in the USA increased the control over ward drug inventories and shifted the ownership of this control from nursing to pharmacy. The system allowed the restriction of the quantities of drugs kept on wards to those imminently due for administration to the patient with minimum manipulation required. This measure was aimed at reducing drug administration errors and, at the same time, reduced the availability of drugs for pilfering or wastage and allowed accurate recording of drug usage for billing purposes. However, the system was inherently labour intensive for hospital pharmacy departments who were individually dispensing all or most drugs for every patient for one drug round at a time. For this reason many hospitals adopted modified versions of the system, either by supplying doses once or twice a day rather than just before each drug round or by retaining a range of drugs as floor stock (drugs dispensed to the ward in bulk containers without patient specific labels). However, these modified unit dose systems were shown to be associated with a higher drug administration error rate than the true unit dose systems (Barker et al 1984a-c). The introduction of automation into the drug distribution system was aimed at making the process less labour intensive, either by reducing the frequency of drug supply to the wards with ward based automated systems or by automating the dispensing process in the pharmacy department, whilst still providing drugs to the nurse according to unit dose philosophy, restricting access to drugs and compiling accurate records.
In the UK, the incentive for designing the current drug distribution systems was to reduce the drug administration error rate; in contrast to the USA, pilfering has never been perceived as a problem and access to accurate drug usage records have not (until recently) been treated as a priority. As a result the current UK system, designed in the 1960's, provides a relatively low level of control over the inventory compared with the US unit dose system. However the trade-off for less control over the ward drug inventory with the UK system is that it is much less labour intensive than the unit dose system. Automated systems such as Meditrol and other ward based systems may be a means of introducing greater control over the ward drug inventory in UK hospitals, though without a significant increase in the staff resources required. The main areas of potential benefit to UK hospitals are; the ability to tailor the ward inventory to the current patient medication profiles and hence reduce the quantity of drugs that need to be held on the ward; the availability of information relating to quantity of drugs held on and consumed by the ward and; improved security due to restricted access cabinets. These areas are discussed further below.

Unit dose systems in the USA minimise the amount of drugs held at ward level by delivering doses either just before they are due or a maximum of 24 hours in advance. Automated, ward-based unit dose systems such as Meditrol allow less frequent re-supply of drugs, though the consequence is that a larger quantity of drugs are kept on the ward than with conventional unit dose systems. The UK stock/non-stock system provides a much lower degree of tailoring of the inventory to current prescriptions than with the conventional US unit dose system and so the inventory is much larger. Therefore, a computerised system which tailors the drugs kept on the ward to current medication records may lead to a reduction in inventories compared with traditional UK stock/non-
stock systems. Drugs are the single largest non-staff cost in most hospitals and significant sums of money may be tied up in ward stocks. With large inventories there may also be an increased opportunity for pilfering, an increased chance of error (the nurse is provided with a wider range of products from which to select doses) and a greater risk of drugs expiring than with smaller inventories. Therefore, an assessment of the impact of the Meditrol system on the quantity of drugs kept on the ward was included in the evaluation.

In traditional UK drug distribution systems computerised stock control is restricted to the pharmacy department; once the drug leaves the ward there is no record of the quantity of drugs kept on the ward and the only record of drug use is the drug chart which is paper based and archived in the patient’s notes. Technician top-up systems were introduced to provide some control over the quantity of medicines ordered for the wards in order to maintain the inventory of stock drugs between pre-determined minimum and maximum levels. Systems such as Meditrol can provide information relating to the amount of resource tied up in the hospital and can allow rapid location of specific products when required in an emergency or in the event of a drug recall. Furthermore, computerised, patient specific medication administration records could provide information for audit and resource management and could be used to support the contracting process. To achieve these goals, all transactions relating to the movement or administration of drugs must be accurately captured by the system. A particular concern was that, for drugs not stored inside the locked cabinet (where access to drugs is only possible by making the appropriate entry into the computer terminal), the system could be by-passed, by administering drugs without making the appropriate transactions on the computer system. In this case the patient medication record would be inaccurate and there would be less drug on the ward than reflected by the computerised inventory report. An assessment of
the accuracy of the computerised inventory was included in the evaluation as it was considered to be a key indicator of system performance; it not only provided a means of validating the information on the quantity of drugs held on the ward but also provided an indication of the level of staff compliance with the system.

In the USA, drug losses have been perceived as a serious problem; anecdotal accounts of financial losses of 15% were heard during visits to US hospitals by members of the research group. Losses have been attributed to wastage and pilfering by staff. For this reason secure systems, such as Meditrol, have been developed. In the UK drug losses have never been viewed as a major problem and certainly not a major source of financial loss, though theft of substances with potential for abuse has created concern in some hospitals. Security is provided by the use of lockable cupboards and drug trolleys with restricted access to the corresponding keys, though the larger inventory may provide a greater opportunity for undetected pilfering of drugs. The extent to which drugs are pilfered from hospital wards in the UK, however, has never been quantified and traditional systems do not provide a convenient audit trail, so the true situation is not known. Therefore, this part of the research also assessed the level of drug losses with the traditional stock/non-stock system compared with that of the Meditrol system.

7.1 General methodology

As described above, the aim of this part of the evaluation was to answer three research questions. These were: 1) Are fewer drugs kept on the ward with the Meditrol system than with the original system? 2) Is the Meditrol computerised inventory accurate? 3) Are there fewer drug losses with the Meditrol system than with the original system?
Research was carried out for a period of one week with both the original system and the Meditrol system on each of six wards. These were 2 medical, 2 surgical and 2 care of the elderly wards. These 3 specialities were selected as they were considered to be typical of most hospitals; individual wards were selected at random by drawing numbers from a hat. The research was carried out at least one month before and at least two months after the Meditrol system was implemented on each ward. Two researchers, both members of the evaluation team collected data or organised data collection during the study. All data processing was carried out using Microsoft Excel® spreadsheets. The definitions of medicines included in the study and the convention used for expressing the quantity of drugs and their costs is described below. With each system drugs were categorised according to how they were supplied and ordered or how they were stored. Medicine categories for each system are also shown below.

Study definitions

Drugs included in the study - The study included all drugs kept on the wards which were usually prescribed on the drug chart or other treatment records. Pharmaceuticals which were kept on the ward (not in the Meditrol cabinet), but were not usually prescribed were excluded. These were lotions, disinfectants, dressings and reagents. Also excluded were Controlled Drugs which were subject to more control and a daily reconciliation against records by 2 nurses.

Drug quantities - A method for expressing drug quantities was developed specifically for this study. All quantities of drugs were expressed in units of use, where a unit is the basic dose unit and consists of 1 tablet, 1 capsule, 1 ampoule, 5ml of an oral liquid or 1 item which was exclusively for a specific patient, for example 1 tube of cream, 1 inhaler.
Exceptions were: multi-dose vials of heparin, where 1 unit of use consists of 5,000 units and salbutamol nebuliser solution where 1 unit of use is 5mg.

**Drug costs** - All financial parameters were allocated using the most recent purchase price, including VAT, on the pharmacy computer system for April 1994.

**Drug categories used for original system**

*Stock drugs* - items included on the ward stock list.

*Individually dispensed medicines (IDMs)* - items supplied for an individual patient, labelled with the patient’s name.

*Non-stock drugs* - items not on the ward stock list and not labelled with a patient’s name. Theoretically these drugs should not be on the ward; they would normally have been obtained from other wards which kept them as stock drugs.

**Drug categories used for the Meditrol system**

*Cabinet drugs* - items on the Meditrol computerised ward inventory and stored in the cabinet as individual dose units.

*Shelf drugs* - items on the Meditrol computerised ward inventory though not stored inside the automated Meditrol cabinet but, as with the original system, on the shelf of the drug cupboard or in other storage space on the ward such as intravenous fluid racks.

*Baggies* - items supplied to an individual patient, labelled with the patient’s name, usually as a contingency until the item was added onto the computerised inventory when it would be supplied as for ‘cabinet drugs’ or ‘shelf drugs’.

*Non-inventory drugs* - items not on the Meditrol inventory and not labelled with a patient’s name. Similar to ‘non-stock drugs’, ‘non-inventory drugs’ should not exist on the ward.
Statistical analysis

The hospital ward was the unit of analysis for each of the studies in this chapter. All parameters used for comparison of the two systems were calculated for each of the six wards and expressed as the mean of these values. Confidence intervals were calculated for mean values using the method described by Altman (1991). Statistical significance at 5% level was concluded if confidence intervals did not overlap.

7.2 The quantity of drugs kept on the ward

Method

The quantity of drugs held on each ward was obtained by manual counts at the start of each one week period of data collection on each ward for both systems. Tablets in opened bottles were counted using ‘triangles’, capsules using capsule counters and liquids were measured using laboratory standard measuring cylinders. If containers were unopened it was assumed that they contained the quantity specified on the label. The results were expressed as average quantity of drugs per ward, average total value per ward and average value per unit. These parameters were also calculated for each inventory category for each system.

Results

The quantity of drugs kept on the ward with the Meditrol system (5379 ± 969 units per ward) was significantly lower than that measured with the original system (10314 ± 2,206 units per ward). However, on examination of stock holding by value, the difference between the two systems was not statistically significant. The average total quantity and value of drugs per ward with both systems are shown in table 7.1.
Table 7.1 Total quantity and cost of drugs kept on the ward

<table>
<thead>
<tr>
<th></th>
<th>Average total quantity of drugs per ward - units (± 95% CI)</th>
<th>Average total cost of drugs per ward (± 95% CI)</th>
<th>Average cost per unit (± 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original system</td>
<td>10,314 (± 2,206)</td>
<td>£1,626 (± £385)</td>
<td>16p (± 1p)</td>
</tr>
<tr>
<td>Meditrol system</td>
<td>5,379 (± 969)</td>
<td>£1,830 (± £507)</td>
<td>34p (± 5p)</td>
</tr>
</tbody>
</table>

Analysis of the data from the original system by inventory category demonstrated that stock drugs accounted for the bulk of the volume (9,334 ± 2,100 units), and the value (£1,226 ± £318). Non-stock drugs (which should not have been present on the ward) accounted for £354 ± £142. There was no difference between the average cost per unit of stock drugs and individually dispensed items (13 ± 2p and 13 ± 3p respectively), though the average cost per unit of non-stock drugs was significantly higher than both of these (56 ± 21p). Table 7.2 shows the distribution of value and volume across inventory categories.

Table 7.2 Distribution of drug quantity and cost by inventory category.

<table>
<thead>
<tr>
<th></th>
<th>Average quantity per ward - units (± 95% CI)</th>
<th>Average cost per ward (± 95% CI)</th>
<th>Average cost/unit (± 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original system</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stock drugs</td>
<td>9,334 (± 2,100)</td>
<td>£1,226 (± £318)</td>
<td>13p (± 2p)</td>
</tr>
<tr>
<td>Non stock drugs</td>
<td>636 (± 184)</td>
<td>£354 (± £142)</td>
<td>56p (± 21p)</td>
</tr>
<tr>
<td>Individual dispensed items</td>
<td>343 (± 129)</td>
<td>£46 (± £21)</td>
<td>13p (± 3p)</td>
</tr>
<tr>
<td><strong>Meditrol system</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabinet drugs</td>
<td>2,625 (± 139)</td>
<td>£340 (± £46)</td>
<td>13p (± 2p)</td>
</tr>
<tr>
<td>Shelf drugs</td>
<td>2,116 (± 616)</td>
<td>£1,155 (± £273)</td>
<td>55p (± 11p)</td>
</tr>
<tr>
<td>Non inventory items</td>
<td>578 (± 396)</td>
<td>£316 (± £293)</td>
<td>55p (± 19p)</td>
</tr>
<tr>
<td>Baggies</td>
<td>60 (± 25)</td>
<td>£19 (± £18)</td>
<td>32p (± 17p)</td>
</tr>
</tbody>
</table>

For the Meditrol system, although there was not a significant difference between the volume of cabinet drugs and shelf drugs, the cost of shelf drugs was significantly higher
(£1,155 ± £273, compared with £340 ± £46). Non-inventory drugs (which should not have been present on the ward) accounted for 578 ± 396 units and £316 ± £293. The average costs per unit of shelf drugs (55p ± 11p), non-inventory items (55p ± 19p) and baggies (32p ± 17p) were significantly higher than that of cabinet drugs (13p ± 2p).

7.3 The accuracy of the Meditrol computerised inventory

To assess the accuracy of the Meditrol computerised inventory, a report was generated by the implementation team just before the drugs were counted at the start of the week period. This report showed the quantity of each drug which should have been on the ward assuming that the only transactions made were those logged on the computer system and that these had been executed accurately. The two values (the actual quantity of drugs on the ward and the quantity according to the computer-generated report) were compared to assess the accuracy of the computer system. Traditional stock-take methods involve measurement and comparison of total stock values or quantities, to provide a net discrepancy. This method, however could give a falsely optimistic measure of accuracy as positive and negative deviations could cancel out. Comparing total quantities or costs would test the ability to account for total resource, yet the net figures produced would provide no indication of the accuracy for specific products and hence the overall accuracy of this information. For this reason, a method was developed which allowed the calculation of discrepancies for individual products expressed as either a surplus or a deficiency. An absolute discrepancy was calculated by summing all of these figures (treating all values as positive) and was considered the most accurate parameter to reflect

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1A transaction refers to drug movements between departments or dispensing for administration to a patient.
the accuracy of the computerised inventory information. These were calculated for cabinet
drugs and shelf drugs; non-inventory drugs and baggies were not included; the quantity of
these drugs found on the wards are shown in the previous section. Definitions of the
parameters calculated are shown below:

*Inventory discrepancy* - for each item, the value obtained by subtracting the number of
units stated on the inventory report from the number of units actually on the ward.

*Net inventory discrepancy* - the sum of all the individual discrepancy values (taking
account of negative and positive signs).

*Inventory deficiency* - the sum of ‘inventory discrepancy’ values for items where there
were fewer drugs on the ward than the inventory report stated (the negative inventory
discrepancy values).

*Inventory surplus* - the sum of ‘discrepancy’ values for items where there were more
drugs on the ward than the inventory report stated (the positive inventory discrepancy
values).

*Absolute inventory discrepancy* - the sum of ‘inventory deficiency’ and ‘inventory
surplus’ ignoring the signs.

Net inventory discrepancies were calculated by quantity and by cost. Inventory
deficiency, inventory surplus and absolute inventory discrepancy were expressed in actual
units and as percentages of the quantity or corresponding cost according to the computer
generated inventory report. In order to examine the influence of the Meditrol cabinet on

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1 This parameter is not shown in the results as it relates to individual drug products rather
than the entire inventory.
inventory accuracy, the data was analysed to produce separate values for 'shelf drugs' and 'cabinet drugs'.

**Results**

The comparison of stock counts with inventory reports showed that for all drugs included on the inventory, the mean net inventory discrepancy was 982 ± 785 units (23 ± 18%) when analysed by quantity and £460 ± £284 (34 ± 21%) when analysed by cost. When each inventory category was considered separately, there were significant differences. For cabinet drugs the mean net inventory discrepancy was -1.3 ± 8.2 units (-0.05 ± 0.31%) by quantity and -£0.16 ± £1.81 (-0.05 ± 0.53%) cost, however for shelf drugs, the mean net inventory discrepancy was found to be 983 ± 780 units (57 ± 46%) by quantity and £461 ± £284 (46 ± 28%) by cost. The comparison of stock counts with the inventory report and the net inventory discrepancies are shown in table 7.3.

The absolute inventory discrepancy (the sum of inventory surplus and deficiency, ignoring the negative sign) was found to be higher than the net discrepancy for both cabinet drugs and shelf drugs. For cabinet drugs, the mean net discrepancy of -1 ± 8 units (-0.05 ± 0.31%) masked a mean absolute inventory discrepancy of 19 ± 8 units, because of the cancelling out of the inventory surplus and deficiency values. However, the absolute inventory discrepancy value for cabinet drugs still remained very low (0.73 ± 0.32%). For shelf drugs, the mean net discrepancy was 983 ± 780 units (57 ± 46%), though the mean absolute inventory discrepancy was 1,796 ± 867 units (105 ± 51%). All of the inventory discrepancy values calculated (net discrepancy, surplus, deficiency and absolute discrepancy) were significantly higher for shelf drugs than for cabinet drugs. The net
inventory discrepancies, inventory surpluses, inventory deficiencies and absolute inventory discrepancies are shown in table 7.4.

<table>
<thead>
<tr>
<th></th>
<th>Mean ward stock count (± 95% CI)</th>
<th>Mean ward inventory report (± 95% CI)</th>
<th>Mean net inventory discrepancy (± 95% CI)</th>
<th>Net Inventory discrepancy % (± 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabinet drugs (units)</td>
<td>2,625 (± 139)</td>
<td>2,627 (± 141)</td>
<td>-1.3* (± 8.2)</td>
<td>-0.05% (± 0.31)</td>
</tr>
<tr>
<td>Cabinet drugs (£)</td>
<td>£340 (± £46)</td>
<td>£340 (± 45)</td>
<td>-£0.16* (± £1.81)</td>
<td>-0.05% (± 0.53)</td>
</tr>
<tr>
<td>Shelf drugs (units)</td>
<td>2,694 (± 969)</td>
<td>1711 (± 459)</td>
<td>983* (± 780)</td>
<td>57% (± 46)</td>
</tr>
<tr>
<td>Shelf drugs (£)</td>
<td>£1,471 (± £462)</td>
<td>£1,010 (± £243)</td>
<td>£461* (± 284)</td>
<td>46% (± 28)</td>
</tr>
<tr>
<td>All (units)</td>
<td>5,319 (± 958)</td>
<td>4,337 (± 526)</td>
<td>982 (± 785)</td>
<td>23% (± 18)</td>
</tr>
<tr>
<td>All (£)</td>
<td>£1,811 (± £497)</td>
<td>£1,350 (± £270)</td>
<td>£460 (± £284)</td>
<td>34% (± 21)</td>
</tr>
</tbody>
</table>

Table 7.3 Comparison of stock counts with inventory reports, showing net inventory discrepancies

Notes: 1. The difference between stock count and inventory report does not equal the net inventory discrepancy due to rounding to nearest £1.

* Denotes significant difference at 5% level between shelf and cabinet drugs.

<table>
<thead>
<tr>
<th></th>
<th>Cabinet units (± 95% CI)</th>
<th>%</th>
<th>Shelf units (± 95% CI)</th>
<th>%</th>
<th>All units (± 95% CI)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean net inventory discrepancy</td>
<td>-1* (± 8)</td>
<td>-0.05 (± 0.31)</td>
<td>983* (± 780)</td>
<td>57</td>
<td>982 (± 785)</td>
<td>23</td>
</tr>
<tr>
<td>Mean inventory surplus</td>
<td>9* (± 8)</td>
<td>0.34 (± 0.30)</td>
<td>1,390* (± 816)</td>
<td>81</td>
<td>1,399 (± 818)</td>
<td>32</td>
</tr>
<tr>
<td>Mean inventory deficiency</td>
<td>-10* (± 3)</td>
<td>-0.39 (± 0.11)</td>
<td>-406* (± 122)</td>
<td>-24</td>
<td>-417 (± 120)</td>
<td>-10</td>
</tr>
<tr>
<td>Mean absolute inventory discrepancy</td>
<td>19* (± 8)</td>
<td>0.73 (± 0.32)</td>
<td>1,796* (± 867)</td>
<td>105</td>
<td>1,815 (± 867)</td>
<td>42</td>
</tr>
</tbody>
</table>

Table 7.4 Comparison of stock count with inventory reports, showing absolute inventory discrepancies

* Denotes significant difference at 5% level between shelf and cabinet drugs.
7.4 Drug losses

Drug losses from a ward, either due to wastage or theft, will be reflected in differences between drugs consumed and those actually administered to patients. However, the movement of drugs into and out of the hospital ward is complex (see figure 7.1). Therefore a method was required which could both track drug movements and provide a measure of the overall control by accounting for gains as well as losses and not simply stating a net figure.

Several studies have examined drug losses in the USA. Barker and colleagues used a method of inventory counts at the start and end of their study period and comparison with drug administration records for drugs administered during the study period (Barker and Heller 1964b). Results were displayed as losses for different categories of inventory, projected to give annual losses for the ward studied and for the entire hospital. A later study (Barker 1969a,b) using a method described by McBryde (1965), estimated drug losses in pharmacy using inventory counts, records of drugs entering the pharmacy department and issued to the wards and statistical sampling of drug administration records. Neither of these methods allowed for the measurement of gains as well as losses. McBryde’s method would have been suitable for studying losses in an entire hospital, though the UK system of archiving records and potential problems with patient movements and lost drug charts limited the application of this method. In a study in the UK, Berns et al (1991) compared drug consumption with drug chart records and

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1 'Consumed' refers to drugs administered to patients, wasted, or pilfered.
Figure 7.1 Drug movements into and out of a hospital ward (from Ridge et al 1996)
presented the findings as a difference in total value. The same study compared bar-code
methods for collection of drug administration data with drug consumption; positive and
negative errors were reported, though no overall measure of the degree of control
obtained was stated.

