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Organizational and Implementation Issues of Patient Data Management Systems in an Intensive Care Unit

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Since the National Health Service reforms were introduced, the NHS has moved towards a greater emphasis on accountability and efficiency of healthcare. These changes rely on the swift delivery of IT systems, implemented into the NHS because of the urgency to collect data to support these measures. The case study details the events surrounding the introduction of a patient data management system into an intensive care unit in a UK hospital. It shows that its implementation was complex and involved organisational issues related to the costing of healthcare, legal and purchasing requirements, systems integration, training and staff expertise, and relationships with suppliers. It is suggested that the NHS is providing an R&D environment which others are benefiting from. The NHS is supporting software development activities that are not recognised, and the true costs of this task are difficult to estimate. It is also argued that introducing PDMS crystallises many different expectations making them unmanageably complex. This could also be due to PDMS being a higher order innovation that attempts to integrate information systems products and services with the core business.

INTRODUCTION

The National Health Service (NHS) costs the UK approximately £38 billion a year (James, 1995) of which £220 million is spent on IT (Lock, 1996). New IT applications not only support administrative functions and medical diagnosis, but are increasingly used to support resource management and medical audit (Metnitz and Lenz, 1995; Sheaff and Peel, 1995). One such application is patient data management systems (PDMS) in intensive care units, where nurses' main task of planning and implementing patient care requires an awareness of a set of physiological parameters which provide an overview of the patient's general condition (Ireland *et al*, 1997). The collection of patient data is also a legal requirement of the NHS Executive. The implementation of these new technologies is not proving easy for the NHS. Healthcare professionals involved with IT projects often lack in experience of IT development. Risks are higher in clinical applications which require strong user involvement. These technologies are also being implemented into the NHS at a fast rate, because of the urgency to collect data to support accountability measures.

The NHS has changed quite dramatically over recent years, not least with the introduction of 'competitive market forces' (Peel, 1996; Protti *et al*, 1996). The current healthcare reforms come from various government White Papers, moving the philosophy of the NHS towards emphasising business themes and client choice, and they rely on the 'swift' delivery of IT systems (Willcocks, 1991). All chief executives of health authorities and NHS Trusts are now 'accountable officers', responsible for the efficient use of resources, and are personally responsible for performance (Warden, 1996). Sotheran (1996) argues that using IT in the NHS entails new work structures and changes in activities performed, and that re-distribution of control and power will occur as a result. Bloomfield *et al* (1992) found a diversity of interpretations by those involved, that the intended focus of the systems varied from management responsibility, medical speciality, doctor to patient group levels, and that views from one peer group could be imposed upon another. Lock (1996) advocates that "the impact of computer systems on patient care as well as on the business objectives of hospitals should be considered". The 'benefits realisation' approach (Treharne, 1995) is recommended to quantify and document benefits. Donaldson (1996) claims that this process can help justify the investments. However, it seems that the 'benefits realisation' methods are not being implemented or are failing for the following reasons (Treharne, 1995): an over emphasis on IT relative to other critical issues; a lack of focus; a shortage of skills; ineffective business/IT partnership; absence of benefit management process.

Generally, the rapid movement of information technologies into health care organisations has raised managerial concern regarding the capability of today's institutions to satisfactorily manage their introduction. Indeed, several health care institutions have consumed "huge amounts of money and frustrated countless people in wasted information systems implementation efforts" and there are "no easy answers as to why so many health informatics projects are not more successful" (Pare, Elam and Ward, 1997). In this light, the aim of this study is to provide a deeper understanding of how clinical information systems are being implemented, using a case study methodology.

OBJECTIVES AND METHODS

From a theoretical standpoint, it is suggested that adoption and diffusion of information systems (IS) depends on the type of IS innovation concerned. Swanson (1994) and McMaster *et al* (1997) suggest there are three IS innovation types:

Process innovations which are confined to the IS core.

Application of IS products and services to support the administrative core of the business.

Integration of IS products and services with core business technology.