The method used involved inventory counts and drug tracking similar to that described by
Barker et al (1964a-e), and, similar to the method described by Berns et al (1991),
discrepancies were expressed as gains (surpluses) and losses (deficiencies) for individual
lines. However, in order to provide a measure of overall control, a method similar to that
used to examine the accuracy of the computerised inventory was used (Ridge et al 1996).
The parameters calculated are shown below:

**Drugs administered** - The amount of drugs, by individual item, recorded as administered
to patients during the study week, extracted from all recognised drug administration
records: the drug chart, anti-coagulant charts and anaesthetic sheets. This was achieved
by keeping a separate record for each patient which was regularly updated and the exact
time that patients were admitted, discharged or transferred to another ward were taken
into account. Where administration records were not completed it was assumed that the
drug was not administered, though the number of blank records was recorded.

**Calculated consumption** - The amount of drugs used in the week was calculated for each
item by subtracting the quantity on the ward at the end of the week from that obtained at
the start of the week, taking account of drugs supplied from and returned to the pharmacy
and drugs borrowed to and lent from other wards in the hospital. Drugs were counted as
described in the methods for assessing the quantity of drugs on the ward. Drugs returned
to the pharmacy department were ‘quarantined’ by pharmacy staff until they had been counted by one of the researchers. The quantity of drugs supplied from the pharmacy department was obtained from paper-based or computer generated records obtained from the dispensary (for IDMs and baggies) or from the distribution area (for stock drugs or cabinet drugs). A record of drugs lent to or borrowed from other wards or departments was kept on a specially designed form by nurses on the study ward.

**Consumption discrepancy**<sup>1</sup> - The value obtained by subtracting ‘calculated consumption’ from ‘drugs administered’ for each item.

**Net consumption discrepancy** - The sum of all the ‘consumption discrepancy’ values, taking account of positive and negative signs.

**Consumption deficiency** - The sum of all the ‘discrepancy’ values where ‘recorded consumption’ was less than ‘calculated consumption’ (the negative consumption discrepancy values).

**Consumption surplus** - The sum of all the ‘discrepancy’ values where ‘recorded consumption’ was greater than ‘calculated consumption’ (the positive consumption discrepancy values).

**Absolute consumption discrepancy** - The sum of ‘deficiency’ and ‘surplus’, (ignoring the signs).

The above parameters were calculated by quantity and cost and were expressed as percentages of calculated consumption. This was considered to be the most appropriate denominator as drug losses are most meaningfully expressed as a percentage of drugs

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<sup>1</sup> This parameter is not shown in the results as it relates to individual drug products rather than the entire inventory.
supplied to the ward (consumption equates to this when inventory levels are stable) rather than as a percentage of drugs actually administered to patients.

To understand whether the Meditrol cabinet provided greater or lesser security in comparison with other locations on the ward, the parameters were calculated for 'cabinet drugs' and 'shelf drugs'. It was possible for some products to have been present on the ward as more than one inventory category during the study period. These items were excluded from the analysis.

**Results**

The mean net consumption discrepancy values for the original system (-2.8 ± 7.3% by quantity and -7.8 ± 12.5% by cost) were lower than with the Meditrol system (net consumption discrepancy of -13.6 ± 5.6% by quantity and -17.9 ± 14.7% by cost), though these differences were not statistically significant. However when absolute consumption discrepancy values are compared, there is less difference between the two systems; 39.8 ± 3.0% and 34.0 ± 8.4% by quantity and 46.4 ± 12.2% and 50.7 ± 26.6% by cost for the original system and the Meditrol system respectively. A comparison of calculated consumption with recorded drug use, including net consumption discrepancy, consumption surplus, consumption deficiency and absolute consumption discrepancy is shown in Tables 7.5 and 7.6 by quantity and cost respectively. The only statistically significant difference was for mean surplus, analysed by drug quantity; 18.5 ± 4.8% for the original system and 10.2 ± 2.8% for the Meditrol system. Drug administration records were incomplete (left blank) for 4.0% of doses due with the original system and for 2.1% of doses due with the Meditrol system.
Comparison of calculated consumption with drugs administered by drug quantity

**Table 7.5**

<table>
<thead>
<tr>
<th></th>
<th>Original system</th>
<th>Meditrol system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean calculated consumption per ward (units)</td>
<td>1916 (± 340)</td>
<td>1928 (± 175)</td>
</tr>
<tr>
<td>Drugs administered - mean per ward</td>
<td>1862 (± 268)</td>
<td>1666 (± 201)</td>
</tr>
<tr>
<td>Mean net consumption discrepancy</td>
<td>-2.8% (± 7.3)</td>
<td>-13.6% (± 6.5)</td>
</tr>
<tr>
<td>Mean consumption deficiency</td>
<td>-21.3% (± 3.0)</td>
<td>-23.8% (± 7.0)</td>
</tr>
<tr>
<td>Mean consumption surplus</td>
<td>18.5% (± 4.8)*</td>
<td>10.2% (± 2.8)*</td>
</tr>
<tr>
<td>Mean absolute consumption discrepancy</td>
<td>39.8% (± 3.0)</td>
<td>34.0% (± 8.4)</td>
</tr>
</tbody>
</table>

* Denotes a significant difference at 5% level

**Table 7.6**

<table>
<thead>
<tr>
<th></th>
<th>Original system</th>
<th>Meditrol system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean calculated consumption per ward (units)</td>
<td>£312.71 (± £76.87)</td>
<td>£504.04 (± £173.40)</td>
</tr>
<tr>
<td>Drugs administered - mean per ward</td>
<td>£288.32 (± £81.19)</td>
<td>£413.82 (± £147.22)</td>
</tr>
<tr>
<td>Mean net consumption discrepancy</td>
<td>-7.8% (± 12.5)</td>
<td>-17.9% (± 14.7)</td>
</tr>
<tr>
<td>Mean consumption deficiency</td>
<td>-27.1% (± 10.8)</td>
<td>-34.3% (± 19.7)</td>
</tr>
<tr>
<td>Mean consumption surplus</td>
<td>19.3% (± 5.9)</td>
<td>16.4% (± 8.5)</td>
</tr>
<tr>
<td>Mean absolute consumption discrepancy</td>
<td>46.4% (± 12.2)</td>
<td>50.7% (± 26.6)</td>
</tr>
</tbody>
</table>

Analysis of the Meditrol system according to inventory category shows no significant difference between net discrepancy values for drugs which had been on the ward exclusively as cabinet drugs and those which had been on the ward exclusively as shelf drugs. However, by drug quantity, cabinet drugs were associated with a significantly lower surplus (3.5 ± 2.2% compared with 25.0 ± 6.4%), deficiency (-9.9 ± 3.6% compared with -45.4 ± 26.6%) and absolute consumption discrepancy (13.4 ± 3.5% compared with 70.4 ± 25.5%) than shelf drugs. By value, the surplus for cabinet drugs was significantly lower than for shelf drugs (2.8 ± 1.1% compared with 25.1 ± 14.8%), though for other parameters, there were no significant differences. A comparison of the two categories of drugs is shown in table 7.7. It should be noted that this table shows
pooled data for the six wards studied, though because drugs which had been kept on the
ward during the study period as both inventory categories was excluded, these figures do
not equate to those shown in tables 7.4 and 7.5.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Cabinet contents only</th>
<th>Shelf stock only</th>
<th>Cabinet contents only</th>
<th>Shelf stock only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean calculated consumption</td>
<td>679 (± 134)</td>
<td>492 (± 164)</td>
<td>£65.41 (± £58.85)</td>
<td>£280.76 (± £140.12)</td>
</tr>
<tr>
<td>Mean recorded drug use</td>
<td>636 (± 128)</td>
<td>391 (± 169)</td>
<td>£59.61 (± £53.77)</td>
<td>£231.41 (± £103.20)</td>
</tr>
<tr>
<td>Net consumption discrepancy</td>
<td>-6.4% (± 4.8)</td>
<td>-20.4% (± 29.0)</td>
<td>-8.9% (± 8.3)</td>
<td>-17.2 (± 25.5)</td>
</tr>
<tr>
<td>Consumption deficiency</td>
<td>-9.9%* (± 3.6)</td>
<td>-45.4%* (± 26.6)</td>
<td>-11.6% (± 8.3)</td>
<td>-42.3% (± 34.0)</td>
</tr>
<tr>
<td>Consumption surplus</td>
<td>3.5%* (± 2.2)</td>
<td>25.0%* (± 6.4)</td>
<td>2.8%* (± 1.1)</td>
<td>25.1%* (± 14.8)</td>
</tr>
<tr>
<td>Absolute consumption discrepancy</td>
<td>13.4%* (± 3.5)</td>
<td>70.4%* (± 25.6)</td>
<td>14.4% (± 8.4)</td>
<td>67.4% (± 45.8)</td>
</tr>
</tbody>
</table>

Table 7.7 Comparison of calculated consumption with drugs administered by Meditrol
inventory category * Denotes a significant difference at 5% level

7.5 Discussion

This is the first study in the UK to examine the impact of an automated drug distribution
system on inventory management. It has been demonstrated that although the Meditrol
system was successful in reducing the quantity of drugs kept on the ward, the

The computerised inventory reports available from
the Meditrol computer system were very accurate (absolute discrepancy of 0.73 ± 0.32%)
for drugs stored inside the Meditrol cabinet, however for drugs stored outside of the
cabinet, the reports were very inaccurate (absolute discrepancy of 105 ± 51%). The
impact of Meditrol on drug losses was examined using a method which combined losses

According to this measure, there was
little difference demonstrated between the original system and the Meditrol system.
However, when the quantity of drugs stored inside the Meditrol cabinet were considered separately, the degree of control (as shown by a relatively low absolute consumption discrepancy value) was shown to be superior to that associated with drugs stored outside of the secure cabinet and to that of the original system.

There were two reasons why the Meditrol system was associated with a reduction in the quantity but an increase in the cost of drugs kept on the ward. Firstly, by supplying drugs in full coils, there was a tendency to reduce the quantities of those previously available in large quantities (for example tablets) but to increase the quantity of those previously available in small quantities (for example eye-drops and injections). The latter products tended to be more expensive and so may explain some of the shift in average cost per ward (though the most expensive products were kept outside of the cabinet). A more considered allocation of stock control parameters on the computer system may have remedied this. Secondly, the average cost of drugs prescribed may have increased by chance; for example, there were more patients receiving expensive intravenous antibiotics when the Meditrol system was studied.

Both systems resulted in drugs being kept on the ward which should not have been there. With the original system, this may have been a result of using the Shotley Bridge system. The implementation of the more common system of scheduled pharmacy technician top-up visits, to re-stock and remove excess or redundant 'stock drugs' and 'non-stock drugs', may well have reduced the size of the problem. The presence of non-inventory items on the Meditrol wards may, in part, have been due to a correctable software problem (correction of which was delayed in order to create stable conditions for the evaluation) which had an impact on the total value of drugs held. The system was
designed to instruct pharmacy staff to remove redundant shelf stock, however this was not functioning, despite the fact that the computer's inventory records were being amended.

The Meditrol computerised inventory report was accurate to around 1% for stock stored in the cabinet. For shelf stock however, the actual stock level exhibited an absolute deviation in excess of 100%. This was mainly a result of excess stock (81%), which may, in part, be due to the software problem which has reportedly been corrected since the study. As it operated, the system could not be relied upon to provide accurate information relating to either total inventory (a net discrepancy of 23 ± 18% by quantity was measured) or the holding of individual items (an absolute discrepancy of 42 ± 20% by quantity was demonstrated). The major limitation appears to be the unsuitability of the cabinet to accommodate a significant proportion of the ward inventory, a factor which severely restricts its potential.

The high degree of accuracy of the inventory record for cabinet drugs and the lower accuracy associated with shelf drugs demonstrates that compliance with the system was compromised for the latter inventory category. The origin of miscompliance with shelf stock transactions may include non-logging of wastage, by-passing the system for medication not yet entered and unrecorded borrowing or lending; errors in supply may

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1 For drugs not entered onto the system, the nurse should use a function on the computer system which records a 'one off' administration of a drug. For cabinet drugs, a transaction on the computer is required in order to obtain the drugs. However, for shelf drugs, the nurse can simply take the drug from the shelf without making the appropriate transaction on the system.
also contribute to this. It is possible there are also errors not related to staff compliance, such as machine malfunction leading to over or under dispensing. The operation of parallel systems, with the drug chart as the definitive record may have influenced compliance; the maintenance of two records was inevitably more-time consuming and the computer record was never used by nurses to determine if a dose had been given. The use of only the computerised system (originally designed to generate a printed drug administration record, against which the computerised information could be updated) may have significantly increased compliance with the system. However, this would still rely on a suitable human-computer interface.

Stock level discrepancies from Meditrol’s inventory give an indication of staff compliance with the stock control requirements of the system. It gives no indication of the accuracy of individual patient records. For example if a unit of dose is not administered, it should be ‘returned’ on the system, so that the patient’s record is updated accordingly, and placed into a purpose made receptacle which is emptied by pharmacy staff during restocking. The drug is not ‘returned’ to the ward inventory but to the pharmacy department. Therefore, miscompliance with this process will not affect the inventory, but will compromise patient records. Therefore, the accuracy of Meditrol’s individual patient records cannot be assumed. This aspect of the system was not examined in this study; emphasis was placed on stock control as a more fundamental function, though later stages of HTA research should consider the accuracy of electronic patient medication records.

The method used to examine the control over the drug inventory (with particular focus on drug losses) has highlighted the limitations of the traditional method of calculating a net loss by stock takes and assuming drug chart records are accurate. This was found to hide
'surpluses' and 'deficiencies'. These discrepancies would be zero in a perfect system and
the sum of 'consumption surpluses' and 'consumption deficiencies' (ignoring the sign) has
been used to give a marker of the system's control. As can be seen, this absolute
consumption discrepancy is greater than the net consumption discrepancy which is over-
simplistic and can misrepresent the true situation. The superior sensitivity of absolute
discrepancy is demonstrated by the comparison of cabinet drug parameters with those of
shelf drugs by drug quantity; there was not a significant difference between the net
discrepancy values (-6.4 ± 4.8% for cabinet and -20.4 ± 29.0% for shelf drugs), though
there was for absolute discrepancy values (13.4 ± 3.5% for cabinet drugs and 70.4 ±
25.6% for shelf drugs). However, this difference was only demonstrated when data was
analysed by drug quantity but not by cost. This is a symptom of the larger degree of
variation (and therefore wider confidence intervals) produced by allocating costs rather
than using 'units' and highlights the benefit of using the latter convention.

For both systems, the absolute consumption discrepancies were considered to be very
large (by drug cost, 46.4 ± 12.2% for the original system and 50.7 ± 26.6% for the
Meditrol system). One reason for such large discrepancies is that the measure was very
sensitive, one tablet or 5ml of liquid being the basic unit. If a ward borrowed a 500ml
stock bottle of antacid and did not record it, 100 units would have been lost. Similarly,
returning an inhaler may 'lose' one unit, but its value could be £18. Without knowing
how much of the observed discrepancy could have been attributed to recording
inadequacies, the actual level of losses (rather than unrecorded movements between
wards) was impossible to calculate. However, on examination of the types of products
for which discrepancies were calculated, it was felt that unrecorded movement, use of
items not recorded on the drug chart (such as diluents for intravenous drugs) or wastage were the cause, rather than theft.

Inaccurate drug administration records may have been a source of error. Despite the fact that it is a disciplinary offence for a nurse not to sign the chart if a drug has been administered, or to enter a code number which explained why a drug had not been given, it was found that the administration record was not always complete. Of the drug administration records examined in the study 4.0% were incomplete with the original system and 2.1% with the Meditrol system. In these cases it was assumed that the drug was not administered, though the nurse may have only neglected to complete the administration record. In the USA, Barker and Heller (1964b) experienced a similar problem, reporting that 2.4% more doses were administered that were recorded. Other records designed to capture drug movements may also have been incomplete. For example: lending and borrowing between wards.

Consumption of drugs was compared with that recorded on the drug chart. The drug chart record was used as this remained the definitive record of both prescribing and administration. This record was limited in that it did not provide a record of all drugs consumed, such as diluents for intravenous injections. The use of only the computerised system may have provided a more complete record of drugs administered to patients. A study comparing data capture techniques for resource management purposes also highlighted the inadequacy of the drug chart (Berns at al 1991); retrospective extraction of data from drug charts could not account for 30 to 40% of the total value of drug supplied to wards. Another study assessing the reliability of apportioning ward drug expenditure to individual clinicians by bed occupancy found that 22 to 55.5% of the total value of
drugs supplied to the ward could not be accounted for by drug chart records (Miller and Ashford 1988). However, as well as wastage and other sources of drug loss, these figures included diagnostic agents (for example urinalysis strips), disinfectants and dressings, the use of which is not usually recorded on the drug chart.

The 'absolute consumption discrepancy' for cabinet stock was much lower than that for shelf stock suggesting that the system exerts greater control over the movement of drugs stored in this location. There are several factors which may have influenced this finding. Firstly, staff are more likely to borrow smaller quantities from the cabinet than off the shelf. Secondly, all products in the cabinet were pre-measured into quantities usually administered to patients. For example, most liquids obtained from the cabinet could just be given to the patient without the need for measuring the dose. However, for liquids kept in bulk containers outside of the cabinet, the nurse needed to measure them; many were witnessed 'guessing' the volume in non-graduated containers, particularly for antacids and laxatives. Thirdly, the cabinet did not contain items with a short expiry date. For example, an antibiotic syrup may represent 20 units and have a high value but its short shelf life (typically one week) means it is prone to undocumented disposal.

The allocation of a drug to the cabinet was based on its suitability to fit into the coils, the availability of the drug packed as a unit of dose and the need for refrigeration. This resulted in higher cost drugs such as the larger volume antibiotic infusions, some inhaler devices and multi-dose products (such as high dose heparin) being kept outside of the cabinet. Financial value, potential for harm to the patient and potential for abuse are factors which should have been considered in deciding cabinet contents. This is in contrast to the criteria described above. Clearly systems such as Meditrol have the
potential to provide tight control over drugs on the ward. However, attention must be paid to the range of products which can be accommodated; for example modules could be designed for dispensing infusion bags and products requiring refrigeration. Alternatively, it may be more appropriate to consider the setting for the use of systems such as Meditrol; the system as evaluated may have performed better in a nursing home where the majority of preparations used are tablets or liquids and where patient prescriptions are changed less often.

In conclusion the Meditrol system as it was operated failed to achieve the desired aims with respect to inventory control. Some of the problems identified, such as software bugs are correctable. The issue of using parallel systems could be overcome by using computerised prescribing, where the computerised record would be compiled in real time and there would be no issues regarding the originality of the order or the possibility of transcription errors. This would require considerable developmental work to achieve and the issue of the usability of the system for nurses may then become a more prominent issue. The system was also severely compromised by the restriction imposed by the cabinet with respect to dose storage. Clearly the use of a secure automated system offers advantages for inventory control and reports, however for items stored outside of the cabinet, this advantage is lost. Again considerable developmental work would be required to modify or redesign the system to accommodate a wider range of products.
8 The impact of Meditrol on information management

In the context of computerised drug distribution systems, the term ‘information management’ can encompass a wide range of functions and processes. These include:

- Decision support software
- On-line reference sources (for example the electronic BNF)
- Computerised archiving of patient drug administration records
- Electronic transmission of information between departments or organisations
- Scheduling of the drug administration process
- Generation of information relating to drug use

Decision support and on-line reference sources have the potential to influence the quality of prescribing when applied to computerised prescribing systems. However, as Meditrol was not implemented as a computerised prescribing system, there was very little potential for impact in this respect. Decision support software was available to the order entry pharmacists, though little effort was directed at tailoring the package to meet user requirements. As a consequence of this, the software was rarely used and so was not evaluated.

Computerised archiving of patient drug administration records could result in improved efficiency from more rapid retrieval of drug histories compared with paper based records. As the drug chart remained the definitive record of drugs administered and the full benefits of electronic archiving would only be accrued over time (as more patients’ records are archived on the system), this feature was not evaluated at this stage.
The benefits of electronic transmission of data and the scheduling of the drug administration process have both been examined in the work study or error research. Future systems may exploit electronic data transfer between hospitals and general practice surgeries and so promote seamless patient care at the primary/secondary interface. The benefits of this strategy should be evaluated in due course.

Probably, the key benefit of the Meditrol system, in terms of information management, is the potential to produce information relating to drugs administered to individual patients. This is in contrast to traditional pharmacy-based systems where information is limited to drugs entering or leaving the pharmacy department. The impacts of applying such information may include a reduction in expenditure and/or an improvement in the quality of care and improved business performance of the hospital. The mechanisms for using this information include medical audit, drug use review or drug use evaluation, resource management and the utilisation of cost per case in the contracting process. The planned method for evaluating this area was to observe activities performed by health care professionals at the trial site and study the benefits using case study techniques. As these activities are aimed at achieving demonstrable improvements in care or financial savings, no additional measurements were to be taken.

During the course of the trial, there was very little information generated by the system, none of which was used for the activities described above. This part of the evaluation, therefore, was confined to a small-scale exploration of the perceptions of key staff regarding the potential benefits of drug use information. In particular, views regarding patient specific drug use information were explored.
8.1 An exploration of staff views on the role and application of drug use information

Method

Semi-structured interviews were carried out with 5 key hospital personnel who were likely recipients of drug use information or who were involved with information strategy. These were, Director of Medicine and Care of the Elderly, Director of Paediatrics (two consultants also present), Director of Ophthalmology, the Information Technology (IT) manager and the Pharmacy Services manager. The interview was designed to explore the following areas:

- Current reports relating to prescribing
- How reports received were used
- Ideal level of information
- Perceived benefits of drug use reports to individual patient level
- The perceived disadvantage of individual patient reports
- The importance of drug use information compared to other patient related information

Answers to questions were taken as notes in the course of the interview.

Results

Current reports relating to prescribing

The information received at the time of the interview varied from a single figure relating to drug spending to spend per month by cost centre, divided down to therapeutic group or specific drug if requested or deemed useful. One clinical director claimed that
information was often inaccurate. The pharmacy services manager received a report of the top 50 or 100 drugs used by spend.

**How reports received were used**

The clinical directors used this information mainly to give an indication of spending. Specific uses were to identify mistakes in costing, to compare junior staff prescribing and to identify high cost prescribing for further investigation. One clinical director stated that it was difficult to influence clinical judgement, though it was useful to monitor the impact of policy changes with respect to prescribing. The pharmacy services manager used the reports to identify increases in spending with a resultant brief to clinical staff to investigate.

**Ideal level of information**

Answers from clinical directors were variable; two were not interested in receiving any more detailed information, stating that it would have little impact on their clinical activities. One of these stated that clinicians should not rely on information, but should influence care at a ward level. One clinical director stated that information to individual patient level would be useful for resource management, for arguing formulary changes and for monitoring junior doctors’ prescribing.

The IT manager stated that he would like to provide information down to individual patient level, relating this to speciality, diagnosis and date. The Pharmacy Services manager said personally he would only use top 50 data, but that case-mix generated data would be passed to staff in the pharmacy department.
Perceived benefits of drug use reports to individual patient level

One clinical director stated that knowing the cost to carry out a specific procedure or comparing different treatment options would be useful, though he envisaged that this would be expensive. He added that outpatient and theatres were more variable with respect to drug treatment. The second clinical director said that cost per case would be useful for financial, but not clinical purposes. The third stated that such information would be useful for specific audits.

The IT manager saw the advantages being the ability to investigate the relationships between drug therapy and other factors, such as age, diagnosis, consultant, length of stay. He also said that it would be useful for contract calculation, clinical audit and for clinicians to be able to monitor the impact of changes in treatment.

The pharmacy services manager considered drug usage review and clinical audit as areas which would benefit from this level of information. He added that the pharmacy approach was often to consider prescribing issues globally - across, rather than within directorates.

Perceived disadvantages of individual patient reports

One clinical director was concerned about the cost of generating such information. Concurrent pricing was viewed as a disadvantage by another clinical director as he felt that cost should not influence the decision making process. The third was concerned about being swamped with information.
Both the IT manager and the pharmacy services manager were concerned about the complexity of the information produced and the task involved with organising it. The latter was also concerned about how to use it once it was obtained.

The importance of drug use information compared to other patient related information

Clinical directors placed low priority on drug use data, stating that caseload and length of stay are more useful, one of these saying that such data was more useful for monitoring performance.

The IT manager considered this information to be very important and that it was currently a gap in the information available (drugs account for the largest non-staff costs in most hospitals). He added that it was more important than information from pathology or x-ray, however information from theatres was possibly more important. The pharmacy services manager considered it high priority, though emphasised that it should not be taken in isolation but used with other data. He added that patient tracking (for example, monitoring for re-admission) was important as the overall aim is to discharge patients fitter as well as quicker.

Discussion

The staff interviewed during this study had only been exposed to very basic summaries of drug usage which were used mainly for monitoring expenditure and also for monitoring the impact of policy changes. Furthermore, the Trust had no IT strategy as such and so there was no local discussion of the potential application of case-specific information.
This may have limited the respondents vision of the potential for utilising such information.

Two of the clinical directors stated that case-specific information would have little impact on the clinical management of their patients. However, all stated that the information would be useful for either resource management and/or clinical audit, processes which may directly influence policies and protocols governing patient management. This suggests a reluctance to associate computer technology with benefits for patient care. Other, more fundamental concerns such as the issue of computers and the security of patient medical records may be influencing the views of these clinicians. A final factor may be ‘techno-phobia’; senior doctors such as clinical directors may have received little exposure to computer technology.

The IT manager, not surprisingly, was very positive of the role of case-specific information and described a somewhat optimistic process equating to epidemiological surveillance of drug use in the Trust. The pharmacy service manager was also very positive and forward thinking with respect to information utilisation, perhaps reflecting the high degree of professional exposure to computer technologies. Both IT manager and pharmacy service manager stated that they were concerned about the complexity of the information generated and how best to manage it, a barrier common to the NHS in general.

These results, from a small scale study, suggest that senior doctors may not place much emphasis on drug use information for clinical purposes, though acknowledge their role in financial management and audit. If the generation and application of patient specific drug
use information is the way forward for facilitating both clinical and business improvements, then there may be two barriers to cross; firstly producing and organising the information and secondly convincing clinicians of the benefits to themselves and their patients.
The assessment of the impact of health technologies commonly involves an exploration of attitudes. In the case of 'conventional' health technologies, this may include an assessment of patients' attitudes towards the technology, or those of society in general. For example, attitudes towards the usefulness or value of a technology may be useful during the commissioning process. The attitudes of health care professionals are also important; with conventional technologies, these are likely to play a major, though often implicit, role in the diffusion of the technology. No matter how cost effective a new technology, it will not succeed if the patient refuses treatment or if staff refuse to work with a technology. In the case of technologies such as the Meditrol system, which support systems of work, the attitudes of workers using the system may be crucial to its success.

With computers and automation, desirable social outcomes may include enhanced job satisfaction, either due to the reduction or elimination of less rewarding tasks and improved efficiency (Robins and Webster 1987). When computerisation is introduced, the worker may be influenced by changes in the nature of the work (Child 1987, Robins and Webster 1987), the perception of management motives (Child 1987, Burnham 1990), ethical considerations (Erman et al 1990), and preconceptions of computers in general. In the health service there are both managerial and professional forces in operation throughout the organisation; the ethical stances made by health care professionals (especially medical staff) may successfully oppose management decisions. For example,
at the Royal United Hospital Bath junior doctors refused to use a newly installed computer prescribing system on grounds of a perceived reduction in safety (Harper 1993). A similar problem was faced in Virginia with the same system, however doctors were persuaded to carry on and the system now attracts junior doctors to the hospital (Sittig and Stead 1994).

The purpose of this study was to explore the attitudes of nursing, pharmacy and medical staff towards the traditional and Meditrol system of drug supply and administration. It was acknowledged that the attitudes of patients and of society in general play an important role; this type of assessment would be scheduled with further evaluative work. At this stage in the development of the Meditrol project, staff attitudes were considered to be more fundamental to the success of the system; it was anticipated that the information obtained could provide valuable contextual insight into the performance of the system, which would complement the quantitative work, and would provide an informal measure of the quality of the human-computer interface.

9.1 General Methods

The attitudes of staff using the Meditrol system were assessed using a series of structured interviews. Alternative quantitative methods, such as Likert scales were considered, though these techniques are more suitable when the nature of the issues has already been elucidated. For the preliminary exploration of attitudes, a structured interview, consisting of broad open questions, was considered to be the most suitable. The study examined the attitudes of medical staff, nurses, pharmacists, pharmacy technicians and pharmacy assistants.
Before the study commenced a sociologist, specialised in pharmacy practice research, was consulted and provided advice on the design and wording of the interviews. Separate interviews were then designed for each category of worker and these were piloted at another hospital. At least one worker from each category was interviewed at the pilot stage. The interviews were then modified as necessary. Following implementation of the Meditrol system, the questions were rephrased accordingly (both sets of interview schedules can be found in appendix 8).

Before the implementation of the Meditrol system, a random sample of 20 qualified nurses (who would regularly conduct a drug round unsupervised) and 20 medical staff (both nursing and medical staff samples were stratified by grade) and all pharmacy staff involved with drug distribution or monitoring were selected for interviews. Nursing and medical staff were identified by lists obtained from the hospital personnel department and individuals selected by drawing numbers from a hat. The process for selecting nursing staff was repeated after the implementation of the new system, though because the system was not implemented throughout the hospital and subjects with direct experience of working with the system were required, staff were selected only from those wards equipped with the Meditrol system. Medical staff were not interviewed post implementation as they were not involved with the system ultimately implemented. The interviews were conducted by one of two researchers (both members of the evaluation team), were recorded onto audio tape, transcribed, and summarised. Interviews were carried out at least one month before and at least two months after Meditrol had been implemented on the last ward.
Before the interview was commenced, the interviewer introduced himself and staff were asked if they had any objections to being recorded and were reassured that the tapes would not go any further than the research group and that any comments made would be anonymised. At the start of each interview before the system was implemented, the interviewer read a description of the Meditrol system. This described the system as it was intended to be implemented, with computerised prescribing performed by medical staff.

9.2 Nursing Staff

Of the 20 nurses selected for interview before the implementation of Meditrol, 14 were interviewed. Of the 20 nurses selected for interview after the implementation of Meditrol, again 14 were interviewed. The grades of those selected and those interviewed are shown in Table 9.1. During each phase 6 nurses were unavailable for interview due to the nature of shift patterns, annual leave, maternity leave or because they had moved jobs since the personnel list had been obtained. No nurses refused to be interviewed.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number selected</th>
<th>Number interviewed - before</th>
<th>Number interviewed - after</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>F</td>
<td>5</td>
<td>3</td>
<td>3</td>
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<td>G</td>
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<td>2</td>
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</tbody>
</table>

Table 9.1 Grades of nurses interviewed

Summary of nurse interviews before implementation of Meditrol

Before the implementation of Meditrol most nurses, when asked on their views on the importance of accuracy of timing of drug administration with respect to the time indicated by the doctor on the drug chart, felt that current practice led to an unacceptable deviation
from the prescribed time. However it was felt that this was the best that was possible
given the available staff resources. Most considered that drug administration one hour
either side of the prescribed time was acceptable for most drugs.

When asked what they considered to be an acceptable time lag between the time a drug is
prescribed and the time a drug is available on the ward, answers ranged from immediately
to 3 or 4 hours, though most nurses said it would depend on the drug. When specific
eamples of drugs were given it was thought antiarrhythmics and dopamine should be
available immediately, antihypertensives within one hour, antibiotics for a urinary tract
infection within one to three hours. Anusol ointment would be given a lower priority but
this would be dependent on the level of patient discomfort.

Generally the nurses had a positive expectation of the benefits of the Meditrol system. It
was expected that following the implementation of Meditrol, drugs would be available
more promptly and that the level of drug administration errors would decrease. There was
a consensus that patient care would improve with respect to drug administration. There
was a general expectation of increased efficiency in the drug supply system so that drug
rounds would take less time. Although there was an overall positive outlook, there were
some concerns over the decreased flexibility of the Meditrol system with respect to timing
of drug rounds and the increased dependence on computer technology. Some nurses felt
they needed to try the system before forming an opinion. Most expected to have more
contact with pharmacy staff although they were unclear whether the pharmacists would be
ward or department based. Most nurses felt indifferent to the use of the new drug trolley
and units of dose, though some felt they needed to try them first before forming an
opinion. Most nurses felt positive towards the forthcoming implementation of Meditrol
although some anxieties were expressed particularly around the need for keyboard or computer skills, some had reservations as to the cost of the system and there was a suspicion as to why an outside agency would wish to install such a system into the hospital. Meditrol was seen by all as an opportunity for professional development, though a few nurses expressed some concerns around the confidentiality of staff actions.

When asked to choose whether they would prefer to use the traditional or Meditrol system all said that they would need to try Meditrol first before making a judgement.

Before implementation, most nurses said that pharmacists rather than doctors should enter prescription data onto the system. This was mainly due to the perceived greater drug knowledge of a pharmacist compared to a doctor. Some said it should be the doctor; reasons given were that it was the doctor's professional role and that they were ultimately responsible for the patient. The doctor also had easy access to the patient and to their records.

**Summary of nurse interviews after the implementation of Meditrol**

Following implementation most nurses, contrary to their expectations, said that more time was being spent on drug rounds (some specifically stated that the operation of the system involved the need to travel back and forth between the patient and the Meditrol cabinet during a drug round) and complaints had been received from patients after waiting too long for their medication. The majority felt that less time was being spent with patients, resulting in a reduction in the level of patient care. The concerns over the decreased flexibility of the timing of drug rounds continued. Most nurses were aware of a decrease in both the time spent on ordering of drugs and the need to travel to pharmacy for
supplies. Some nurses perceived that the number of drug administration errors had decreased, though some said that medical staff had noticed examples of drugs doses being missed due to non availability of medication. One nurse expressed her concern that there was no safety mechanism to restrict the quantity of a drug that could be obtained by nurses on a one-off basis (this function was used when a drug had been prescribed on the drug chart but had not yet been entered onto the system by the pharmacist).

The majority of interviewees felt that the trolley was predominantly of unsuitable design and involved excessive bending down, though individual patient drawers were useful and the ability to split the trolley into smaller sections enabled a greater degree of primary nursing. Most nurses disliked the units of dose, some had experienced problems with the packaging, finding it difficult to get drugs out and some thought that they were particularly unsuitable for doses of drugs that involved opening several individual packages. It was thought that they were unsuitable for elderly patients or those with arthritis to open the packages themselves. Some felt that the units of dose involved less manipulation and hence were more hygienic and some felt that there was less waste with the unit doses. The majority of nurses felt comfortable with using a computer terminal to obtain drug doses (there was a perceived improvement in computer and keyboard skills), although in areas where there was a need to obtain drugs quickly it was felt to be unsuitable. Some stated that stock control had improved though others said that stock levels of drugs were too small. Some thought that the information generated by Meditrol would be useful for costing purposes.

It was perceived that pharmacists spent more time on the ward and there was an improvement in their professional relationship with pharmacist, though it was felt that the
workload, and stress levels of pharmacy had increased. However there was perceived to be additional tension between nurses and doctors; that medical staff had to wait for nursing staff to obtain drugs for them from the Meditrol cabinet whereas before they would obtain drugs from drug cupboards themselves.

The majority stated that nursing staff were more stressed and that Meditrol was leading to feelings of frustration and dread of drug rounds. However, a minority said they enjoyed using the Meditrol system. Meditrol was now balanced between being seen as a threat or an opportunity. The perceived threat to confidentiality of staff actions remained. After implementation the majority said the would prefer to return to the traditional system, though some nurses were happy to continue using Meditrol.

After implementation more nurses felt that it was a pharmacists role to enter the prescription data for the same reason. Additional reasons were that doctors are already very busy and are liable to make mistakes. Pharmacists were said to be trusted more to perform the task accurately.

### 9.3 Medical staff

Of the 20 doctors selected, 14 were interviewed. The grades of those selected and interviewed are shown in table 9.2. Six doctors were unavailable for interview due to heavy work schedules. At the time these interviews were conducted it was anticipated that medical staff would be prescribing directly onto the Meditrol system. As this never occurred, these interviews were only conducted before the implementation of the Meditrol system.
Table 9.2 Grades of doctors interviewed

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number selected</th>
<th>Number interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>House office</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Senior house officer</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Registrar/senior registrar</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Consultant</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

The most common concern expressed by doctors was that the system would be more time consuming for themselves, nursing or pharmacy staff. Most doctors stated that some aspects of patient care would improve, either by improvements in prescribing and a neater, more accurate drug chart or safer and more timely drug administration. Some, however said there would be no change or changes would need to be proven. Some stated that the alerts provided by the drug information software would be useful and some stated that stock control and medicines supply would improve. Concerns were expressed over the use of computer terminals, particularly if they were to be remote to the patient.

Most doctors stated that there would be no change to working relationships, however other predictions included that their relationship with nurses would suffer, that clearer prescriptions would improve relationships with nurses, that there would be more contact with pharmacy, and that there would be less contact with pharmacy. Predictions of the change to nurses’ role included a de-skilling of the drug administration process, inflexible drug administration times and difficulties using computers. Not all doctors were able to comment on the changes pharmacy staff included, though some said they would benefit from drug use information. One doctor said pharmacists would be working remote to the ward, another said pharmacy ‘would benefit the most’.
Most doctors said they were concerned about the prospect of using the system, some saying they felt apprehensive and others that it would be difficult at first. Some doctors were positive about the prospect of using Meditrol. The main disadvantage was said to be the need to use a keyboard and a resistance to using computers. Other predictions were difficulties due to down time and difficulties using the system such as changing prescriptions and prescribing drugs to be administered as required. However, when asked to express a preference, most were unable to without using the Meditrol system first, though some said they would rather use the traditional system and one said he would not choose the Meditrol system. One doctor said he would only want to use a computerised system if the standard of nursing staff was poor. The majority of doctors were open minded to a trial of the system, however only slightly fewer were negative towards the introduction and less still were positive.

9.4 Pharmacists

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number interviewed before</th>
<th>Number interviewed after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-registration*</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Locum</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
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<td>E</td>
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<td>F</td>
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<td>1</td>
</tr>
</tbody>
</table>

Table 9.3 Grades of pharmacists interviewed
* Pre-registration pharmacist was about to qualify and was working as a pharmacist.

Ten pharmacists were interviewed before implementation and 15 after (there was an increase in the number of pharmacist following implementation of the system). One interview before implementation was not used as the recording was of a very poor quality.
The grades of the pharmacists interviewed (excluding the pharmacist whose interview was discarded) are shown in table 9.3.

Summary of pharmacist interviews after the implementation of Meditrol

Pre-implementation, pharmacists not expecting to be directly involved with order entry expected no change in their department based work, while those entering orders expected major changes and expressed concern over changes in working hours. Pharmacists expected an improved working relationship with doctors and nurses with more contact and an enhanced advisory role on medicines usage. Two pharmacists commented that pharmacy may be blamed for any failures in the Meditrol system.

The majority of pharmacists expected nurses to experience an increase in efficiency due to time saved on drug administration rounds and on ordering drugs from pharmacy and a resultant improvement in patient care. Pharmacists said that other staff employed in the pharmacy would experience a change in role. Concerns were expressed about the imminent change in structure of the department, the resultant change in staff roles and the workload necessary to implement and operate the system. The general view was that there would be no change experienced by medical staff if they were not entering orders, except that they may have to clarify their prescribing more.

Before implementation most pharmacists stated that there would be improvements in patient care due to more timely drug administration and a decrease in errors. However, others were not sure that Meditrol would affect the number of errors made in the drug use system. Concerns were also expressed over the potential for errors to occur whilst entering data onto the Meditrol system, problems due to running two systems at the same
time and the increase in the number of steps in the drug use system and the resultant increase in potential for error.

There was a balance of statements expressing both the advantages and disadvantages of pharmacists entering prescription data. Some stated that advantages would be the pharmacist checking orders as they are entered, the system would be under pharmacy ownership and that it would be good experience. Stated disadvantages were the duplication of effort (resulting from doctors prescribing then pharmacists entering the same information) and the tedious nature of the job. Some pharmacists said they would not mind entering data if it was not their sole role or if it was an intermediate measure. Those in favour of doctor order entry stated that it would avoid duplication of effort. Some stated that it could be a role for either pharmacist or doctor and others said that if doctors were entering orders, a pharmacist should validate them.

Before implementation most pharmacists said they were not worried about the prospect of working with units of dose, though some were not convinced of the benefits of this practice. Some expected less wastage with Meditrol, however some pharmacists were not sure that the system would save money. Other pharmacists anticipated problems with software and anticipated that the system would be expensive.

Before implementation, the most commonly stated opportunity was to spend more time on clinical activities and to utilise the information generated by the system. However, the majority of pharmacists also said that Meditrol was a potential threat to the role of the clinical pharmacist. When asked if they felt that Meditrol was an opportunity or a threat, the majority said opportunity. When asked to choose whether they would prefer to use
the traditional system or the Meditrol system, all three possible views were expressed; some said they would need to experience Meditrol first, some said the traditional system and others said they were willing to give Meditrol a try. When asked to summarise their feeling toward the introduction of Meditrol, the comments were generally negative and highlighted poor communication, time-scale slippage and bad management.

Summary of pharmacist interviews after the implementation of Meditrol
Following the implementation of Meditrol, the majority of comments were negative stating that the system was more labour intensive and generated more problems. The majority of pharmacists said there was an increase in their pharmacy based workload and the resources required to pack unit doses, though others said there was no personal change. There was a perceived closer working relationship with nurses, though there were also more complaints about the system. The general view was that nurses were taking longer on drug administration rounds and that there were problems with medicines supply and stock control, though positive comments concerning improved drug administration remained. Some felt that Meditrol still had the potential to improve stock control and medicines supply even though these benefits had not been seen. The general view was that doctors had experienced no major changes except that they now had to ask nurses to get drugs from the system for them.