PDMS are innovative computer systems, which attempt to integrate administrative functions and clinical decision-making. Introducing this third type of innovation tends to have far broader ramifications across the overall business domain. Our research objective is to illustrate the resulting complexity of the relationship between this type of technology and organisational change through the investigation of as many facets as possible of the implementation of a PDMS in an intensive care unit (ICU).

The case study explores these implementation issues and is based on an in-depth examination of the introduction of a PDMS in an ICU in order to offer insights to those who have responsibility for managing complex and risky information system implementation projects. Intensive fieldwork was carried out with members of a PDMS project in an intensive care unit (ICU) in a Northwest hospital, over a period of one year (July 1996 to July 1997). This corresponded to the introduction of a commercial PDMS and its early adaptation to this particular context, which was an interesting opportunity as PDMS were still rare in the UK in 1996. An online PDMS system was being introduced to help with the enormous amount of data that is produced from advanced monitoring equipment.

The case study approach was chosen because it allows the researcher to ask penetrating questions and capture the richness of organisational behaviour. A case study approach is also generally recommended in order to gain insight into emerging and previously unresearched topics and when it is difficult to control behavioural events or variables (Benbasat, Goldstein and Mead, 1987; Kaplan and Maxwell, 1994). This qualitative approach seemed particularly appropriate since incorporating computers into all aspects of daily ICU operations is a "formidable task" both technically and logistically, which requires "close cooperation between physicians, nurses, basic scientists, computer specialists, hospital administrators and equipment manufacturers" (Nenov, Read and Mock, 1994).

Given the research has a descriptive and exploratory focus, a combination of data collection techniques was utilised, as recommended by Marshall and Rossman (1989): observation of everyday practices, attendance at meetings and training sessions, informal participation and in-depth interviews with all members of the PDMS project (software suppliers, hospital information systems staff, medical physicists, nurses, medical consultants, hospital administrators). Of particular importance at the time were the legal, purchasing and administrative constraints specific to the NHS that were placed on the ICU. These were also researched using secondary internal sources to gain an understanding of the broader organisational set up and also because they affected how the software was purchased, modified and implemented. The commercial PDMS had to be dramatically modified to suit its users, and this transformation is currently still continuing.

This combination of such qualitative techniques has been used in other IS studies in healthcare (Kaplan and Maxwell, 1994); they enable the elicitation of organisational members' views and experiences in their own terms about sensitive matters and issues of their own choice, instead of collecting data that are simply a choice among preestablished response categories. Additionally, research of this kind is appropriate for unravelling the complexities of organisational change, for providing rich insights and generating an understanding of the reality of a particular situation, and can provide a good basis for discussion. On the other hand, relying on organisational members' qualitative interpretations and complex associations between events, facts and a range of organisational issues makes it more difficult to separate 'data' from findings.

The evolution of information systems in healthcare and their introduction in intensive care is first briefly described. The case study events are then presented covering: the history of the project, the initial specifications, the choice of software, the hardware requirements and difficulties, the programming changes performed, the training carried out, the practical problems experienced, the continuing issue of software upgrades, user satisfaction, organisational practices and the role of suppliers. The main findings about implementation and organisational issues are identified as: time and cost constraints, underestimation of labour effort, the perception of IS implementation as a one off event, the power of suppliers, the lack of project management, the difficulties in managing expectations, the issues of IT expertise and internal conflicts. Discussion points centre on the vision of IS as a technical fix, the difficulty in transferring technical solutions to different contexts, the problem in estimating benefits, and the institutional barriers and politics. Finally, it is concluded that these implementation difficulties are symptomatic of a complex IS innovation which attempts to integrate technology to core business processes.

INFORMATION SYSTEMS IN HEALTHCARE

The introduction of PDMS in intensive care units is taking place in a broad context of using computers in the NHS. Hospital information support systems (HISS) are integrated systems supporting all the hospital operations. The activities and data relating to every patient (tests requested, results reported, etc.) are fed into the financial and information systems of the hospital, to enable hospitals to meet the requirements of the contracting environment (Thorp, 1995a). Guidelines were published as a result of studies of HISS implementation (Thorp, 1995b), which recommend, for instance, data interchange standards and the need for 'benefits realisation'.