Following implementation, the majority of pharmacists commented on the amount of additional staff time required to operate pharmacist order entry. However, some pharmacists stated the value of the pharmacist's check as orders are entered. Others said they considered this process to be an extra step at which errors could occur. Some pharmacists commented that the medicines supply role of order entry pharmacists and
clinical pharmacists was not clearly differentiated. Some felt that technicians could enter prescription data, with a clinical check provided by a pharmacist.

Following implementation, half the pharmacists could not identify any opportunities, however nor could half identify any threats. Statements similar to those before implementation were made concerning the nature of opportunities and threats. When asked if they felt that the Meditrol system was an opportunity or a threat, the majority still said an opportunity, however some of these added that this would only realise with modifications to the system. Some pharmacists stated that it was neither opportunity nor threat. Following implementation, the majority said they would rather use the traditional system, some of these saying the traditional system with improvements made. Comments concerning the implementation remained mainly negative, focusing on the cost and bad feelings. Some pharmacist however were positive, stating that Meditrol was the way forward or that they had gained from the experience.

9.5 Pharmacy Technicians

Nine technicians were interviewed before and after implementation. The grades of technicians are shown in table 9.4.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number interviewed before</th>
<th>Number interviewed after</th>
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<tr>
<td>MTO4</td>
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Table 9.4 Grades of technicians interviewed
Summary of pharmacy technician interviews before the implementation of Meditrol

Before the implementation technicians said that they expected that their own role would change to become more ward based with the Meditrol system. The majority said that there would be no change in their working relationships with pharmacists, though there would be increased contact with nurses and doctors (the Shotley Bridge system provided technicians with less opportunity to visit the wards than with technician top-up systems). They thought that pharmacists would spend more time on wards with the role of order entry and that their working hours would be extended in order to fulfil this role. The change in role of pharmacists and technicians and the extension of working hours were stated as disadvantages. Also mentioned was the expected generation of excess paper. The majority of technicians said the role of the pharmacy assistant would change from packing pharmacy boxes to packing coils for the Meditrol system.

There was a general view that nurses would experience an increase in efficiency due to time saved on drug administration rounds and on ordering drugs from pharmacy. Other expected advantages included improved ward stock control with decreased stock holding, more secure storage of drugs, there would be less waste. Though some technicians expected that there would be excessive amounts of paper generated by the new system.

Technicians stated that the pharmacist was the most appropriate person to enter prescription data onto the system, due to a perceived greater level of drug knowledge compared to doctors. A reason given in favour of doctor order-entry was that they make the final decision on drug treatment. Some commented that if doctors were to carry out order entry, they would need to develop the necessary computer skills.
Most technicians felt positive towards the forthcoming implementation of Meditrol, although some anxieties were expressed, particularly with respect to the method of introduction of the trial to the hospital and the adoption of an American drug administration system into the UK. Meditrol was expected to offer the experience of using a different medication system and the opportunity to visit wards. Few technicians saw Meditrol as a threat, though a few concerns about potential staff reductions were expressed. At this stage, the majority saw Meditrol as an opportunity. When asked they would prefer to use the traditional or Meditrol system, all but one said they would need to try Meditrol first before they could make a judgement. Concerning the implementation of Meditrol, the comments were generally negative with poor communication, bad feeling and mistrust being highlighted.

Summary of pharmacy technician interviews after the implementation of Meditrol

Following implementation, the majority commented on increased staff requirements. The expectation that technicians would become more ward based was not met; this role was delegated to pharmacy assistants. Comments were made that staff re-deployment from dispensary to distribution area resulted in insufficient staff in the former area. A minority stated that they had increased contact with nursing staff. The general view was that pharmacists spent more time on the wards and worked longer hours. For doctors, the majority of technicians were either unsure of any effect or said there was no change; some stated that access to medicines for doctors was more restricted. A major change in the nurse's working practice was commented on; specifically the use of computer technology to obtain drug doses. Most were unsure of the impact on patient care, though a minority commented that the level of patient care had declined and others though that the drug
administration process was safer. The expected major change to pharmacy assistants was confirmed. One technician commented on the decreased supervision of assistants in their redefined role.

Technicians remained positive about units of dose, some stating that there was less waste, though others forwarding an opposing view. Specific concerns about the quality of the system software were expressed. Concerns over excessive paper generation were confirmed.

After implementation there was a consensus that the pharmacist should enter data; reasons given were that it gave the opportunity for the pharmacist to carry out clinical monitoring using a greater knowledge of drugs and that doctors workload would not allow it.

Following implementation few technicians remained positive towards working with the Meditrol system. Some technicians said that it was an opportunity to develop computer skills and to be more involved on the wards. The majority did not see Meditrol as a threat, though some said it was neither opportunity or threat. There was a balance between preferring a return to the traditional system and using Meditrol. Negative feelings remained concerning the implementation process.
9.6 Pharmacy Assistants

Four assistants were interviewed before implementation and 5 after implementation.

Summary of pharmacy assistant interviews before the implementation of Meditrol

Before implementation assistants stated that their jobs would change and described the different nature of the work. Two assistants said there would be less work and therefore less people. Two said they would not like to pack unit doses and 1 said there were no problems with the way things were. They could not see how their jobs would get better and 3 said it would get worse due to the nature of the work. Three out of the four said they would rather their jobs stayed the same. Concerning the implementation, comments were mainly negative, concerns being expressed over lack of the trust in the Boots company and the time scale.

Summary of pharmacy assistant interviews after the implementation of Meditrol

After implementation, changes in the nature of work were described. The majority said that there were more drugs being returned from the wards and two commented that the stock levels in the stores were now more inaccurate. Three out of the five assistants were positive about working with the new system though one commented on the amount of waste paper and another on the amount of work involved. Two did not like working with the system. There were no positive replies about how they felt about working with unit doses; one said it was a waste of time and another said it was silly. Three said their jobs had got worse one said it was about the same, and the remaining assistant said her job was better because of going to the wards. Reasons for jobs getting worse included, 'more hassle', more time consuming, longer hours, the amount of complaints from ward staff,
the lack of explanation provided to them and the volume of drugs returned from the wards.

Following implementation, 3 said they would have liked their jobs to have stayed the same and 2 said they would not. When asked to summarise their feelings, comments were varied, some positive, but saying the system could be improved and others very negative towards the Meditrol system. One assistant stated that staff had left the department because of Meditrol.

9.7 Discussion

The pre implementation interviews revealed that most staff expected the system to bring about improvements in efficiency, safety and patient care at ward level. Most doctors interviewed however, said that the system would take more time for doctors, nurses and pharmacists. This may have been due to the sensitive nature of working hours for doctors. Post implementation nurses and pharmacists said that drug administration was taking longer, an observation supported by the activity sampling study which detected an extra 70 minutes per ward per day spent on drug administration with the Meditrol system.

Pre implementation, most pharmacy staff thought that stock control would improve with the Meditrol system. Following implementation there were some staff that thought stock control had improved and some that said it wasn’t working. Some nurses stated that stock control had improved after implementation. This may reflect that one of the objectives with respect to stock control, a reduction in the volume of drugs held on the wards, had been met by the system, but adequate accounting for drug usage was not
achieved. Nurses may have perceived a reduction in their involvement in this process as an improvement.

Nurses reported a higher level of stress following the implementation of Meditrol. Stress in the work environment can be caused by both under-stimulation and over-stimulation (Bradley 1989). Under-stimulation can arise from (amongst other things) repetitive work, lack of variety and not enough responsibility. Certainly the Meditrol system makes some aspects of the drug round more repetitive, such as obtaining doses from the cabinet and less varied due to the uniform nature of the doses. The reduced degree of flexibility reported by nurses with the Meditrol system may translate into the nurse feeling less responsible for the drug round due to the removal of some professional discretion; the unit dose philosophy of reducing nursing responsibility for dose preparation and the secure nature of the cabinet, eliminating nursing responsibility for the storage of these drugs, may further compound this. Over-stimulation may include (amongst other things) too much work, too much physical load and too great demands for further training. Certainly the drug rounds were taking longer which suggests more work; physical load may have increased, for example nurses reported the unsuitability of the trolleys which put strain on their backs. The training required to operate the system may have been a further cause of the reported stress, particularly for those staff not familiar with computerisation. Furthermore, the use of computer (in addition to a paper based system) may itself be a source of additional stress; a large study of computerisation in the insurance industry reported that workers using VDUs experienced more stress than non-terminal users (Bradley 1989). With particular reference to the hospital environment, workers have shown that computer technology can be a relatively minor source of stress, though this is
compounded by staff shortages and increased cognitive demands (European Foundation for the improvement of working and living conditions 1987).

Pharmacy staff did not mention stress as a symptom of the introduction of the Meditrol system. This may be due to the fact that pharmacy staffing levels were increased in response to the additional demands of the Meditrol system. Nursing staff, on the other hand, were not provided with additional staff to cope with the extra time required.

There was a general expectancy that the safety of the drug administration process would improve following implementation. The views of staff post implementation were mixed, some stating that the safety had improved, others stating a deterioration. This balance of views parallels the true situation; the observation studies revealed that the error rate had remained the same.

Few concerns were expressed during the pre implementation concerning the usability of the system; some nurses were concerned about the flexibility of the system and doctors were concerned about the fact that the system was accessed via static terminals rather than portable ones and anticipated problems with when required drugs. Following implementation many staff raised issues concerned with the usability, varying from the amount of travel required, the time taken to operate the system, software problems and problems with the way the system processed when required medication. The views of staff on the usability of systems have been incorporated into very efficient, structured methods for improving the human-computer interface (for example co-operative evaluation, Monk et al 1993). Application of such a technique may have improved the cognitive ergonomics of the Meditrol system.
A few pharmacists mentioned problems concerned with the operating of parallel systems and the resulting lack of efficiency, though no staff groups attributed any problems occurring to the use of dual systems of recording or problems with unentered drugs.

Both before and after implementation the majority of nurses interviewed and a number of pharmacists and technicians said that the pharmacist was the most appropriate person to enter orders. With the inefficiency of drug administration and pharmacist order entry and errors related to the order entry step, this was an unexpected view.

Pharmacy staff and some nurses were very suspicious of the agenda of the Boots Company, and were critical of the project management and implementation time-scale slippage. The negative feelings towards the Boots Company may originate from the company's previous (unsuccessful) attempts to gain access to other hospital sites where bad feelings were created within the pharmacy department (anon 1991a). The suspicion that the ultimate agenda of the Meditrol trial may have been to gain a contract for the pharmacy service may have fuelled some of the initial negative feelings. Further potentiating these feelings may have been the lack of consultation with any pharmacy staff during the negotiation of access to the trial site. Bad feelings may have been further generated due to the continual slippage of the project time-scale and the changes to the implementation plans.

It is not surprising that with the failure to meet crucial performance goals (both reflected by objective measurements and staff views) in terms of efficiency and smooth running of the system that the majority of staff said they would rather use the traditional system. A
further influence may be the failure to demonstrate any applications of the information compiled by the system and hence any overall benefit.
10 Discussion

This is the first study in the UK to examine the impacts of ward based automation on the drug distribution system. A HTA approach has been taken, using a framework adapted from those described in the literature. This chapter provides a summary of the findings and discusses the limitations of the study, both in terms of the evaluation design and the methods and the constraints due to changes in implementation plans. Also discussed are the lessons learnt for the future development of drug distribution systems in the UK and the management of the introduction of new technologies. Finally, the implications for HTA policy and the NHS R&D programme are considered.

10.1 Summary of the study findings

The findings of the study are summarised in table 10.1. The major expected benefits of the system were not realised; the error rate remained unchanged, additional time and staff were required to operate the system, there was no measurable difference in drug losses and information was not applied to either cost saving or quality improvement initiatives. Staff attitudes were mainly positive before implementation, though were mainly negative afterwards. As a result of these findings and because of the perception of the implementation team (and workers at the trial site), the development of the Meditrol system was stopped. The system implemented did show some improvement in the timeliness of drug administration and exhibited greater control (computerised inventory accuracy and level of drug losses) over drugs stored in the Meditrol cabinet. In areas
<table>
<thead>
<tr>
<th>Potential Impact</th>
<th>Measures</th>
<th>Key findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient safety</strong></td>
<td>Drug administration error rate</td>
<td>• DAE rate unchanged (3.5%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improved timeliness of drug administration</td>
</tr>
<tr>
<td></td>
<td>Quality of prescription writing*</td>
<td>• Some deficiencies which could compromise safety and efficiency</td>
</tr>
<tr>
<td></td>
<td>Pharmacist intervention patterns</td>
<td>• Increased intervention rate with Meditrol (+28 ± 10 interventions/100 beds/wk)</td>
</tr>
<tr>
<td><strong>Staff time</strong></td>
<td>Staff time required for drug rounds</td>
<td>• An extra 68 minutes per ward per day (21%) spent on drug rounds (p=0.03)</td>
</tr>
<tr>
<td></td>
<td>Staff time required for ordering drugs</td>
<td>• 10 minutes per ward per day saved on ordering and putting away stock</td>
</tr>
<tr>
<td></td>
<td>Pharmacists’ ward based time</td>
<td>• Order entry required an additional 30 minutes per ward per day (an increase in ward based time of more than 100%)</td>
</tr>
<tr>
<td></td>
<td>Net changes in pharmacy staff levels</td>
<td>• 20% increase in staffing levels (7.5 FTEs) to maintain Meditrol service on 11 of 27 wards</td>
</tr>
<tr>
<td><strong>Inventory management</strong></td>
<td>Volume and cost of drugs on the ward</td>
<td>• 48% reduction in quantity of drugs on each ward (significant at 5% level)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No change in cost of drugs on each ward</td>
</tr>
<tr>
<td></td>
<td>Computer inventory accuracy</td>
<td>• Absolute inventory discrepancy of 42 ± 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Meditrol cabinet very accurate - absolute inventory discrepancy of 0.73 ± 0.32</td>
</tr>
<tr>
<td></td>
<td>Drug losses</td>
<td>• Absolute consumption discrepancy - 40 ± 3% (original) and 34 ± 8% (Meditrol)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Absolute consumption discrepancy for cabinet drugs (13 ± 3%) superior to that of shelf drugs (70 ± 26%)</td>
</tr>
<tr>
<td><strong>Information management</strong></td>
<td>Descriptive accounts of cost savings</td>
<td>• Information was not used to for cost saving initiatives during the study period</td>
</tr>
<tr>
<td></td>
<td>Descriptive accounts of improved quality of care</td>
<td>• Information was not used for quality improvement initiatives during the study period</td>
</tr>
<tr>
<td></td>
<td>User perception of potential value</td>
<td>• Senior clinicians acknowledged financial though not clinical benefits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• IT manager and pharmacy services manager were positive of clinical and financial benefits</td>
</tr>
<tr>
<td><strong>Staff attitudes</strong></td>
<td>User perception</td>
<td>• Pre- implementation - mostly positive, though some concerns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Post-implementation - Mainly negative</td>
</tr>
</tbody>
</table>

Table 10.1 Summary of key findings of the evaluation

*Original system examined only
where most drugs used could fit into the cabinet, such as nursing homes, the system may be more successful.

10.2 Lessons for the introduction of new technologies

Had the pre-implementation findings been known when the Meditrol trial was first considered, the system would probably not have been perceived as a viable product for the UK market. However, the Meditrol trial was conducted at considerable expense only to be abandoned because the expected benefits were not achievable. This section discusses how (with hindsight) the trial could have been managed more efficiently and more effectively. Specifically, the advantages of a needs assessment prior to the trial and a smaller scale implementation and evaluation are discussed.

The Meditrol system was first encountered by members of the implementation team during a visit to the states. The system seems to have been ‘sold’ to Boots on the basis of claims to reduce drug administration errors, provide secure storage to avoid pilfering, reduce the number of staff needed for drug distribution and provide patient specific drug use information. These claims were not supported by research (except for small studies published as abstracts in conference proceedings) and the marketing strategy for the product was based on the established need of American hospitals. The claimed benefits of the system were extrapolated to the UK, despite the lack of evidence supporting the need for systems such as Meditrol. In business terms, this extrapolation carried considerable risk. Furthermore, from a HTA perspective, the decision to evaluate a technology should, according to current philosophy, be driven by need and not purely by the existence of a new technology (Yergen and Tugwell 1995, Tugwell et al 1995). The generation of
patient specific drug use information was the only potential benefit of the Meditrol system for which there was an identified need (for resource management purposes and as part of the NHS information technology strategy).

The pre implementation studies revealed that the traditional system of drug supply and administration in the UK was both more effective and efficient than the Boots company had perceived. This highlights the importance of obtaining baseline information relating to established technologies and risks of importing technologies designed to solve the problems of other countries. The commissioning of a needs assessment study before commitment was made to a particular technology may well have been a rational and less expensive option. This approach should have combined quantitative and qualitative research in order to determine the strengths and weaknesses of the existing drug distribution system and also to assess the demand for intervention. The research could have examined the same areas as the Meditrol evaluation pre implementation research and, with fewer constraints with respect to the study site, could have been conducted in a variety of different clinical settings (for example a ‘district general’, a teaching hospital and a nursing home). The data obtained could have been used to produce an economic analysis of the drug distribution system in order to assess the business potential of different technologies.

The philosophy of the Meditrol evaluation team was to work completely independently of the implementation, to provide no developmental guidance except to warn of impending disaster, and to withhold results until the end of the trial; a similar approach to that of a clinical trial of a new drug. The rationale was that the provision of feedback during the trial would create an artificial situation which may not be available to subsequent
implementations. The situation of the Boots team was also politically sensitive, particularly within the pharmacy profession and so an independent evaluation offered credibility to the findings. At this stage this may not have been the best approach. A close relationship between the evaluation and the implementation may have provided more direction and assigned priority to problematic areas, thus improving performance. This concept of actively seeking benefits by integrating evaluation with implementation has been adopted by the HISS Central Team (Keen 1995). Rossi and Freeman (1989), in the context of evaluating social interventions, refer to this approach as ‘formative’. In essence these types of evaluation are conducted at an early stage in the development of an intervention, normally examining a small scale pilot, and are either directed at specific questions relating to development, or are ‘mini-impact’ studies to estimate the potential benefits, or are a combination of the two. The Meditrol evaluation was commissioned to allow Boots to assess the business potential of the system in the UK. The initial expectation was that system could be slotted directly into the UK, however in reality the system needed considerable modification. A formative evaluation asking questions relating to the design would have provided structure and direction for the development of the system. Furthermore, a small scale ‘mini-impact’ study, on one or two wards, would certainly have provided adequate information on the potential impact of the study. This strategy may have increased the likelihood of a successful impact or at any rate would have reduced the expense of the trial.

Formative studies not only provide insight into the problems faced by an intervention and ways to overcome them, but also allow pre-testing of the research methods used. However the role of the evaluator does change significantly. Rossi and Freeman (1989) state:

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‘Evaluators involved in formative studies obviously must become involved in the actual design and programming effort, since the emphasis here is on increasing the success of subsequent intervention efforts and their evaluations. Thus, the evaluator frequently becomes an advocate in programme development and implementation activities.’

This role is very different to that adopted by the Meditrol evaluation team. It would be very difficult to justify the same evaluators conducting both formative research and, later, a formal health technology assessment; the ‘ownership’ of the technology established in the developmental phase would not be conducive to a neutral assessment.

In summary, the ideal process for the introduction of the Meditrol system into the UK should have included a number of filters. The process should have started with a needs assessment of the current UK drug distribution system (see figure 10.1). It is likely that the findings of this exercise would probably have steered the Boots Company away from Meditrol and towards other applications, such as computerised prescribing where emphasis is placed on information management and other ‘value added’ benefits. An early formative evaluation should have been considered on a small scale pilot of the system (1 or 2 wards) in order to guide development and estimate the potential impact of the system. A formal HTA should then have been commissioned to evaluate the system implemented on a larger scale (a single hospital site) using the framework developed in this thesis. The findings of the early stages of HTA should be used to develop (or modify) the business plan for marketing the system. The later stages of HTA should parallel the continued diffusion of the technology.
Figure 10.1 Suggested process for the introduction of a new drug distribution technology
10.3 Limitations of the Meditrol trial

This section considers the limitations of the evaluation and includes the study design, the methods and the effect of compromised implementation plans.

10.3.1 Limitations of the study design

A well designed comparative study should allow conclusions to be drawn on the impact of an intervention with a high degree of certainty. This is achieved by eliminating or compensating for bias. Broadly speaking, two forms of bias can be introduced; that due to extraneous variables and that due to the research process itself. This can be represented as:

\[
\text{Gross outcome} = \text{Effects of intervention} + \text{Extraneous confounding factors} + \text{Design effects factors}
\]

These factors and their relevance to the Meditrol evaluation design are discussed below.

Bias due to extraneous variables

The Meditrol trial was conducted at a single hospital site using a before and after study design. However, this approach could have lead to bias from two sources. Firstly, the site was probably hand-picked because the hospital management were convinced of the potential benefits of the system, the drug trial equivalent of recruiting patients who are likely to benefit the most (selection bias). Secondly, the time lag between the ‘before’ and ‘after’ phases could have predisposed the study to an uneven effect of extraneous variables; the characteristics of the site could have changed during the course of the trial. The ideal study design (assuming the absence of any constraints) and further measures
which could have been used to identify and isolate extraneous variables are discussed below.

The gold standard design for scientific research is the randomised controlled trial (RCT). Ideally, this design should have been used to compare the Meditrol system with the original drug distribution system. The principle of the RCT is to select a number of subjects and randomly allocate an intervention to a proportion of them, with the remainder acting as controls. The key elements in the design of a RCT of the Meditrol system would have been: what constituted 'subjects' (for example patients, wards or hospitals); the number of subjects in the experimental and control groups; inclusion and exclusion criteria; subject selection; and the randomisation process.

The Meditrol trial was designed to examine the implementation in an entire hospital. This was appropriate as some of the potential impacts (for example, the generation of drug use information and improved efficiency for the pharmacy department), could not be studied fully with partial implementation. The results of this study demonstrate that sufficient data can be obtained from studying each system at one hospital site (in effect, each site consists of groups of subjects, either hospital wards or staff). Therefore, one experimental site and one control site would have been adequate. The initial selection of potential sites should have been based on explicit criteria for number of beds, case mix, activity, staff to patient ratios, skill mix, management structure and budget. This may have involved a 'trawl' of all hospital sites in the UK. At this stage, consent from potential sites should have been sought and final selection could have been based on the best 'match' obtainable. The Meditrol system would then simply have been allocated to one of the sites using a standard randomisation technique.
Some of the research described in this thesis was conducted on selected wards in the hospital. The selection process was achieved by stratifying the wards by speciality and randomly selecting 2 wards from each of the specialities considered to be typical of a district general hospital (general medicine, general surgery and care of the elderly). This process should be carried out at both control and experimental sites in order to select the wards on which the research is to take place. The ideal selection and randomisation processes are summarised in figure 10.2. This approach could have been used in later stages of the HTA framework, though more varied sites would be included, for example different size hospitals or teaching hospitals.

Whether a before and after study or a RCT design had been used, it would still have been possible to encounter unequal effects of extraneous variables between control and experimental groups purely by chance. For example, drug administration error rate may be influenced by a number of variables including grade of nurse, the length of the drug round, the number of patients and the frequency of interruptions. Difference in the incidence or patterns of each variable between the two groups could have been identified. For example the drug administration error rate data sets could have been compared by examining the proportion of drug rounds conducted by each grade of nurse and corresponding 95% confidence intervals calculated. For statistically significant differences, the influence of the variables could then have been assessed using regression analysis. This technique not only involves the calculation of confidence intervals for each stratification according to each variable (for example allowing identification of significant differences in error rate between different grades of nurse), but also quantifies the extent to which some or all of the variates account for the variation in the outcome.
Potential sites satisfying inclusion criteria

Hospital A  Hospital B  Hospital C  Hospital D

Selection of matched sites

Hospital 1  Hospital 2

Randomisation

Meditrol  Control

Stratification and randomisation of study wards

Meditrol ward 1  Control ward 1
Meditrol ward 2  Control ward 2
Meditrol ward 3  Control ward 3
Meditrol ward 4  Control ward 4
Meditrol ward 5  Control ward 5
Meditrol ward 6  Control ward 6

Figure 10.2 Randomised controlled trial of the Meditrol system
measurements. In this way, conclusions concerning cause and effect relationships could have been made with a greater degree of confidence.

The best option for the evaluation of Meditrol would have been to conduct a RCT as summarised in figure and analyse the findings using regression analysis. In practice, it was not feasible to construct a scientifically robust trial, though statistical modelling techniques should have been used to examine the variation in the data.

**Bias due to design**

Bias due to the influence of the research itself is a well recognised phenomenon. In observation studies, the most well defined design bias is the Hawthorne effect. This manifests itself as enhanced performance of subjects whilst under observation. The Hawthorne effect may have introduced bias into several of the evaluation studies. Ward staff may have been less inclined to pilfer whilst researchers were conducting inventory studies on the ward, ward pharmacists may have made more clinical interventions or have modified their activities and nurses may have been more diligent on drug rounds. For much of the research it is impossible to eliminate the Hawthorne effect as observation is an unavoidable feature and although it is tempting to assume that this bias was equal in each of the study phases, it would be desirable to demonstrate this.

A feature of the Hawthorne effect is that it is diminishes with time and so subjects revert to their normal behaviour. Examination of changes in effect in relation to the duration of observation may, therefore provide some insight into the magnitude of the effect. The only data set where this was possible was the DAE rate study. When the drug administration error rate data for each individual study phase were analysed according to
the day of each one week study period, no significant differences were seen (all of the 95% CIs overlapped). However, examination of a larger data set, obtained by pooling results for all 3 study phases, revealed a statistically significant difference (95% CIs do not overlap) between the DAE rate on day 1 compared to days 2, 3 and 6 (see figure 10.3). This suggests that the presence of the observers on the ward had a significant effect on the behaviour of the subjects, though this effect quickly diminished (though it cannot be assumed that it disappeared) and a stable DAE rate was observed. This picture is an oversimplification of the situation; due to nursing shift patterns, subjects could have been first observed at any time during the study week. A more appropriate analysis would therefore be by the total observation time for each nurse. However, it was not possible to perform this analysis due to the structure of the data.

<table>
<thead>
<tr>
<th>DAE rate and 95% CIs</th>
</tr>
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<tbody>
<tr>
<td>Day</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Figure 10.3 The relationship between DAE rate and day of the study week
In summary, the Hawthorne effect is inevitable in observational studies. In future studies total duration of observation of individual nurses should be documented when errors are made so that the influence of the Hawthorne effect can be examined. Similarly, other observation studies should be designed to allow analysis of data stratified according to lapsed observation time. If necessary, data collected early on in a period of observation can be discarded.

10.3.2 Limitations of the research methodology

This section discusses how, if repeated, the research methods would be modified; how the next stage of the HTA process (had it been deemed appropriate) would have differed from this one and; further research required to develop methods suitable for the assessment of drug distribution systems.

Safety

Drug administration error rate was a key indicator used to assess the system's performance. This is an intermediate or proxy outcome as it does not directly assess the clinical impact on the patient or the financial impact on the hospital or on society. Observational studies could be employed to study the consequences of errors, however the ethical issue arises of allowing an error to occur and not preventing. Furthermore, the incidence of clinically significant drug administration errors is probably very low. Ideally, at the next assessment stage large cohorts of patients should be observed and true outcomes such as length of stay or mortality rates should be measured. As an intermediate measure, modelling techniques should be used to estimate the potential impact of drug administration errors. As the incidence and nature of drug administration
errors is known, hypothetical drug errors could be randomly allocated to an observed patient population and expert panels then used to assess the likely impact.

The drug administration error study was conducted in a covert fashion. This raises a further ethical issue. Certainly, a clinical trial would be considered unethical if patients were unaware of their participation. However, it could be argued that this study was not strictly covert as nurses were aware that they were being observed by qualified pharmacists and were certainly not surprised that the observers noticed when they were about to make a mistake. In fact some of the nurses said that they were reassured by the presence of a pharmacist at their side. The use of a hidden camera to observe nurses on drug administration rounds would have been truly covert; more accurately, this study was 'disguised' by the activity study. Furthermore, the publication of 3 more studies using this methodology demonstrates that this is being recognised as the standard way of measuring DAE rate in the UK. Nonetheless, the ethics of this method should be explored further with nursing professional bodies and academics.

Intervention rate was used to assess the impact of the Meditrol system on pharmacists' clinical activities. However, this study was originally designed to test the hypothesis that decision support software in conjunction with doctors prescribing directly onto the computer system would relieve the pharmacist of the more trivial problem solving activities. However, similar to the DAE rate, this is a proxy measure which is compromised because it is not known how patient outcomes are changed as a result of modified prescribing. Studies have demonstrated the benefit of diagnosis-based system (for example de Dombal et al 1985 examined the diagnosis of acute abdominal pain) applying criteria such as correct early diagnosis as a measure of performance. However,
prescribing decision support is more complex; ideally, large, outcome-based studies or modelling techniques should be used at the next HTA stage. Intervention analysis should more appropriately be used to examine the influence of decision support on the level of performance of pharmacists by using decision models (for example, Campagna 1995), the hypothesis being that, by automating the straightforward interventions, the pharmacist could perform at a higher level.

At the early stages of HTA, the use of proxy measures is acceptable (Sculpher et al 1995). Ideally, in the later stages of HTA true outcomes should be measured, though in practice this may not be achievable; modelling techniques and the measurement of proxy outcomes would be a reasonable compromise. However, proxy outcomes should be validated (by separate research) so that a more accurate estimation of true impact can be performed. For example, blood pressure reduction is a proxy outcome which has been directly linked to a reduction in the risk of stroke and cardiovascular events. The lack of research validating the proxy outcomes described here severely compromises their application. This issue is a priority for further research.

Measurement of inventory control

It was difficult to account for drug usage using the drug chart due to the complex nature of drug movements, the lack of records for the use of many drug products (for example diluents for intravenous fluids) and the lack of completeness of the drug chart record. There was no evidence that theft was occurring, though any pilfering would have been difficult to detect with the amount of 'background noise'. The method used to express control (absolute discrepancy) was considered to be superior to methods described in the
past. However, the methodology should be further improved so that drug movements can be more accurately tracked, thereby differentiating background noise from pilfering.

**Measurement of staff time**

The methods used to examine changes in pharmacy staff time (activity analysis of ward pharmacy and observation of trends in staffing levels) were considered to provide adequate information on the impact of the change in system at this stage. A more in-depth examination would be desirable at the next stage of HTA, considering changes within the pharmacy department in greater detail. For example, an activity analysis of the dispensary was carried out before Meditrol was implemented (Ridge *et al* 1995). This work (not presented in this thesis) was not repeated with the Meditrol system as incomplete implementation throughout the hospital resulted in two systems operating in the dispensary.

The implications of packing units of dose in the pharmacy department were not considered in the evaluation. With further diffusion of the Meditrol system it was anticipated that individually packaged doses would have been obtained from the manufacturers at no extra cost (as occurs in the USA); the small scale packaging of unit doses was therefore viewed as a temporary measure and so was not studied. However, there was a degree of uncertainty surrounding this matter. If necessary, later stages of HTA should consider the economic implications of this process.

Examination of nursing activities was confined to the drug round and to ordering and putting away drugs. However, the Meditrol system had wider reaching impacts on nursing time than these activities alone. For example, nurses were required to use the
system to admit, discharge or transfer patients. An additional activity analysis of the entire nurses day should have been carried out at this stage. A study using observers or, similar to the ward pharmacy study, using self reporting methods would have been suitable.

Assessment of information management

Information was not used during the study period except to monitor the performance of nursing staff. The initial aim of this research was to identify any financial and clinical benefits achieved by applying this information, using case study techniques. The main difficulties which would have been anticipated were firstly trying first to isolate the benefits of information and secondly, in allocating a value to the information generated (Keen 1994). Furthermore information related to workload and performance may itself be used to review procedures and resource allocations, a factor which again is difficult to quantify. Several methods may be applicable for later HTA stages; economic analyses such as cost-utility analysis or information economics; accounting techniques such as return on investments or return on management (where management costs are isolated).

The information management benefits of the system are likely to be accrued much more slowly than other, more 'direct', benefits. Moreover, the full benefits will not be achieved unless implementation covers a significant proportion of the clinical activities of the organisation (for example, at least all inpatient prescribing for a clinical directorate) and prescribing data is used to supplement other treatment and activity data. A sufficient time must be allowed for the development of systems for managing, disseminating and utilising this information and so complete assessment of this benefit (in the later stages of HTA) should be carried out much later than that of the other benefits. The exact time scale is
likely to vary from site to site. System maturity should be assessed using explicitly defined criteria; the meeting of key objectives defined in the hospital information strategy would be suitable.

Assessment of attitudes

This study examined staff expectations of the Meditrol system and their attitudes towards the implemented system. This is in contrast to the rest of the research where the original system was compared with the Meditrol system. An assessment of attitudes towards the original system would have been more consistent with a comparative study. However, in terms of methodology, structured interviews were considered to be suitable at this stage of HTA. At the next stage techniques could be used which examine themes established by this early work. Quantitative methods should be used which could be applied to a larger proportion of the workforce.

10.3.3 Implications of changes to the implementation schedule for the evaluation

The Meditrol system was not implemented according to original plans; it was only installed on 11 out of 26 wards and pharmacists were entering orders instead of doctors. In addition, the implementation time scale had slipped by 1 year. The influence of implementation factors on the results obtained have been discussed in the individual research chapters. These are summarised in table 10.2.

According to the evaluation framework, this stage should examine the system under ideal implementation conditions (the equivalent of measuring efficacy, according to Jennett’s framework). If ‘ideal’ refers to the resources allocated to the implementation, then these criteria may have been met. However, this is a fairly arbitrary criterion on which to base a
<table>
<thead>
<tr>
<th><strong>Implementation factor</strong></th>
<th><strong>Measures</strong></th>
<th><strong>Possible influence</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacist order entry,</td>
<td>Drug</td>
<td>• More errors due to ‘non availability’</td>
</tr>
<tr>
<td>retention of drug chart</td>
<td>administration error rate</td>
<td>• Transcription errors</td>
</tr>
<tr>
<td></td>
<td>Quality of</td>
<td>• No improvements in prescription clarity and</td>
</tr>
<tr>
<td></td>
<td>prescription writing</td>
<td>completeness</td>
</tr>
<tr>
<td></td>
<td>Pharmacist intervention patterns</td>
<td>• No decision support software - no reduction in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wrong dose and drug interaction interventions</td>
</tr>
<tr>
<td></td>
<td>Staff time required to conduct drug</td>
<td>• Longer drug rounds due to parallel systems and</td>
</tr>
<tr>
<td></td>
<td>rounds</td>
<td>failure to exploit computerised dose scheduling</td>
</tr>
<tr>
<td></td>
<td>Pharmacists’ ward based time</td>
<td>• Doubling of ward based time</td>
</tr>
<tr>
<td></td>
<td>Net changes in pharmacy staff levels</td>
<td>• Additional pharmacists required</td>
</tr>
<tr>
<td></td>
<td>Computer inventory accuracy</td>
<td>• Parallel system encourages miscompliance with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>computer</td>
</tr>
<tr>
<td></td>
<td>Drug consumption not accounted for</td>
<td>• Record of drug administration less complete</td>
</tr>
<tr>
<td>Deviation from unit dose</td>
<td>Drug</td>
<td>• Full potential to reduce drug administration errors by</td>
</tr>
<tr>
<td>philosophy</td>
<td>administration error rate</td>
<td>use of unit dose system not exploited</td>
</tr>
<tr>
<td>Software bugs</td>
<td>Volume and cost of drugs on the</td>
<td>• Accumulation of drugs on wards</td>
</tr>
<tr>
<td></td>
<td>ward</td>
<td></td>
</tr>
<tr>
<td>Failure to fully consider</td>
<td>Computer</td>
<td>• Greater quantity and value of drugs on the ward than</td>
</tr>
<tr>
<td>stock control parameters</td>
<td>inventory accuracy</td>
<td>achievable</td>
</tr>
<tr>
<td>Failure to produce usable</td>
<td>Descriptive accounts of cost savings</td>
<td>• No opportunity for applying information to quality</td>
</tr>
<tr>
<td>information</td>
<td></td>
<td>improvement initiatives</td>
</tr>
<tr>
<td></td>
<td>Descriptive accounts of improved</td>
<td>• No opportunity for applying information to cost</td>
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<tr>
<td></td>
<td>quality of care</td>
<td>improvement initiatives</td>
</tr>
<tr>
<td>Time scale slippage,</td>
<td>User</td>
<td>• Negative feelings towards system</td>
</tr>
<tr>
<td>failure to meet</td>
<td>perception</td>
<td></td>
</tr>
<tr>
<td>implementation objectives</td>
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Table 10.2 Possible influence of implementation factors on study findings
distinction between efficacy and effectiveness. A more rational approach would be to consider whether all implementation objectives had been met and a stable system had been achieved. In this case this study does not satisfy these criteria; the evaluation was carried out too soon. This issue is an important consideration for future work if the true potential of drug distribution technologies are to be assessed and is discussed in more detail later in this chapter. A further consideration is that computer systems are likely to evolve with time and hence performance may improve with diffusion. This is in contrast to other technologies such as drugs, where diffusion outside of ideal conditions often results in reduced performance.

Incomplete implementation of the system and the failure to implement doctor order entry also had implications for the research process. Work examining time spent by doctors on the prescribing process was abandoned and studies of the quality of written prescription and dispensary activity were only conducted before Meditrol implementation. Incomplete implementation compromised the validity of control data for the analyses of ward pharmacy time and interventions. The important lesson is that changes to implementation plans are likely to occur. Wherever possible, contingency plans should be built into the research design and data sets should be produced which can easily be subdivided if necessary. For example, collection of the ward name for each intervention in the pre-implementation phase would have allowed comparison of data generated by Meditrol wards before and after implementation.
10.4 Lessons for the development of drug distribution systems in the UK

The results of this study provide valuable insight into the strengths and weaknesses of the current drug distribution system in the UK. This knowledge is useful for determining the most cost effective measures for improving the system. This is discussed below in the context of drug administration errors, staff time, inventory management and information management. Also discussed is the role that automation can play in improving the drug distribution system.

Drug administration errors

The drug administration error rate was comparable with that measured in the USA (a median error rate of 3.7% was reported by Allan and Barker, 1990). The non-availability of drugs accounted for a large proportion of the errors witnessed (1.5% of all drug administrations), which suggests that an increase in efficiency of supply of drugs could markedly improve on the measured drug administration error rate. Additional risk management strategies such as the investment in staff training, new systems or work and/or technology may reduce this error rate further. With the assumption that the greater the resource put into risk management strategies, the lower the error rate that can be achieved, decision makers will need to know the cost benefit of such investments.

'What if' analysis could be used to support decision making. For example this simple analysis is based on the assumption that a proportion of omitted doses of medication could lead to the patient spending an additional day in hospital:

- There are 45 doses per drug round (from error study)
- This extrapolates to 985,500 doses per year on the 15 medical, surgical and care of the elderly wards in the study hospital
• 2.3% of doses are omitted (combination of errors due to non-availability and omissions)

• 22,667 omitted doses per year

• Bed occupancy cost per day = £150 (estimate based on information provided by the trial hospital)

• Table 10.3 shows the relationship between the incidence of omissions which cause an extra day in hospital and cost avoidance from a 50% reduction in the incidence of omitted doses.

<table>
<thead>
<tr>
<th>Omissions causing an extra day in hospital</th>
<th>Annual cost of omissions</th>
<th>Cost avoidance from 50% reduction in omitted doses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in 10</td>
<td>£340,000</td>
<td>£170,000</td>
</tr>
<tr>
<td>1 in 100</td>
<td>£34,000</td>
<td>£17,000</td>
</tr>
<tr>
<td>1 in 1,000</td>
<td>£3,400</td>
<td>£1,700</td>
</tr>
</tbody>
</table>

Table 10.3 'What if analysis of the cost of omitted doses due to extended length of hospital stay on 15 general wards.

The use of 'what if' analyses combined with expert judgement can provide useful guidance on the likely impact of an intervention. The above analysis shows that with the range of values considered, the potential savings are between £1,700 and £170,000 per annum. The true incidence of omissions which cause an extra day's stay in hospital is likely to be much nearer to 1 in 1,000 than 1 in 10. The potential savings due to reducing the incidence of omitted doses by 50% is therefore likely to be more on the scale of £1,000s rather than £100,000s per annum. Similar analyses could be performed for other adverse incidents such as morbidity and mortality. The cost avoidance potential could then be calculated for various combinations of occurrences of these events. Such analyses
(beyond the scope of this thesis), should be used to provide guidance for investment appraisal in the absence of real outcome data.

Staff

The results of this evaluation suggest that pharmacist order-entry is unlikely to be viable: the increase in staff costs was not offset by benefits in terms of enhanced intervention patterns and many of the deficiencies of the Meditrol system were attributed to the failure to implement computerised prescribing. The demarcation of ward based pharmacist activities into ward pharmacy and order entry, however, may not have been the most efficient solution. Other options, such as ‘near patient’ ward pharmacy may have been more suitable. A ‘near patient’ ward pharmacy model involves the pharmacist spending all or most of their day on or near the wards. Typically a pharmacist will cover a small number of wards (usually 2 or 3) and will be more accessible to patients and staff than with the traditional, pharmacy-based system. This arrangement can facilitate an extension of the normal ward pharmacy activities to include medication history taking, patient counselling and discharge planning. If this model had been adopted, where the clinical and the order entry functions were carried out by the same, ‘near patient’ pharmacist, the process may have been more efficient. The entry of the drugs prescribed on the patient’s admission could have been carried out at the same time as patient medication history taking. Two staff could have covered the extended working day on each group of 2 or 3 wards, one working an early and the other a late shift. This is in contrast to a ward pharmacist spending half an hour a day on the ward and the order entry pharmacist, at times, covering 11 wards. The former arrangement would have promoted a greater consistency of care, more responsive order entry and a more in-depth knowledge of the patients. There would have also been time savings due to reduced travel time. This
model or similar ones should have been considered by the implementation team as it may have been more efficient and could have provided additional ‘value added’ features. However, pharmacist order entry goes against current information management philosophy which promotes systems which integrate with and support processes without additional effort or duplication of data entry; whichever model is used, pharmacist order entry is inherently less efficient than computerised prescribing.