The development of the electronic patient record (EPR) further supports clinicians in the recording of medical records (McKenna, 1996). The EPR describes the record of the periodic care provided by one institution. One aim of EPRs is to be developed into a 'comprehensive' information system for the whole of a hospital and beyond. The UK EPR programme has five EPR and Integrated Clinical Workstation demonstrator sites (Peel *et al*, 1997; Urquhart and Currell, 1999). Implementing an EPR is a very complex operation and involves major organisational and technological changes (Atkinson and Peel, 1997). By holding all patient data electronically and interfacing with the various administrative and clinical systems, the aim is to extract information for all levels. For example, as part of its EPR project, the Wirral Hospital NHS Trust has implemented electronic prescribing, whereby patient data is assembled and the prescription can be issued and printed without the need to access manual records. Wirral Hospital has the largest computerised prescribing system in the UK and is developing a rule based decision support system to trigger pharmacy interventions (Moore, 1995).

Decision support systems enhance medical diagnoses and there are broadly two tyoes of support systems (Modell *et al*, 1995). Firstly, there are medical diagnostic DSS; these systems give alternative/supportive diagnostic information based on the input from the user and are implemented into specific areas of medicine. Broader systems are being developed to make use of EPRs (Miller, 1994; Pitty and Reeves, 1995). Secondly, there are databases that support the collection of clinical data, presenting and analysing the information for medical decision support (Wyatt, 1991). An example can be found in ICUs, where monitoring equipment collects data, which feed into a patient data management system.

Intensive care costs can account for up to 20% of a hospital's total expenditure (Metnitz and Lenz, 1995), and there is an increasing demand by management to cut these costs. Rapid development of monitoring devices has increased the data available from ICUs ten-fold. The aim of PDMS is to collect data from monitoring devices at the bedside of the patient, for medical and statistical management reporting. The ability to fully analyse this data has not previously been available, due to the large amounts of data that have to be processed and the slow arrival of outputs. There are only a few systems that have the ability to process PDMS data for quality management and cost accounting (Metnitz *et al,* 1996).

Nonetheless, 'basic' PDMS are being introduced to help support these functions in the future. For instance, the University Clinics of Vienna have developed a system called ICDEV (Intensive Care Data Evaluation System), which is a scientific database tool for analysing complex intensive care data (Metnitz *et al,* 1995). It is built to interface with two commercially available PDMS, Care Vue 9000 (Hewlett Packard, Andover, USA) and PICIS Chart+ (PICIS, Paris, France). The ICDEV enables the PDMS to be used for cost accounting, quality control and auditing. ICDEV was first used at the Medical ICU of the Vienna General Hospital in June 1994 and its Neonatal ICU in December 1994 with Care Vue 9000, and in April 1995 with PICIS Chart+ at its Cardiothoracic ICU. Metnitz *et al* (1995) report problems of integration with existing local networks and databases, which have required the expertise of engineers. Metnitz and Lenz (1995) have found that commercial PDMS can help optimise bed-occupancy and facilitate analysis for scientific and quality control.

On the other hand, they are expensive, require specialised maintenance, and they may not be faster than manual techniques. Metnitz and Lenz (1995) conclude that commercial PDMS still have some way to go before they are truly useful for both clinical and management analysis purposes. They state that those implementing PDMS must plan sufficiently before installation and implementation for reconfiguration, as most PDMS interfaces are presently not practical or reliable, and that co-operation between the system developer and purchaser is mandatory. Urschitz *et al* (1998) report on local adjustments and enhancements of Care Vue 9000 such as knowledge-based systems for calculating the parenteral nutrition of newborn infants or for managing mechanical ventilation in two neonatal ICUs. They state that PDMS have to be constantly adapted to the users' needs and to the changing clinical environment, and that there are yet unsolved problems of data evaluation and export.