In a climate where a reduction in doctors’ hours is an objective, computerised prescribing must not lengthen the time doctors needed to prescribe unless this is offset by time saved performing other tasks. Improvements in the clarity and the completeness of prescription and improved prescribing due to decision support may reduce contact time with nurses and pharmacists spent clarifying or correcting prescriptions. Careful design of systems and, in particular, the human computer interface is required to positively influence the precarious balance between time saved and time consumed. For these reasons an in-depth analysis of the entire doctor’s day will need to be performed to assess the impact.

**Inventory management**

It was difficult to establish the extent to which drugs were pilfered or wasted on the wards (though it was felt that theft was not a major problem). ‘What if’ analysis may provide further guidance on the benefit of secure systems:

- Average cost of drugs consumed on a per ward per week = £312
- This extrapolates to £243,360 per year on 15 wards.
- The percentage of this consumption which is due to losses and wastage is unknown, though is unlikely to be above the measured net discrepancy of -7.8%.
• If 10% is due to loss and wastage this amounts to around £1,900 per year
• If 100% is due to loss and wastage this amounts to £19,000 per year.

In terms of potential savings by reducing the amount of drugs held on the wards, the mean value per ward was found to be £1,600 or £24,000 on 15 wards. There is therefore a potential to make a small saving using this strategy.

The potential savings by reducing the amount of drugs held on the ward and by reducing waste and pilfering are relatively small. In addition, good accounting practice may be an advantage and a high level of control may promote the accuracy of data collected. Computerised inventory management may also allow centralised distribution of at least the more commonly used drugs direct from the manufacturer on a 'just in time' basis and may significantly reduce overheads.

**Information management**

The benefits of patient specific data remain unclear, though will be fundamental in directing the future development of drug distribution systems. The use of information systems may improve the business management of the hospital, both by facilitating more accurately costed contracting arrangements and by monitoring performance with a view to optimising procedures and resource allocation. It is anticipated that patient specific information will support clinical medical audit and drug use review and drug histories will form part of the electronic patient record. The value of information is, however, sensitive to political influences, for example the adoption of case-specific contracts rather than block contracting arrangements would make this information less valuable or a change in government could prompt a revision of the entire health service philosophy. Also drug
costs are low for most patients (Jenkins et al 1995 measured a median drug cost per inpatient stay as less than £5), which questions the appropriateness of indiscriminate data collection for financial purposes. Finally, the cost effectiveness of the current medical audit process is not known and so it is difficult to predict the impact of improved information management. Also, the interview work carried out suggested that there may be differing expectations of the benefits of information between senior clinicians and managers; clinicians may be reluctant to accept that computer-generated information may influence patient care.

The role of automation
Figures from the USA suggest that the Meditrol system costs around $1.3 to $1.5 million for a 20 cabinet device (Perini and Vermeulen 1994), though other systems are less expensive. The benefits of automation in the UK must be sufficient to justify this cost. The main reason why automation has been considered to be cost effective in the USA is because it allows a reduction in the number of staff required to operate the inherently labour intensive unit dose system (Somani and Woller 1989). The UK system is less labour intensive and so there is less scope for saving money by improving efficiency. The benefits of automation must be found in areas other than the reduction of staff costs. If systems could provide better inventory management than Meditrol, perhaps by providing restricted access to a wider range of products, or Meditrol was used in clinical areas (such as nursing homes) where a larger proportion of products can be accommodated, further savings would be made. However, ‘what if’ analysis estimated a maximum of £19,000 per year on 15 ‘general’ wards could be saved by eliminating drug losses and only modest capital could be recouped by reducing ward stock holding (total value of stock on 15 general wards was estimated to be £24,000). Further work is necessary before the
benefits of improved safety and information utility can be quantified. Though given the current expense of automation, it is unlikely that ward-based automated systems will be cost effective.

10.5 HTA of drug distribution systems - policy context

The NHS R&D strategy is aimed towards making information on health technology assessment available to healthcare providers (and purchasers) as an aid to choice and management of technology. The specific technologies in need of assessment are identified and prioritised by the Standing Group on Health Technology. The prioritised research is then funded centrally or by regional health authorities and postgraduate hospitals. Clearly the Meditrol trial fell outside of this process. The ‘problems’ with the current system were identified by and the research commissioned by a commercial company. The company however were inaccurate in their assessment of the existing drug distribution system, presumably because they were basing their strategy on impressions gained from the USA. There was very little objective research into the performance of the existing UK pharmacy systems, a problem which probably applies to a range of treatments, procedures and systems of work established in the NHS. Although there is a need to perform a timely assessment of potentially useful new technologies, it seems sensible to first examine existing technologies and systems of work in order to assess the need for intervention. This information could then be used to justify public sector funded research according to the R&D strategy or to guide commercial companies in their own research and development.
The evaluation of information systems presents a daunting task to the NHS. For pharmacy systems, the information generated is unlikely to be used in isolation as drug costs and medication records are only a part of the complete data set accumulated during a hospital stay. It will be more appropriate and cost effective to consider the benefits of information in a more global context. The cost of obtaining patient specific drug use information could be fed into the calculation of the total cost of a hospital’s information system. Likewise, the benefits specific to drug distribution system, such as reduced error rate, could be evaluated separately. The principles of the framework described in this thesis could still be applied, though a more generic version may be required to accommodate other non-pharmacy components of the information system.

10.6 Conclusions

1. This thesis has made a number of contributions to the pharmacy practice and HTA fields. Firstly, it has provided a detailed insight into the UK drug distribution system (which has not been provided for around 30 years) which offers direction for future development. A HTA framework has been developed which, at an early stage, has proven to be suitable for the evaluation of drug distribution systems. Methodology has been tested and recommendations have been made where further research is necessary. Finally, recommendations have been made concerning the way in which drug distribution technologies are introduced into the UK.

2. The Meditrol system did not provide the benefits anticipated. The error rate remained unchanged, additional time and staff were required to operate the system, there was no measurable difference in drug losses and information was not applied to either cost
saving or quality improvement initiatives. Staff attitudes were mainly positive before implementation, though were mainly negative afterwards. Incomplete implementation was identified as a major reason for poorer than expected performance, in particular the failure to implement computerised prescribing.

3. At present there is little scope in the UK for funding high cost automated drug distribution systems based on improvements in efficiency and inventory management. This is in contrast to the USA where automation can reduce the staff costs needed to operate the labour intensive unit dose system. Further research is required to establish the benefits that can be achieved by improved safety and information management.

4. This work used proxy outcomes; these were deemed acceptable in early stages of HTA where evaluation is aimed at measuring potential. Ideally, real outcomes should be used in later stages of HTA. If this is not possible further research should be carried out to validate proxy outcomes, such as drug administration error rate, which are likely to be used in the evaluation of drug distribution systems.

5. HTA is an approach which can be used to evaluate drug distribution systems. However these technologies have not been examined by the formal R&D processes within the NHS. Awareness must be heightened at all levels of the NHS of the importance of thorough evaluation of new systems. Emphasis should also be placed on the thorough evaluation of existing systems in order to allow needs assessment and prioritisation in the commissioning process.
6. Consideration of the way in which Meditrol was introduced has shown that principles applied to the introduction of other systems and technologies are relevant to drug distribution systems. Firstly, a needs assessment is an essential component of the process of managing the introduction of new technologies. Secondly, a formative evaluation should be considered if there is further developmental work required or the lack of certainty of the potential impact does not warrant a HTA.
## Appendix 1  Ward configuration at the study hospital

<table>
<thead>
<tr>
<th>Directorate</th>
<th>Ward types</th>
<th>No. of wards</th>
<th>No. of beds</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>General surgery / Urology</td>
<td>Surgical</td>
<td>3</td>
<td>90</td>
<td>Includes one 5 day short stay ward</td>
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<tr>
<td>Orthopaedics / Accident and Emergency</td>
<td>Orthopaedic surgery</td>
<td>2</td>
<td>58</td>
<td></td>
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<tr>
<td>Specialist surgery</td>
<td>Ear, Nose &amp; Throat</td>
<td>*</td>
<td>*</td>
<td>* Share wards &amp; beds with General Surgery</td>
</tr>
<tr>
<td></td>
<td>Oral surgery</td>
<td>*</td>
<td>*</td>
<td>* Share wards &amp; beds with General Surgery</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>Ophthalmology</td>
<td>1</td>
<td>19</td>
<td>Regional speciality</td>
</tr>
<tr>
<td>Obstetrics &amp; Gynaecology</td>
<td>Maternity</td>
<td>3</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labour</td>
<td>1</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gynaecology</td>
<td>1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Medicine</td>
<td>General Medicine</td>
<td>4</td>
<td>106</td>
<td>Includes one medical admissions ward</td>
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<tr>
<td></td>
<td>Coronary Care Unit</td>
<td>1</td>
<td>5</td>
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<tr>
<td></td>
<td>Medicine for the Elderly</td>
<td>5</td>
<td>147</td>
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<tr>
<td>Paediatrics</td>
<td>Paediatrics</td>
<td>3</td>
<td>46</td>
<td></td>
</tr>
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<td></td>
<td>Special Care Baby Unit</td>
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<td>5</td>
<td>Regional Speciality</td>
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<td>Theatres and Anaesthetics</td>
<td>Intensive Therapy Unit</td>
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<td>4</td>
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<td></td>
<td>Day Unit</td>
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<td>19</td>
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<td><strong>Total</strong></td>
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<td><strong>27</strong></td>
<td><strong>625</strong></td>
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</table>

Table A1.1  Ward configuration at the study hospital

NB psychiatric wards are not included
Appendix 2  Consultant episodes per annum at the study hospital

<table>
<thead>
<tr>
<th>Directorate</th>
<th>Consultant episodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Surgery / Urology</td>
<td>5988</td>
</tr>
<tr>
<td>Orthopaedics / Accident &amp; Emergency</td>
<td>3001</td>
</tr>
<tr>
<td>Specialist Surgery</td>
<td>4399</td>
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<tr>
<td>Ophthalmology</td>
<td>1632</td>
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<tr>
<td>Pain Relief</td>
<td>375</td>
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<tr>
<td>Obstetrics &amp; Gynaecology</td>
<td>10486</td>
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<tr>
<td>Medicine</td>
<td>11357</td>
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<tr>
<td>Paediatrics (not including healthy babies)</td>
<td>4112</td>
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<tr>
<td>Pathology</td>
<td>119</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>41469</strong></td>
</tr>
</tbody>
</table>

Table A2.1  Consultant episodes per annum at the study site
Appendix 3  Pharmacy department staffing levels before and after the implementation of the Meditrol system

<table>
<thead>
<tr>
<th>Staff type</th>
<th>Grade / description</th>
<th>FTEs Pre Meditrol</th>
<th>FTEs Post Meditrol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacist</td>
<td>F</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td></td>
<td>E</td>
<td>2.00</td>
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<td>D + +</td>
<td>1.00</td>
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<td></td>
<td>D</td>
<td>3.40</td>
<td>4.40</td>
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<tr>
<td></td>
<td>C</td>
<td>0.40</td>
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<tr>
<td></td>
<td>B</td>
<td>4.00</td>
<td>0.00</td>
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<tr>
<td></td>
<td>Pre Reg</td>
<td>2.00</td>
<td>2.00</td>
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<tr>
<td></td>
<td>Boots</td>
<td>0.00</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13.80</td>
<td>17.35</td>
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<tr>
<td>Technicians</td>
<td>MTO4</td>
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<td>1.00</td>
</tr>
<tr>
<td></td>
<td>MTO3</td>
<td>3.00</td>
<td>3.00</td>
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<tr>
<td></td>
<td>MTO2</td>
<td>6.85</td>
<td>5.85</td>
</tr>
<tr>
<td></td>
<td>MTO2 vacancy</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>MTO1 Restock</td>
<td>0.00</td>
<td>1.00</td>
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<tr>
<td></td>
<td>MTO1 Production</td>
<td>0.00</td>
<td>1.00</td>
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<tr>
<td></td>
<td>Student</td>
<td>2.00</td>
<td>1.00</td>
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<td></td>
<td>Boots</td>
<td>0.00</td>
<td>0.40</td>
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<tr>
<td></td>
<td>Total</td>
<td>11.85</td>
<td>14.25</td>
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<tr>
<td>Assistant</td>
<td>Assistant Production</td>
<td>4.00</td>
<td>4.00</td>
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<td></td>
<td>Assistant Stores</td>
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<td>Assistant UD packing</td>
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<td>Total</td>
<td>9.00</td>
<td>10.49</td>
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<tr>
<td>Storekeeper</td>
<td>Storekeeper</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td>Clerical officer</td>
<td>Office</td>
<td>2.00</td>
<td>2.00</td>
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<tr>
<td></td>
<td>Grand Total</td>
<td>37.65</td>
<td>45.09</td>
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</tbody>
</table>

Table A3.1  Pharmacy department staffing levels before and after the implementation of Meditrol
Appendix 4 The drug chart used at the study hospital
**General Notes:**
1) Use APPROVED NAME, METRIC DOSES and SIGN to legalise prescription.
2) Do not alter existing prescriptions, rewrite the prescription if a change is made.
3) Discontinue a drug by drawing a line through it and a similar line through the next recording panels.
4) Antibiotics: therapeutic – usual duration 5-7 days/prophylactic – maximum duration – 24 hours (1-3 doses).

## ONCE ONLY AND PRE-ANAESTHETIC MEDICATION

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Drug</th>
<th>Dose</th>
<th>Route</th>
<th>Prescribers Signature</th>
<th>Time Given</th>
<th>Nurses Signature</th>
<th>Pharm</th>
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</tbody>
</table>

South Bedfordshire Community Health Care Trust
### REGULAR MEDICATION

<table>
<thead>
<tr>
<th>Date</th>
<th>Start Date</th>
<th>Duration</th>
<th>Route</th>
<th>Dose</th>
<th>Additional Instructions</th>
<th>Signature</th>
<th>Pharmacy</th>
<th>Signature</th>
<th>Pharmacy</th>
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<tbody>
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**NURSING STAFF:** Record administration of a drug by initialling the box. When a drug is not administered, record the appropriate number from below.

1. PATIENT AWAY FROM WARD
2. DRUG NOT AVAILABLE
3. PATIENT REFUSED DRUG
4. PATIENT VOMITING
5. PATIENT NIL BY MOUTH
6. PRESCRIPTION ILLEGIBLE/ILLEGAL
### REGULAR MEDICATION

<table>
<thead>
<tr>
<th>Drug</th>
<th>Start Date</th>
<th>Duration</th>
<th>Route</th>
<th>Dose</th>
<th>Additional Instructions</th>
<th>Signature</th>
<th>Pharmacy</th>
<th>Date</th>
<th>Time</th>
<th>Additional Instructions</th>
<th>Signature</th>
<th>Pharmacy</th>
<th>Date</th>
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### AS REQUIRED MEDICATION

<table>
<thead>
<tr>
<th>Drug</th>
<th>Max Frequency</th>
<th>Date</th>
<th>Time</th>
<th>Additional Instructions</th>
<th>Route</th>
<th>Dose</th>
<th>Signature</th>
<th>Start Date</th>
<th>Pharmacy</th>
<th>Given by</th>
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249
INTRAVENOUS MEDICATION FOR BOLUS OR INTERMITTENT INFUSION

Note: Intravenous prescriptions must be reviewed every THREE days. The Prescriber must sign and date for treatment to continue.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Diluent/Volume</th>
<th>Dose/Rate</th>
<th>Start Date</th>
<th>Additional Instructions</th>
<th>Pharmacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>08</td>
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**INTRAVENOUS THERAPY**

FOR INFUSION FLUIDS, BLOOD, PLASMA AND DRUGS
BY INTERMITTENT OR CONTINUOUS INFUSION

**Note:**
1. No additives to Blood Products, IV Nutrition Solutions or Sodium Bicarbonate.
2. For information on additive compatibilities contact Pharmacy Drug Information.
3. Ensure instructions are clear when more than one line is in use.

<table>
<thead>
<tr>
<th>Date</th>
<th>Start time</th>
<th>Infusion Fluid</th>
<th>Volume</th>
<th>Duration</th>
<th>Additives</th>
<th>Dose</th>
<th>Prescribers Signature</th>
<th>Nurses Signature</th>
<th>Time Started</th>
<th>Time Finished</th>
<th>Amount Infused</th>
<th>Pharm</th>
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Appendix 5  The impact of Meditrol on the quality of written prescription

Methods

The potential for improvement of the quality of prescription writing following the computerisation of the prescribing process for hospital inpatients was assessed by Jenkins (1990) using a criteria based method. These criteria, adapted to individual hospitals, can be used to audit prescription writing (Jenkins et al 1993). This method has been used in this study to establish base-line quality of written prescriptions in the study hospital. As the drug chart remained the definitive document for directing drug administration rather than the anticipated computerised record, the study was only conducted during the pre-implementation phase.

Current prescriptions written on all available charts, from 11 wards within the hospital, were assessed against pre-determined criteria, using a method by Jenkins et al (1993). These criteria govern legibility, completeness of information and other safe prescribing practices. Some criteria were based on guidelines listed in the British National Formulary and in the hospital drug policy and others, such as those governing legibility were considered essential for safe practice. Inevitably the criteria needed some modification for use with the drug charts at the study hospital. Standards were specific to the type of prescription; drugs administered on a regular basis, drugs administered when required, drugs given once only, intravenous fluids, additives to intravenous fluids and intermittent intravenous drugs. The criteria and descriptions are shown in tables A5.1 to A5.5.
<table>
<thead>
<tr>
<th>Component</th>
<th>Criteria</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug name</td>
<td>Approved name</td>
<td>Drug name must be written as British approved name without abbreviations</td>
<td>Hospital policy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BNF</td>
</tr>
<tr>
<td>Legible &amp;</td>
<td></td>
<td>Must be legible on its own and there must be no confusion over the intended dosage form.</td>
<td>BMA Hospital</td>
</tr>
<tr>
<td>Capitlar</td>
<td></td>
<td>Drug name must be written in capital letters</td>
<td>BMA Hospital</td>
</tr>
<tr>
<td>letters</td>
<td></td>
<td></td>
<td>policy</td>
</tr>
<tr>
<td>Start date</td>
<td>Specified</td>
<td>Start date written in appropriate box</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Dose</td>
<td>Specified</td>
<td>The dose must be written in the appropriate box</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Units</td>
<td></td>
<td>Acceptable abbreviations are ‘ml’, ‘g’, and ‘l’. ‘Units’ and ‘micrograms’ must be written in full.</td>
<td>BNF</td>
</tr>
<tr>
<td>Legible and</td>
<td></td>
<td>Must be legible on its own and there must be no confusion over the intended strength.</td>
<td></td>
</tr>
<tr>
<td>unambiguous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decimal</td>
<td></td>
<td>The minimal number of decimal places should be used, prescribing in micrograms where appropriate.</td>
<td>BNF</td>
</tr>
<tr>
<td>places</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
<td>Quantity should be expressed as a weight or volume except for compound preparations when the quantity should be written in words or Arabic numerals. Roman numerals should be avoided.</td>
<td>BNF</td>
</tr>
<tr>
<td>Unaltered</td>
<td></td>
<td>There should be no evidence of striking out or altering the dose without writing a new prescription entry.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Route</td>
<td>Specified</td>
<td>The intended route must be written in the appropriate box.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Legible and</td>
<td></td>
<td>Must be legible on its own and no confusion over intended route</td>
<td></td>
</tr>
<tr>
<td>unambiguous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only one specified</td>
<td></td>
<td>For any one prescription there should only be one route indicated.</td>
<td></td>
</tr>
<tr>
<td>Unaltered</td>
<td></td>
<td>There must be no evidence of striking out or altering the route without writing a new prescription entry.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Duration</td>
<td>Specified</td>
<td>The desired duration of treatment must be specified in the appropriate box.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Timing</td>
<td>Legible and unambiguous</td>
<td>Time of administration must be clearly indicated by ticking/ringing the appropriate times.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Timing</td>
<td>Unaltered</td>
<td>The timing must not be altered without writing a new prescription entry.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Frequency</td>
<td>Unaltered</td>
<td>The frequency must not be reduced or increased without writing a new prescription entry.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Signature</td>
<td>Present</td>
<td>Prescription entry must be signed.</td>
<td>Hospital policy</td>
</tr>
</tbody>
</table>

Table A5.1 Quality criteria for regular prescription entries
### Table A.5.2 Quality criteria for as required medication.