In terms of implementation issues, Langenberg (1996) argues that PDMS require good organisation, specifications need to be defined before the process is started, a system should include data acquisition, database management and archiving of data, and coupling with a hospital information system and the possibility of data exchange is mandatory. However, Butler and Bender (1999) claim that: the current economic climate makes the cost of ICU computer systems prohibitive for many institutions; that the literature describing ICU computer system benefits is often difficult to interpret; and that each implementation has many unique variables which make study comparison and replication potentially impossible. They suggest changes and issues can only be evaluated uniquely in each study unit or institution.

Pierpont and Thilgen (1995) measured the effects of computerised charting on nursing in intensive care; they found that the total time manipulating data (entering or reviewing data) post-installation was unchanged; that time spent in patients' rooms did not alter, although nurses had more time available for monitoring at the central station; and that computerised charting will not necessarily provide ICU nurses with a net excess of time for tasks unrelated to manipulating data.

CASE STUDY IN AN INTENSIVE CARE UNIT

History of the project

The ICU at a UK Northwest hospital had long felt the need for a PDMS. The consultants first raised the idea for a computerised system that would collate and generate information from bedside monitors in the early 1980s. At the time the technology was not available. The 'management team' for the ICU consists of medical consultants, a Directorate manager, representatives of the nursing staff, medical physicists and maintenance staff. The medical physicists build medical applications and equipment for the hospital. The management team determines organisational and purchasing issues for the ICU. In 1994 the management team realised that the ICU would have to update the existing patient monitoring system to function effectively. Investigations started and a request for purchasing a monitoring system and possibly a PDMS was given to the Regional Purchasing Office.

At the beginning of December 1994 the request for funds for capital equipment was agreed. The system, monitors and PDMS had to be on site by the end of the financial year (31st March 1995). All purchasing for the NHS has to go out to European Open Tender before it is bought; this further reduced the time available to the management team to choose a system, leaving no more than six weeks for appraisal of possible systems.

PDMS specifications

The management team developed the following criteria to which the system had to adhere: the hardware was to have a life span of 7-10 years; the PDMS was to be combined with the monitoring system; the cheapest system had to be chosen, unless the case was strong enough to convince the Regional Office otherwise; the PDMS could be adapted to 'fit' around users; charts produced had to be the same as the existing paper charts. The paper charts used by the staff are an agreed standard within the unit, which has taken a very long time to develop.

Choice of software

Due to the time constraints, the scale of evaluation had to be considerably reduced and investigations were limited to the UK. The only PDMS in working practice that the team was able to review was at Great Ormond Street Hospital in London. This PDMS did not fulfil all their criteria and was considered to be too difficult to use by the nursing staff representative. Once the purchase had been put out to European Open Tender, the ICU was then obliged to choose the cheapest system, which was the PICIS Marquette system, and also the team's preferred choice due to its adaptability, at a cost of approximately £600,000. The monitoring system was introduced in March 1995. However, the PDMS was not fully implemented due to problems with the reporting/charts facility and was still not fully implemented two years (summer 1997) after purchasing the system.

Hardware laboratory connections

The PDMS software program was to collate blood gas levels and observations directly from the monitoring equipment at the bedside of the patient. Some examples of measures are tracheal suction, heart rate, blood temperature, sedation score, peak pressure, ventilation mode, pain score, and pulmonary mean. However, data from laboratory results, ventilators, drug infusions and bedside observations which were intended to be available automatically through laboratory connections, were still entered manually during the period of the study.

Programming changes

A systems manager from the medical physics department was appointed to adapt the system and has had to make considerable changes to it. PICIS Marquette have had to divulge information about the software that would not normally be given to the client. The systems manager has become an expert in the adaptation of this product and is consulted by the supplier for her expertise. There is no formal contractual agreement between the two parties. The relationship is very much based on trust. The systems supplier has reflected that, "*the software was never meant to be adapted as much as it has been*" (Interview 1997). On the other hand, a medical consultant commented that "*the software was chosen because it could be adapted. The software would not have been used [as it was], even with training*" (Interview 1996). The systems manager was originally employed to spend 1-2 days a week adapting the software. However, she worked full-time for the period 1995-1997 and the following modifications were made: medical charts from the monitors and manual inputs have been reformulated to be the same as the written medical reports; new icons have been designed to ease user interaction; the drug list was extended; 10 screens have had to be altered to fit with nurses' practices, which has meant changing the original programming.

Training

Training for the monitoring equipment was relatively smooth since staff was already familiar with this technology. Generally within the unit, the nursing staff is not used to computers. The Directorate manager, who had considerable input into choosing the system, is not computer literate. Nursing staff received training from clinical trainers from PICIS Marquette for the monitoring equipment before the equipment was introduced. The PDMS software has been in constant development so the system manager has run the PDMS training, since she is adapting the system. A charge nurse was designated to work with the systems manager and to give user feedback about the modifications. Five nurses identified as 'super' trainers are trained by the systems manager, and they then train the other staff.

Practical equipment problems

The ICU staff did not want the PCs that operate the PDMS to be on tables at the bedside. Firstly, this would violate health and safety regulations; secondly this would not be practical in an already busy and hectic environment. The PDMS that the team saw before selection were desk-based. A 'cart' was designed to put the PCs in, which was at an extra cost to the ICU. The first cart to arrive was like a giant washing machine, which was too big and obscured the view of the patient. It is vital in an ICU environment for the nurses to always see the patients. Once the PCs were housed in the carts, it was then found that the monitors were over heating and blowing up. Fans were fitted to the carts to cool the monitors; however, dust particles were then being blown over the patient, carrying the obvious danger of germs being spread. Such practical problems have generally been sorted out on-site by the Directorate manager. However, because of the charting and reporting problems, a paper system was still running alongside the computer system for two years after the introduction of the system.

Continuing software upgrades

Partly based on their experiences at this hospital, PICIS Marquette then decided to improve reporting and were at the time producing an upgrade of the system to make it act as a database. New facilities were to include a drug prescription facility and laboratory connections. Moreover, the PDMS was to enable data collation for different statistical purposes (Therapeutic Intervention Scoring System, Intensive Care National Audit & Research Care, Contract Minimum Data Set and Hospital Episode Statistics). All of these areas overlap and the NHS Executive was still in discussions to decide if such duplication of information is required (Interview Hospital Administrator 1997).

Whereas in the first implementation "*time has been the big problem*" (Interview Medical Physicist 1996), the systems manager envisaged the upgrade implementation being a smoother operation, as the first version was already partly in use and there would be an overlap period. A spare PC was to be used to make changes and test the new software before installing it for the nursing staff. A further difficulty was that upgraded software needs all the changes that were implemented into the original software. This will be the case for all future upgrades. The systems manager is expected to carry out this time consuming activity along with any maintenance that the system requires.

User satisfaction

Overall, nursing staff felt that they adapted well to the new monitoring equipment, after a few teething problems. The management team expected the ICU to be totally 'paperless' by June 1996, however, this did not happen. The Directorate manager felt that this caused the nursing staff to become disenchanted with the system. Major adaptations to the system caused considerable delays. The Directorate manager commented that, the implementation has "*taken longer than anticipated, probably because we incorporated more as we have gone along*" (Interview 1996).

Matching working practices

Using the software as it stood would have meant totally changing the work procedures of the staff and this is not possible in a working ICU. The management team decided to change the software package not the working practices, and the software was chosen because it could be adapted. However, the Directorate manager reflected that at the time of purchase the medical consultants "*thought that the system was going to do exactly what they wanted. We didn't realise there would be so many problems*" (Interview 1996). PICIS Marquette were able to convince the medical consultants of the adaptability of the system and the concerns of the systems manager were overlooked. The organisational hierarchy and the power of the medical consultants obviously played an important part in the decision making process (Knights and Murray, 1994).