<table>
<thead>
<tr>
<th>Component</th>
<th>Criteria</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum frequency</td>
<td>Specified</td>
<td>Maximum frequency must be entered in the appropriate box.</td>
<td>BNF</td>
</tr>
<tr>
<td></td>
<td>Within recommended range</td>
<td>The stated maximum frequency must be within the recommended range (as stated in the data sheet for the drug).</td>
<td>BNF</td>
</tr>
</tbody>
</table>

Table A.5.2 Quality criteria for as required medication. Standards for drug name, dose, route and signature are the same as for regular medication.

### Table A.5.3 Quality criteria for once only and pre-anaesthetic medication.

<table>
<thead>
<tr>
<th>Component</th>
<th>Criteria</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Specified</td>
<td>The date on which administration of the drug is desired must be entered.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Time</td>
<td>Specified</td>
<td>The time at which the dose is to be administered must be entered. Time relative to surgery is acceptable.</td>
<td>Hospital policy</td>
</tr>
</tbody>
</table>

Table A.5.3 Quality criteria for once only and pre-anaesthetic medication. Standards for drug name, dose, route and signature are the same as for regular medication.

### Table A.5.4 Quality criteria for intravenous infusions.

<table>
<thead>
<tr>
<th>Component</th>
<th>Criteria</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Specified</td>
<td>The date on which administration of the infusion is desired must be entered</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Start time</td>
<td>Specified</td>
<td>The time the infusion is to start must be entered</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Volume</td>
<td>Specified</td>
<td>The volume of the fluid must be entered</td>
<td>Hospital policy</td>
</tr>
<tr>
<td></td>
<td>Legible and unambiguous</td>
<td>The volume must be clear on its own and there must be no confusion over the volume of the product required</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Duration</td>
<td>Specified</td>
<td>The duration must be stated as either the total infusion time or the rate in volume per unit time or the weight of drug per unit time.</td>
<td>Hospital policy</td>
</tr>
</tbody>
</table>

Table A.5.4 Quality criteria for intravenous infusions. Standards for drug name and signature as for regular medication. Criteria for additives to intravenous fluids are as for regular medication (drug name, dose and signature only).

### Table A.5.5 Quality criteria for intermittent intravenous medication.

<table>
<thead>
<tr>
<th>Component</th>
<th>Criteria</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>Specified</td>
<td>The desired rate should be entered in the appropriate box, expressed as total infusion time, as weight of drug per unit time or as 'bolus', 'push' or 'slow injection'.</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Diluent</td>
<td>Specified</td>
<td>Desired diluent must be entered</td>
<td>Hospital policy</td>
</tr>
<tr>
<td>Volume</td>
<td></td>
<td>The desired volume of diluent or total volume of infusion/injection must be entered.</td>
<td>Hospital policy</td>
</tr>
</tbody>
</table>

Table A.5.5 Quality criteria for intermittent intravenous medication. Standards for drug name, start date, dose, timing, frequency and signature as for regular medication.

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Results

A total of 1246 prescription entries for 189 patients were examined. Breakdown by speciality is shown in table A5.6.

<table>
<thead>
<tr>
<th>Speciality</th>
<th>Number of patients</th>
<th>Number of prescription entries*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical</td>
<td>44</td>
<td>296</td>
</tr>
<tr>
<td>Surgical</td>
<td>42</td>
<td>310</td>
</tr>
<tr>
<td>Care of the elderly</td>
<td>50</td>
<td>336</td>
</tr>
<tr>
<td>Orthopaedic</td>
<td>22</td>
<td>147</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>5</td>
<td>55</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Neonatal intensive care</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>Coronary care</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>189</td>
<td>1246</td>
</tr>
</tbody>
</table>

Table A5.6 Origin of prescriptions by speciality
* 1 prescription entry = 1 drug prescribed

Regular medication

There were 666 prescription entries for regular medication. The percentage of prescription entries failing each of the standards are shown in table A5.7. Nineteen prescriptions had no dose specified. Fourteen of these were for ophthalmological preparations, 2 were for topical preparations, 1 for simvastatin had the dose added by the ward pharmacist and the remaining 2 were for ketovite and isosorbide mononitrate.

Fifty five prescriptions were written with dose units inappropriately written or abbreviated. These were mainly heparin (23) with 'units' written as 'u' or 'iu', and digoxin (14) with 'micrograms' written as 'mcg' or 'µg'. Other prescriptions included ipratropium (5), thyroxine (2), soluble insulin (2) and alfacalcidol (2). Inappropriate decimal places were used in 6 prescriptions. These were for digoxin (2), dexamethasone, premprack and flupenthixol. Quantity was written in roman numerals in 45 prescriptions.
Thirteen of these were for combination diuretics and 10 were for inhalers. There was 1 prescription for aminophylline and 1 for potassium chloride slow release (both prescribed using the proprietary name). The route of administration was not specified for 19 prescriptions, 7 of which were for ophthalmological preparations.

<table>
<thead>
<tr>
<th>Quality criteria</th>
<th>Failures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug name</strong></td>
<td></td>
</tr>
<tr>
<td>Approved name</td>
<td>21</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>6</td>
</tr>
<tr>
<td>Written in capitals</td>
<td>70</td>
</tr>
<tr>
<td><strong>Start date</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Dose</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>2.9</td>
</tr>
<tr>
<td>Units written correctly</td>
<td>8</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>3.3</td>
</tr>
<tr>
<td>Appropriate decimal places</td>
<td>0.9</td>
</tr>
<tr>
<td>Quantity written correctly</td>
<td>7</td>
</tr>
<tr>
<td>Dose altered</td>
<td>3</td>
</tr>
<tr>
<td><strong>Route</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>3</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>1.1</td>
</tr>
<tr>
<td>Only one specified</td>
<td>0.7</td>
</tr>
<tr>
<td>Route unaltered</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>93</td>
</tr>
<tr>
<td><strong>Time of administration</strong></td>
<td></td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Unaltered</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table A5.7 Criteria failures for regular prescription entries

When required medication

There were 469 prescription entries for when required medication. The failures are shown in table A5.8.
Dose was unspecified for paracetamol, salbutamol inhaler and topical sugar paste. Dose units were written incorrectly for buprenorphine, ibuprofen (no units), ipratropium (3 prescriptions), ketoprofen (no units) and soluble insulin. The dose was considered illegible/unambiguous for 8 prescriptions, including diamorphine, prochlorperazine and nebulised salbutamol. The quantity was written inappropriately (mostly as roman numerals) for 106 prescriptions. Most of these were for paracetamol or codydramol, however 5 were for dihydrocodeine, 20 were for GTN and one was for chlormethiazole capsules.

<table>
<thead>
<tr>
<th>Quality criteria</th>
<th>Failures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug name</strong></td>
<td></td>
</tr>
<tr>
<td>Approved name</td>
<td>19</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>4</td>
</tr>
<tr>
<td>Written in capital letters</td>
<td>72</td>
</tr>
<tr>
<td><strong>Start date</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Dose</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>0.6</td>
</tr>
<tr>
<td>Units written correctly</td>
<td>1.5</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>1.7</td>
</tr>
<tr>
<td>Appropriate decimal places</td>
<td>0.2</td>
</tr>
<tr>
<td>Quantity written correctly</td>
<td>23</td>
</tr>
<tr>
<td>Dose unaltered</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Route</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>1.1</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>0.4</td>
</tr>
<tr>
<td>Only one route</td>
<td>13</td>
</tr>
<tr>
<td>Route altered</td>
<td>0</td>
</tr>
<tr>
<td><strong>Maximum frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>8</td>
</tr>
<tr>
<td>Within recommended dose range</td>
<td>7</td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>0</td>
</tr>
</tbody>
</table>

Table A.5.8 Criteria failures for when required medication orders
Route of administration was unspecified in 5 prescriptions, 3 for paracetamol, 1 for codydramol and 1 for dihydrocodeine. The route was considered illegible in 2 prescriptions for buprenorphine and ketoprofen. More than one route was specified for 60 prescriptions, nearly half being for metoclopramide (none for prochlorperazine), 15 for ketoprofen, 3 for diamorphine, 11 for paracetamol, one for chlorpromazine, one for haloperidol, and one for codeine.

The maximum frequency was not specified for 39 prescriptions. The most notable were for chlorpromazine, pethidine (2), metoclopramide (3), ketoprofen, ibuprofen, terbutaline, diazepam rectal and salbutamol. In 82 prescriptions, the specified maximum frequency was higher than the recommended maximum dose. These included, codydramol (26), metoclopramide (17), prochlorperazine (16) and paediatric paracetamol (3).

**Once only medicines**

There were 23 prescription entries for once only medication. The failures are shown in table A5.9. Drug names were considered illegible in 8 prescriptions. The majority of these were for ophthalmological preparations and by one prescribe. The dose was not specified in 3 prescriptions. 2 of these were for ophthalmological preparations and the other for lignocaine and prilocaine cream (Emla). The dose was illegible in one prescription for pethidine. The route of administration was not specified in two prescriptions, both for amethocaine eyedrops. The route was illegible or ambiguous in 7 prescriptions, all for ophthalmological preparations. The time of administration was not included in 4 prescriptions for pethidine, aspirin, heparin and a phosphate enema.
### Quality criteria

<table>
<thead>
<tr>
<th>Drug name</th>
<th>Failures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved name</td>
<td>13</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>35</td>
</tr>
<tr>
<td>Written in capitals</td>
<td>78</td>
</tr>
<tr>
<td>Date</td>
<td>Specified</td>
</tr>
<tr>
<td>Dose</td>
<td>Specified</td>
</tr>
<tr>
<td></td>
<td>Units written correctly</td>
</tr>
<tr>
<td></td>
<td>Legible/unambiguous</td>
</tr>
<tr>
<td></td>
<td>Appropriate decimal places</td>
</tr>
<tr>
<td></td>
<td>Quantity written correctly</td>
</tr>
<tr>
<td></td>
<td>Dose unaltered</td>
</tr>
<tr>
<td>Route</td>
<td>Specified</td>
</tr>
<tr>
<td></td>
<td>Legible/unambiguous</td>
</tr>
<tr>
<td></td>
<td>Only one route</td>
</tr>
<tr>
<td></td>
<td>Route unaltered</td>
</tr>
<tr>
<td>Time of administration</td>
<td>Specified</td>
</tr>
<tr>
<td>Signature</td>
<td>Present</td>
</tr>
</tbody>
</table>

Table A5.9 Criteria failures for once only medication orders

**Intravenous fluids**

There were 33 prescription entries for intravenous fluids. The failures are shown in table A5.10.

Twenty-five prescriptions were not written as approved names. These included sodium chloride 0.9% infusion (17), which were written as 'normal saline', 'N/S', or 'NaCl', potassium containing preparations (4), where potassium chloride was abbreviated to 'KCl' and sodium chloride and glucose infusion (3), written as 'dex saline'. One prescription for a glucose and potassium infusion was considered illegible. One prescription for sodium chloride infusion did not include the volume to be infused. The
duration of the infusion was not specified in 7 prescription entries which included 2
prescriptions for sodium chloride and glucose infusion with potassium and 2 for sodium
chloride and glucose infusion, all for paediatric patients.

<table>
<thead>
<tr>
<th>Quality criteria</th>
<th>Failures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug name</strong></td>
<td></td>
</tr>
<tr>
<td>Approved name</td>
<td>76</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>3</td>
</tr>
<tr>
<td>Written in capitals</td>
<td>70</td>
</tr>
<tr>
<td><strong>Date</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>6</td>
</tr>
<tr>
<td><strong>Dose</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>0</td>
</tr>
<tr>
<td>Units written correctly</td>
<td>0</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>0</td>
</tr>
<tr>
<td>Appropriate decimal places</td>
<td>0</td>
</tr>
<tr>
<td>Quantity written correctly</td>
<td>0</td>
</tr>
<tr>
<td>Dose altered</td>
<td>0</td>
</tr>
<tr>
<td><strong>Start time</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>85</td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>9</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>3</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>21</td>
</tr>
</tbody>
</table>

Table A5.10 Criteria failures for intravenous fluid orders

**Additives to intravenous fluids**

There were 11 prescription entries for additives to intravenous fluids. The failures are
shown in table A5.11. Two prescriptions for isosorbide dinitrate were written in an
abbreviated form as 'ISDN'. The dose was not specified for one prescription for
isosorbide dinitrate infusion. There were 8 prescriptions, all for heparin infusion, which
were written with the word 'units' abbreviated to 'u'. For one prescription for heparin
infusion the dose was considered to be illegible.
### Table A5.11. Criteria failures for fluid additive orders

<table>
<thead>
<tr>
<th>Quality criteria</th>
<th>Failure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug name</strong></td>
<td></td>
</tr>
<tr>
<td>Approved name</td>
<td>18</td>
</tr>
<tr>
<td>Legible unambiguous</td>
<td>0</td>
</tr>
<tr>
<td>Written in capitals</td>
<td>91</td>
</tr>
<tr>
<td><strong>Dose</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>9</td>
</tr>
<tr>
<td>Units written correctly</td>
<td>73</td>
</tr>
<tr>
<td>Legible unambiguous</td>
<td>9</td>
</tr>
<tr>
<td>Appropriate decimal places</td>
<td>0</td>
</tr>
<tr>
<td>Quantity written correctly</td>
<td>0</td>
</tr>
<tr>
<td>Dose unaltered</td>
<td>0</td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>9</td>
</tr>
</tbody>
</table>

**Intermittent intravenous medication**

There were 40 prescription entries for intermittent intravenous medications. The failures are shown in table A5.12. Approved name was not used in 16 prescriptions, 12 of which were sodium chloride injection. Inappropriately abbreviated units were used in 1 prescription for insulin. The diluent was specified in only 4 prescriptions, though 16 prescriptions did not require a diluent (e.g. sodium chloride for flushing and metronidazole infusion). The rate of infusion was not specified for 32 prescriptions, however of the 8 where a rate was specified 5 were sodium chloride ‘flush’ which was considered as an acceptable alternative to an actual rate. Those where a rate was not specified included a diamorphine infusion.
<table>
<thead>
<tr>
<th>Quality Criteria</th>
<th>Failures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug name</strong></td>
<td></td>
</tr>
<tr>
<td>Approved name</td>
<td>40</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>2.5</td>
</tr>
<tr>
<td>Written in capitals</td>
<td>45</td>
</tr>
<tr>
<td><strong>Start date</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Dose</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>0</td>
</tr>
<tr>
<td>Units written correctly</td>
<td>2.5</td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>0</td>
</tr>
<tr>
<td>Appropriate decimal places</td>
<td>0</td>
</tr>
<tr>
<td>Quantity written correctly</td>
<td>0</td>
</tr>
<tr>
<td>Dose unaltered</td>
<td>7</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td></td>
</tr>
<tr>
<td>Legible/unambiguous</td>
<td>0</td>
</tr>
<tr>
<td>Unaltered</td>
<td>7</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Unaltered</td>
<td>0</td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>0</td>
</tr>
<tr>
<td><strong>Infusion rate</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>80</td>
</tr>
<tr>
<td><strong>Diluent</strong></td>
<td></td>
</tr>
<tr>
<td>Specified</td>
<td>50</td>
</tr>
</tbody>
</table>

Table A5.12 Criteria failures for intermittent intravenous medication orders

**Discussion**

These results show that a relatively small though significant number of prescriptions failed to fulfil the criteria used. This translates into an increased chance of harm to the patient, an inefficiency in the drug use process, due to time wasted in interpreting or clarifying prescriptions, or an unclear drug prescription and administration record.

According to the criteria used, the drug name should be written legibly, in capital letters and using the approved name. The lack of legibility of a drug name is dangerous and deaths have occurred due to confusion over the intended drug (Anon 1982a,b). For once
only prescriptions, 35% were considered illegible. This was so high because of bias introduced due to the majority of these prescriptions being written by one prescriber with particularly poor handwriting. Failure to write the drug name in capital letters was the most common infringement overall. This guideline is aimed at promoting legible prescribing, though failure to write in capitals is probably not considered to be particularly bad practice by most doctors, nurses, or pharmacists. However, while writing in capital letters is no guarantee of legibility, without the facility to generate printed prescriptions, it is probably the most effective measure that can be taken. The use of approved names on prescriptions ensures that the name on the prescription matches the name on the drug container dispensed by the pharmacy department and so avoids potential confusion. In addition this practice trains junior doctors to use generic names and communication to general practitioners, such as discharge summaries, include approved names. This may promote the more cost-effective, generic prescribing in the community.

The dangers associated with misinterpretation of the drug dose are obvious. Furthermore, many of the prescriptions which failed the criteria concerning the dose were for potentially harmful drugs such as digoxin, heparin, insulin and analgesics. The incorrect writing of the dose units could lead to overdose of the drug, for example reading ‘μg’ as ‘mg’ could lead to a digoxin overdose or reading ‘u’ as ‘ml’ could lead to a heparin overdose. A small number of prescriptions failed because of the inappropriate use of decimal places (the use of an ‘unprotected’ decimal point), which can cause confusion over the dose to be administered. Failure to write the dose quantity correctly was particularly common for when required prescriptions. The most common infringement was writing ‘2’ in roman numerals as ‘ii’ which could be read as ‘11’. Most of the prescriptions were for paracetamol containing analgesics where it is unlikely that 11
tablets would be administered, however in some circumstances the administration of this quantity of tablets may be appropriate (for example oral sodium preparations in renal disease).

The most common infringement associated with the route of administration was the inclusion of two routes on when required prescriptions, for example ‘im/po’, where the nurse is given the option of giving the drug by the intramuscular or oral route. This practice can create two problems. Firstly, for drugs with a low oral bio-availability, the parenteral dose may be higher than that given by mouth, thus predisposing to over- or under-dosing. Secondly, where the drug chart does not require the nurse to enter the route by which the drug was administered, the record of drug administration remains incomplete.

The duration of treatment was not specified for most of the regular prescriptions. While for most drugs this may not be a problem, for drugs such as antibiotics, stating the duration of treatment may limit the patient’s exposure to the drug to the minimum required and will reduce expenditure on unnecessarily prolonged treatment courses.

For regular prescriptions, the maximum frequency which the drug could be administered to the patient was not stated for 8% of prescriptions (including 2 prescriptions for pethidine) and for 7% of prescriptions (mostly analgesics) where the maximum frequency was stated, could have allowed an overdose of the drug to be administered.

For intravenous fluid prescriptions, the main infringement was the omission of the start time, however most prescriptions included the duration over which the fluid was to be
infused. For a few prescriptions however, including some potassium containing fluids for paediatric patients, the duration was not included. This omission could contribute to rapid infusion of potassium with fatal consequences. Similarly, the infusion rate was not specified for 80% of intermittent intravenous medication prescriptions, including one for an opiate infusion. Again too rapid an infusion of this drug would be extremely dangerous.

Some of the shortcomings in prescription writing detected in this study are trivial and are probably viewed as acceptable or usual by nurses and pharmacists, for example writing in capital letters is not important if the prescription is still clear and legible. Others are potentially more serious and have contributed towards fatal incidents reported by the media. The introduction of a definitive computerised prescription record could overcome all or most of these shortcomings leading to a substantial increase in quality, though the layout of computer printed documents or screens and the quality of print could effect legibility. It is therefore imperative that a thorough assessment of the quality of computer generated prescriptions is performed.
<table>
<thead>
<tr>
<th>PROBLEM NO</th>
<th>BRIEF DESCRIPTION OF PROBLEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WARD (note 2)</td>
<td>Consultant speciality (note 3)</td>
</tr>
<tr>
<td>2. PROBLEM IDENTIFIED BY:</td>
<td>Pharmacist (indicate grade or L for locum)</td>
</tr>
<tr>
<td></td>
<td>Doctor (indicate status (note 4))</td>
</tr>
<tr>
<td></td>
<td>Nurse (indicate status (note 5))</td>
</tr>
<tr>
<td></td>
<td>Patient</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td>3. NATURE OF PROBLEM</td>
<td>Rx illegal/legible/incomplete</td>
</tr>
<tr>
<td></td>
<td>Formulary/Blacklist (note 7)</td>
</tr>
<tr>
<td></td>
<td>Administration/formulation/route (note 8)</td>
</tr>
<tr>
<td></td>
<td>Dose/frequency (note 9)</td>
</tr>
<tr>
<td></td>
<td>Duration</td>
</tr>
<tr>
<td></td>
<td>ADRs</td>
</tr>
<tr>
<td></td>
<td>Interaction/incompatibility</td>
</tr>
<tr>
<td></td>
<td>Choice of therapy</td>
</tr>
<tr>
<td></td>
<td>TDM/kinetics</td>
</tr>
<tr>
<td></td>
<td>Pharmacology</td>
</tr>
<tr>
<td></td>
<td>TTA problem (note 15)</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous (note 16)</td>
</tr>
<tr>
<td>4. OUTCOME</td>
<td>Rx altered</td>
</tr>
<tr>
<td></td>
<td>Rx unchanged advice accepted</td>
</tr>
<tr>
<td></td>
<td>Rx unchanged advice not accepted</td>
</tr>
<tr>
<td></td>
<td>Problem resolved without intervention</td>
</tr>
<tr>
<td></td>
<td>Information only (note 18)</td>
</tr>
<tr>
<td></td>
<td>Problem not resolved at study end</td>
</tr>
<tr>
<td>5. TIME TAKEN</td>
<td>Record number of minutes taken (note 19)</td>
</tr>
<tr>
<td>6. PRIME REASON (NOTE 20)</td>
<td>Safety</td>
</tr>
<tr>
<td></td>
<td>Effectiveness</td>
</tr>
<tr>
<td></td>
<td>Value for money</td>
</tr>
<tr>
<td></td>
<td>Quality of life</td>
</tr>
<tr>
<td></td>
<td>CD legislation</td>
</tr>
</tbody>
</table>

NAME:…………………………………………… WEEK STARTING………………………………………………

PROBLEMS IDENTIFIED IN DISPENSARY (D)/ ON WARDS (W)/ ON CALL (O):………………………………
**SUMMARY SHEET FOR WARD PHARMACY VISITS**

Please complete one of these sheets for every ward you visit during the study period (including evening and weekend order entry visits).