Role of suppliers

Throughout the interviews it became very apparent that the PDMS was still very much in the R&D stage. Little was known by the users about how much the software would have to be modified. The software was chosen because of its adaptability, but this was based upon the suppliers' views of their own product. Suppliers played a great part in the introduction of this system. However, without informed professionals within the NHS, the IT systems purchased may not meet internal organisational needs easily. In this situation, it is hardly surprising that: *"the most difficult aspect of the implementation has been to convince staff that the system will save time when it is fully implemented, but at the moment this is not the case"* (Interview Hospital Administrator 1997).

ANALYSIS OF FINDINGS

Time and cost constraints

The PDMS had to be purchased quickly and to a strict budget, which is fairly typical in the NHS. For instance, the failed introduction of a computer-aided dispatching system at the London Ambulance Services also suffered from arbitrary time and cost constraints. Purchasers were obliged to take the lowest tender unless there were "good and sufficient reasons to the contrary" (Flowers, 1996). However, "tight time-scales and inaccurate, inflexible funding have often occurred (...) due to government and departmental political exigencies, policies and pressures. (...) these factors need to be counterbalanced, even if this slows up decision making and implementation, if effective systems are to be delivered" (Willcocks 1991).

Underestimation of labour effort

Knowledge-based systems such as diagnostic tools are likely to require more, rather than less, labour (Drucker, 1996). However, this extra cost was not accounted for when the system was purchased. The lifetime of the system was assumed to be 7-10 years rather than 4-5 years, which is recognised as more appropriate (Sotheran, 1996). There is the danger of staff responsible for procurement failing to recognise that it is dealing with something it does not understand.

It was found that the systems manager has had to work on the project full-time. With little training, she has been able to keep up to date with the documentation, to ensure that modifications are recorded. The commitment by those involved has resulted in the software being modified and developed at a relatively cheap cost. However, the institution has not benefited from the experiences and knowledge gained from this project. The project is not seen as a long-term project and, as a consequence, detailed information is not available and the true costs are very difficult to judge. Furthermore, the hospital cannot secure a method of benefiting from profits produced by the sales of software they have helped to develop. Equipment (such as the modified cart) or software (such as better charting/reporting tools) produced by the Medical Physicists Department are not patented.

One off purchase vs long term investment

Despite the existence of a set of guidelines governing the procurement of NHS computer systems, called POISE (Procurement of Information Systems Effectively), there was little evidence that these guidelines were employed at the ICU. POISE seems to be regarded by ICU staff as useful for large systems, such as HISS. Funding for the project did not reflect the fact that the PDMS was an infrastructure investment and required long-term investment (Willcocks and Fitzgerald, 1993). It is recommended that off the shelf systems be purchased by the NHS, with some later modification (Bates, 1995), thereby giving more power to suppliers.

When computers are used to support patient care in the NHS, budgets are often funded year to year. They are seen as one-off software projects with some modification. The extent of modification can be very ambiguous, as has been seen in the case study. The introduction of computers in areas other than administration is bringing with it new challenges for healthcare professionals. The medical consultants felt that the modifications they required could be achieved, based on the advice of the supplier. Internal staff can have a far better understanding of the application. Yet giving responsibility of IT applications in critical environments to non-specialists can bring an enormous amount of risk (Heathfield *et al,* 1997).

Power of suppliers

Due to the problems encountered during implementation, PICIS Marquette have probably made a considerable loss. On the other hand, the supplier has been able to lock in the customer by providing monitoring equipment that is only compatible with its own PDMS. The vendor planned to use the system at the ICU as a launch pad for further sales, as it was their only reference site in the UK. It can be used to show other NHS clients how the system can be adapted. The systems manager has built a trust-based relationship with the supplier and she imparts her knowledge to the supplier, which was made available on the PICIS Marquette Website (PICIS, 1997). Adaptability is a strong selling point, especially since off the shelf systems with some modification are recommended for purchase at the NHS. PICIS Marquette supplies free copies of the upgraded software to the ICU (Interview Systems Manager 1997), whilst it benefits from the development work being carried out at the NHS expense. At present this situation may suit the ICU. However, there are no formal contracts that could help resolve problems if relations deteriorate.

Moreover, the true cost of the system and its development is hidden, not only in terms of upgrade purchasing, but labour costs. The main developer of the system, the systems manager, is employed as a medical physicist and not at the ICU. So the cost of this labour has not been added to the system cost. Also, should PICIS Marquette decide that they would no longer supply free software, the ICU will have an extra cost that they will not have planned for. PICIS Marquette made the coding of areas of the software more accessible to the ICU, which will mask the true effort required for other modifications. As a result, other NHS departments could start to follow the same route, unaware of the hidden costs. The case study has shown that suppliers can bring useful expertise; but they are not entirely without their own interests. The suppliers need to gain command of the business they are applying their IT products to; and conversely, the purchasers must become more knowledgeable about their own IT requirements (Peel, 1994).

Project management

The ICU project has not benefited from any project management methodology such as PRINCE, as recommended by the NHS. The systems manager had no training into methodologies or formal software development methods. This has meant that she has had to "*find her way around*" (Interview Systems Manager 1997). This led to "a lack of appreciation of complexity of the project" (Flowers, 1996). Negotiating and constantly changing requirements have highlighted the difficulties in agreeing aims. Without experience and knowledge of project planning, it is generally acknowledged that difficulties will arise. The case study has shown that medical systems are still evolving. This continual enhancement requires management and resources, just as the project required at its birth.

Managing expectations

Initially the users of the PDMS were very excited about the implementation, with medical consultants pushing for its installation (Interviews Medical Consultants and Nurses 1996-97). However, over the implementation period enthusiasm dwindled (Interview Hospital Administrator 1997). This has probably occurred due to expectations being raised too high by "unrealistic claims of immediate advantages and benefits" (Thorp 1995a). User involvement has gone far beyond working with a requirements analysis team. The users have been actively involved with producing their own specifications even though they had no experience or training (Interview Nurse Manager 1996).

IT expertise and internal conflicts

The Medical Physicists department in which the systems manager works is not part of the IT department. The IT department deals with administrative hardware and software applications. The Medical Physicists department is responsible for clinical equipment and applications. Medical physicists are only responsible for the clinical software they are asked to deal with. Departments often have their own arrangements for clinical IT. This makes the dissemination of information particularly difficult (Interview Medical Physicist 1997). The laboratory connections were not implemented due to internal conflicts between the Laboratory and the ICU as to their areas of responsibilities. The Laboratory may have felt that by giving information they may have become redundant or that the ICU and the department of Medical Physics were treading on their territory. These fragmented relationships between departments reflect the complex mix of expertise required in medical informatics.

DISCUSSION

Technical fix?

There is a "growing awareness amongst those involved in the development and implementation of clinical systems, that social and organisational issues are at least of equal importance as technical issues in ensuring the success of a system" (Protti and Haskell, 1996). However, there is still a tendency to see technology as void of values (Bloomfield, 1995) and perhaps paradoxically, to expect it to solve clinical, financial, management and quality problems, but without realising the organisational and technical complexities, human resources implications and associated costs. As Atkinson (1992) claims, information is now perceived as the lifeblood of the NHS to "enable all operations, clinical, nursing, financial, estates, human resources". But Coleman *et al* (1993) argue that the clinical computing system is complex and that as we press it further to work in the complete care context, it tends to become unmanageably so. Hagland (1998) also argues that automating intensive patient care areas requires a different level of IT product, design and development. Medical consultants' clinical expectations of the PDMS were high. As Hoffman (1997) has found, persuading US doctors to use IT goes beyond monetary incentives. However, the technology could not deliver and this may be because it was intended to fulfil both medical and management requirements.