WARD NAME ................................................................................................................... PHARMACIST NAME ........................................................................................................

**SPECIALITY OF WARD**

No. OF BEDS ................................................................................................................

WEEK STARTING ...........................................................................................................

**SUMMARY OF VISITS**

<table>
<thead>
<tr>
<th>DAY</th>
<th>TIME ARRIVED ON WARD</th>
<th>No. NEW ADMISSIONS SINCE LAST VISIT (note 3)</th>
<th>No. BEDS OCCUPIED (note 4)</th>
<th>No Rx SEEN (note 5)</th>
<th>No PROBLEMS IDENTIFIED (note 7)</th>
<th>TIME LEFT WARD</th>
<th>FV or WO (note 8)</th>
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Appendix 7  Data collection form used in nurse activity analysis
No of nurses: ___________________  grades: ____________
Start: ____________  Finish: ____________  No beds: ________  No occupied beds: ________
Title of round: ____________  Ward: ____________  Date: ____________  Page: ____________  of ____________

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Appendix 8  Interviews used to assess staff attitudes
Pre-Meditrol Attitudinal Interview for Nursing staff

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

The current system

The first questions I would like to ask concern the way in which drugs are currently prescribed and administered.

On the ward prescription chart, there are seven options for administration times of regular medication, yet there are only four drug rounds, ie doses due at 6, 8 and 10 am are given on the 8am drug round and doses due at 12 and 2pm are given on the lunchtime round at around 12.30pm. What is your view on this practice?

Prompt: For what specific drugs do you consider administration at the exact time indicated on the drug chart to be important?

For other drugs, what deviation from the specified time would you consider to be acceptable?

1 hr, 2 hrs, 3 hrs, 4 hrs.

When a drug is prescribed on the ward it is not always immediately available. What time lag between the drug being prescribed and being available on the ward do you consider acceptable?

An antiarrhythmic for a life threatening arrhythmia?
Dopamine for acute renal failure?
An antihypertensive for moderate hypertension?
An antibiotic for a non-complicated urinary tract infection in an adult?
Anusol ointment for haemorrhoids?

Definition of the Meditrol system

The remaining questions are concerned with your views on the Meditrol system. First, in order to ensure all interviewees have the same basic understanding of the way Meditrol will work, I will give you a definition of the Meditrol system. Meditrol will be installed on each ward and can be thought of in two parts; a computer keyboard and screen for entering prescription data and an automated unit dose dispensing cabinet. The computer will also store some basic patient information. Initially, the system will operate as follows: doctors will prescribe in the normal way onto the drug chart, however details of all drugs prescribed will be entered onto the computer system by a pharmacist. Software on the computer will provide the pharmacist with drug information, drug interaction and therapeutic duplication alert and may offer additional features. Once the prescription data are entered, if the drug is not available on the ward or on a nearby ward, the computer will generate an order in the pharmacy department who will supply the drugs to the ward.
Drugs which are available as unit doses will be loaded into the automated cabinet. Other drugs which are not available as unit doses will be dispensed in the normal way as will items which are too large to fit in the cabinet. When a drug dose is due for a patient the system will alert the nursing staff. Using the computer terminal, the nurse will initiate the dispensing of the dose from the automated cabinet. This cabinet stores individually packed drug doses, including liquids and injections and gives the nurse a sufficient quantity for the patient at that time. For items not stored in the cabinet, an entry is made on the computer as a record of dispensing. Orders for re-supply of most drugs are generated by the system automatically. A drug trolley containing labelled draws for each patient on the ward will be available to transport doses around the ward and to store suitably sized items not loaded into the cabinet as unit doses. Pharmacists will be available to enter information onto the computer system between 6am and 10pm. Outside of these hours and in emergencies, nursing staff will be able to draw doses from the machine as a one off until the pharmacist is available. During the trial period, it is intended that, on a number of wards, doctors and not pharmacists will enter prescription data onto the system.

Are there any points you would like me to clarify?

**Meditrol/computerised prescribing**

**What changes do you think you would see following the implementation of Meditrol?**

*Prompt: In your work routine?*
*In your working relationships with other professionals?*
*For medical staff?*
*For pharmacy staff?*
*In patient care?*

**How do you feel about the prospect of using the Meditrol system?**

*Prompt: How do you feel about using a computer terminal to obtain drug doses?*
*How do you feel about using the new type of drug trolley and unit doses?*

**Who do you think is the most appropriate person to enter data onto the system?**

*Please tell me your reasons.*

**What advantages would you expect from the Meditrol system?**

*Prompt: Unit doses?*
*The new trolley?*

**What disadvantages would you expect from the Meditrol system?**

*Prompt: Unit doses?*
The new trolley?

What do you feel are the opportunities that Meditrol generates for you?

What do you feel are the threats that Meditrol generates for you?

Overall do you feel that Meditrol is an opportunity or a threat?

Given the choice, would you rather use the current system of dispensing and administering drugs or the Meditrol system?

Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Background information
Grade
Speciality
Year of registration
Sex
Age
Research commitment
Involvement in audit
Due to leave L&D? If yes, when.
Post-Meditrol Attitudinal Interview for Nursing staff

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

Meditrol/computerised prescribing

What changes have you seen following the implementation of Meditrol?

Prompt: In your work routine?
In your working relationships with other professionals?
For medical staff?
For pharmacy staff?
In patient care?

How do you feel about working with the Meditrol system?

Prompt: How do you feel about using a computer terminal to obtain drug doses?
How do you feel about using the new type of drug trolley and unit doses?

Who do you think is the most appropriate person to enter prescription data onto the system?

Please tell me your reasons.

What, in your opinion are the advantages of the Meditrol system?

Prompt: Unit doses?
The new trolley?

What, in your opinion are the disadvantages of the Meditrol system?

Prompt: Unit doses?
The new trolley?

What do you feel are the opportunities that Meditrol generates for you?

What do you feel are the threats that Meditrol generates for you?

Overall do you feel that Meditrol is an opportunity or a threat?
Given the choice, would you rather use the traditional system of dispensing and administering drugs or the Meditrol system?

Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Background information
Grade
Speciality
Year of registration
Sex
Age
Research commitment
Involvement in audit
Due to leave L&D? If yes, when.
Pre-Meditrol Attitudinal Interview for Medical Staff

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

The current system

The first questions I would like to ask concern the way in which drugs are currently prescribed, administered and supplied.

On the ward prescription chart, there are seven options for administration times of regular medication, yet there are only four drug rounds, i.e., doses due at 6, 8 and 10 am are given on the 8 am drug round and doses due at 12 and 2 pm are given on the lunchtime round at around 12.30 pm. What is your view on this practice?

Prompt: For what specific drugs is administration at the exact time you have specified important? For other drugs, what deviation from the specified time would you consider to be acceptable?

1 hr, 2 hrs, 3 hrs, 4 hrs.

To what extent do you consider medication administration errors are a problem?

Could you estimate the current error rate?

Prompt: None at all, 1 in 10, 1 in 100, 1 in 1000, 1 in 10,000

When a drug is prescribed on the ward it is not always immediately available. What time lag between the drug being prescribed and being available on the ward do you consider acceptable?

An antiarrhythmic for a life threatening arrhythmia?
Dopamine for acute renal failure?
An antihypertensive for moderate hypertension?
An antibiotic for a non-complicated urinary tract infection in an adult?
Anusol ointment for haemorrhoids?

Definition of the Meditrol system

The remaining questions are concerned with your views on the Meditrol system. First, in order to ensure that everyone we talk to has the same basic understanding of the way Meditrol will work, I will give you a definition of the Meditrol system. Meditrol will be installed on each ward and can be thought of in two parts; a computer keyboard and screen for entering prescription data and an automated unit dose dispensing system. The computer will also store some basic patient information. As prescription data are entered
by the doctor, the software will provide drug information, will alert to drug interactions and therapeutic duplication and may offer additional features. Once the prescription data are entered, if the drug is not available on the ward or on a nearby ward, the computer will generate an order in the pharmacy department who will put the required drugs into the machine. When a drug dose is due for a patient the system will alert the nursing staff. Using the computer terminal, the nurse will initiate the dispensing of the dose from the automated cabinet. This cabinet stores individually packed drug doses, including liquids and injections and gives the nurse exactly what is needed for the patient at that time. A drug trolley containing labelled draws for each patient on the ward will be available to transport doses around the ward.

Are there any points you would like me to clarify?

Meditrol/computerised prescribing

What changes will you see following the implementation of Meditrol?

Prompt: What changes in your work routine?
What changes in the work routines of your colleagues?
What changes in your working relationships with other professionals?
What changes will nursing staff experience?
What changes will pharmacy staff experience?
What changes will you see in patient care?

How do you feel about the prospect of using the Meditrol system?

Prompt: How do you feel about entering prescription data into a computer terminal?

How do you think the information provided by the software would help?

What benefits would you expect to see from the Meditrol system?

What problems would you expect to see with the Meditrol system?

Which of these problems are likely to be short term and which are likely to be long term?

Given the choice, would you rather use the current system of prescribing onto a drug chart or the Meditrol system?

Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Prompt: Why?
Background information
Grade
Speciality
Year of registration
When did you start at L & D?
Sex
Age
Research commitment
Involvement in medical audit
Due to leave L&D? If yes, when.
Pre-Meditrol Attitudinal Interview for Pharmacists

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

Definition of the Meditrol system

The remaining questions are concerned with your views on the Meditrol system. First, in order to ensure all interviewees have the same basic understanding of the way Meditrol will work, I will give you a definition of the Meditrol system. Meditrol will be installed on each ward and can be thought of in two parts; a computer keyboard and screen for entering prescription data and an automated unit dose dispensing system. The computer will also store some basic patient information. Initially, the system will operate as follows: doctors will prescribe in the normal way onto the drug chart, however details of all drugs prescribed will be entered onto the computer system by a pharmacist. Software on the computer will provide the pharmacist with drug information, drug interactions and therapeutic duplication alert and may offer additional features. Once the prescription data are entered, if the drug is not available on the ward or on a nearby ward, the computer will generate an order in the pharmacy department who will put the required drugs into the machine. When a drug dose is due for a patient the system will alert the nursing staff. Using the computer terminal, the nurse will initiate the dispensing of the dose from the automated cabinet. This cabinet stores individually packed drug doses, including liquids and injections and gives the nurse exactly what is needed for the patient at that time. A drug trolley containing labelled draws for each patient on the ward will be available to transport doses around the ward. Pharmacists will be available to enter information onto the computer system between 6am and 10pm. Outside of these hours and in emergencies, nursing staff will be able to draw doses from the machine as a one off until the pharmacist is available.

During the trial period, it is intended that, on a number of wards, doctors and not pharmacists will enter prescription data onto the system.

Are there any points you would like me to clarify?

Meditrol/computerised prescribing

What changes do you think you would see following the implementation of Meditrol?

Prompt: In your ward-based work routine?
          In your pharmacy based work routine?
          In your working relationships with other professionals?
          For medical staff?
          For nursing staff?
          In how drugs are prescribed?
          For other pharmacy staff?
          In patient care?
How do you feel about the prospect of working with the Meditrol system?

Prompt: How do you feel about the decreased involvement of ward pharmacists in the supply of individual patient medicines? How do you feel about pharmacists entering prescriptions at a computer terminal? How do you feel about working in a department where drugs are packed and dispensed as unit doses?

How do you think the information provided by the software would help?

What advantages would you expect from the Meditrol system?

What disadvantages would you expect from the Meditrol system?

What do you feel are the opportunities of that Meditrol generates for you?

What do you feel are the threats that Meditrol generates for you?

Overall do you feel that Meditrol is an opportunity or a threat? Given the choice, would you rather work with the current system of dispensing and administering drugs or the Meditrol system?

Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Background information
Grade
Speciality
Year of registration
Sex
Research commitment

Involvement in medical audit
Due to leave L&D? If yes, when.
Post-Meditrol Attitudinal Interview for Pharmacists

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

Meditrol/computerised prescribing

What changes have you seen since working with Meditrol, compared with your previous hospital experience?

Prompt:
- In your ward-based work routine?
- In your pharmacy based work routine?
- In your working relationships with other professionals?
  - For nursing staff?
  - For other pharmacy staff?
- In patient care?
- For medical staff?
- In how drugs are prescribed?

How do you feel about working with the Meditrol system?

Prompt:
- How do you feel about pharmacists entering prescriptions at a computer terminal?
- How do you feel about working in a department where drugs are packed and dispensed as unit doses?
- How do you feel about the decreased involvement of ward pharmacists in the supply of individual patient medicines?
- How do you feel about your hours of work? (OE p'cists)

How does the information provided by the software influence your work?

What, in your opinion are the advantages of the Meditrol system?

What, in your opinion are the disadvantages of the Meditrol system?

What do you feel are the opportunities of that Meditrol generates for you?

What do you feel are the threats that Meditrol generates for you?

Overall do you feel that Meditrol is an opportunity or a threat?

Given the choice, would you rather work with the traditional system of dispensing and administering drugs or the Meditrol system?
Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Who do you think is the most appropriate person to enter prescription data onto the system?

Give your reasons.

Background information
Grade
Speciality
Year of registration
Sex
Research commitment
Involvement in medical audit
Due to leave L&D? If yes, when.
What was your previous post?
Pre-Meditrol Attitudinal Interview for Pharmacy Technicians

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

Definition of the Meditrol system

The remaining questions are concerned with your views on the Meditrol system. First, in order to ensure all interviewees have the same basic understanding of the way Meditrol will work, I will give you a definition of the Meditrol system. Meditrol will be installed on each ward and can be thought of in two parts; a computer keyboard and screen for entering prescription data and an automated unit dose dispensing cabinet. The computer will also store some basic patient information. Initially, the system will operate as follows: doctors will prescribe in the normal way onto the drug chart, however details of all drugs prescribed will be entered onto the computer system by a pharmacist. Software on the computer will provide the pharmacist with drug information, drug interaction and therapeutic duplication alert and may offer additional features. Once the prescription data are entered, if the drug is not available on the ward or on a nearby ward, the computer will generate an order in the pharmacy department who will supply the drugs to the ward. Drugs which are available as unit doses will be loaded into the automated cabinet. Other drugs which are not available as unit doses will be dispensed in the normal way as will items which are too large to fit in the cabinet. When a drug dose is due for a patient the system will alert the nursing staff. Using the computer terminal, the nurse will initiate the dispensing of the unit doses from the automated cabinet. This cabinet stores individually packed drug doses, including liquids and injections and gives the nurse a sufficient quantity for the patient at that time. For items not stored in the cabinet, an entry is made on the computer as a record of dispensing. Orders for re-supply of most drugs are generated by the system automatically. A drug trolley containing labelled draws for each patient on the ward will be available to transport doses around the ward and to store suitably sized items not loaded into the cabinet as unit doses. Pharmacists will be available to enter information onto the computer system between 6am and 10pm. Outside of these hours and in emergencies, nursing staff will be able to draw doses from the machine as a one off until the pharmacist is available. During the trial period, it is intended that, on a number of wards, doctors and not pharmacists will enter prescription data onto the system.

Are there any points you would like me to clarify?

Meditrol/computerised prescribing

What changes do you think you would see following the implementation of Meditrol?

Prompt: In your work routine?
In your working relationships with pharmacists?
In your working relationships with non-pharmacy staff?
For pharmacists?
For doctors?
For nursing staff?
In how drugs are prescribed?
For other pharmacy staff?
In patient care?

How do you feel about the prospect of working with the Meditrol system?

Prompt: How do you feel about working in a department where drugs are packed and dispensed as unit doses?

Who do you think is the most appropriate person to enter data onto the system? Please tell me your reasons.

What advantages would you expect from the Meditrol system?

What disadvantages would you expect from the Meditrol system?

What do you feel are the opportunities that Meditrol generates for you?

What do you feel are the threats that Meditrol generates for you?

Overall do you feel that Meditrol is an opportunity or a threat?
Given the choice, would you rather work with the current system of dispensing and administering drugs or the Meditrol system?

Please tell me your reasons.

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Background information
Grade
Pharmacy section
Year of registration
Sex
Due to leave L&D? If yes, when.
Post-Meditrol Attitudinal Interview for Pharmacy Technicians

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

Meditrol/computerised prescribing

What changes have you seen since working with Meditrol, compared with your previous hospital experience?

Prompt: In your work routine?
In your working relationships with pharmacists?
In your working relationships with non-pharmacy staff?
For medical staff?
For nursing staff?
In how drugs are prescribed?
In other pharmacy staff?
In patient care?

How do you feel about working with the Meditrol system?

Prompt: How do you feel about working in a department where drugs are packed and dispensed as unit doses?

What, in your opinion are the advantages of the Meditrol system?

What, in your opinion are the disadvantages of the Meditrol system?

What do you feel are the opportunities of that Meditrol generates for you?

What do you feel are the threats that Meditrol generates for you?

Overall do you feel that Meditrol is an opportunity or a threat?

Given the choice, would you rather work with the current system of dispensing and administering drugs or the Meditrol system?

Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Background information
Grade
Speciality
Year of registration
Sex
Research commitment
Involvement in medical audit
Due to leave L&D? If yes, when.
Pre-Meditrol Attitudinal Interview for Pharmacy Assistants

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

Definition of the Meditrol system

The remaining questions are concerned with your views on the Meditrol system. First, in order to ensure all the people we question have the same basic understanding of the way Meditrol will work, I will describe Meditrol. Meditrol will be installed on each ward and will consist of two parts; a computer which doctors use for prescribing and a machine which dispenses, individually packed doses, for example single tablets. When the doctor prescribes into the computer, it tells him or her if the drug is available on the ward or on a nearby ward or, if this is not the case, an order will be automatically produced in the pharmacy. When the order is received the drug will reach the ward by one of two ways. Firstly, if the drug is already packed as single doses, it will be sent to the ward like this. Secondly, if the drug is not available in single dose form, a small supply will be dispensed in the normal way and sent to the ward. This will then be followed by a supply of single doses at a later time. An order for resupply will be generated automatically when the stock is running low. When a drug dose is due for a patient the system will tell the nursing staff. Using the computer, the nurse will obtain the dose from the machine. This machine stores individually packed drug doses and gives the nurse what is needed for the patient at that time. A drug trolley containing labelled draws for each patient on the ward will be available to transport doses around the ward.

Are there any points you would like me to make clearer?

Meditrol/computerised prescribing

What changes do you think you would see when Meditrol is working?

Prompt: On how your job will change?

On how you work with other people in the pharmacy?

How do you feel about the prospect of working with the Meditrol system?

Prompt: How do you feel about working in a department where drugs are packed and dispensed as single doses?

How do you feel your job will get better?

How do you feel your job will get worse?

Overall do you feel that Meditrol is a threat to you?
Given the choice, would you rather your job stayed the same?

Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Background information
Job title
Sex
Age
Due to leave L&D? If yes, when.
Post-Meditrol Attitudinal Interview for Pharmacy assistants

I am one of two independent researchers from the University of London and the University of Manchester who are currently evaluating the implementation of Meditrol, including a survey of attitudes. We are part of an independent research team and are not employed by the Boots company. This interview will take approximately 20 minutes and with your permission will be recorded on audio tape. All answers given will be treated with the strictest confidence.

Meditrol/computerised prescribing

What changes have you seen since Meditrol started working?

Prompt: How has your job changed?
How has the way in which you work with other people in the pharmacy changed?

How do you feel about working with the Meditrol system?

Prompt: How do you feel about working in a department where drugs are packed and dispensed as single doses?

In what way do you feel your job has got better?

In what way do you feel your job has got worse?

Overall do you feel that your job has got better or worse?

Given the choice, would you rather your job had stayed the same?

Please tell me your reasons

Overall how would you summarise your feelings about the introduction of Meditrol at Luton and Dunstable hospital.

Background information
Job title
Sex
Age
Due to leave L&D? If yes, when.

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