Transferring technical solutions to different contexts

An example problem arising from seeing technology as a neutral solution can be seen in the unforeseen large number of software modifications, which were due to the commercial package not fitting in with ICU nursing practices. An important factor was that the package used is European, and care planning embedded in the software reflects more hierarchical and prescription oriented care planning practices, that differ from UK practices where responsibility is more equally spread across staff.

BENEFITS DIFFICULT TO ESTIMATE

The drivers for change have been accountability, demands for high quality services and cost effectiveness, but introducing IT may not be as beneficial as expected. With respect to hospital information systems, Bloomfield (1995) comments that "it is not evident that the efficiency gains secured through IT will outweigh the costs of constructing and implementing the systems involved". Friesdorf *et al* (1994) claim that the flexibility of PDMS is far from expectations and that maintenance requires continuous effort which cannot be afforded. East (1992) states that few conclusive studies prove that ICU systems have a favourable cost-to-benefit ratio.

Institutional barriers and politics

Because of the NHS internal market, NHS Trusts purchase their own off the shelf IT systems through tendering. They are therefore foregoing the economies of scale previously possible in a unified NHS. NHS Trusts may save money through the tendering process, and benefit from a freedom of choice (as long as it is the lowest tender), but overall at an extra cost. It is considered that indirect human and organisational costs can be up to four times as high as the technology and equipment costs; this saving seems small in comparison (Willcocks 1991).

Implementation of IT will not automatically guarantee communication between departments, as witnessed by the failure to set up laboratory connections. The way technology is introduced and used is a political process, involving people with different occupational cultures (Knights and Murray, 1994), with values influencing its use.

CONCLUSION

Healthcare is now a service that can be bought and sold, and whose effectiveness and efficiency can be measured. IT provides the means of collating this information, not only for administrative functions but also within patient care and clinical decision making. It is being used for clinical diagnosis, along with on line data collection from monitoring equipment. Research into the introduction of PDMS in an ICU shows that there is still some way to go before their usefulness can be realised, partly because the demands on the technology are complex and technology itself has yet to be fully assessed. Realistically, the project investigated in our case study is still at the development stage, even if it is not recognised.

It would appear that the introduction of IS in the NHS is still perceived as an innovation of the second type (Howcroft and Mitev, 2000), i.e. one which only supports administrative processes, as opposed to a third type which integrates IS to core business processes. This would explain: the one off purchasing approach; the difficulties in sustaining enthusiasm and user involvement; the underestimation of continuing labour costs and the dependence on a particular individual; and generally the lack of awareness of complex organisational implications of such integration. For instance, software had to be extensively modified to adapt to complex working practices in the ICU, which led to undue reliance on suppliers. IT skills were poor and also needed to be complemented with medical physics and this was not supported organisationally.

Recommendations from the supplier about the possible adaptability to their product were considered to be the most informed; even though the hospital systems manager eventually carried out many modifications. There has been a lack of understanding about the complexities surrounding development both by purchaser and supplier. The cost and times for the project were completely arbitrary, laid down by managers outside of the implementation. Whilst suppliers are having to put a great deal of work into getting these new technologies into NHS sites, in the long run the supplier will benefit most from the development that is carried out at the NHS's expense. Healthcare professionals are performing tasks outside of their experience, purely out of necessity to get the project implemented. They were unable to perform to the best of their abilities or understand the complex minefield they were embarking upon.

An understanding of PDMS as innovations of the third type would see them as long term investments with important organisational ramifications. It may ensure that cost and time constraints are more realistic; that project management is better applied; that adequate labour resources are allocated; that collaboration between medical physics and IT skills is taken into account; that expectations are better managed; and that institutional barriers are removed. This mismatch in terms of perception needs to be addressed to avoid future difficulties.

It is also argued that introducing PDMS crystallises too many different expectations making them unmanageably complex, particularly in the current economic climate; that more generally technology is perceived as a blank screen on which many expectations are projected; and that it takes on the often conflicting values of its promoters, developers and users.

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