The organisational and communication implications of electronic ordering systems for hospital pathology services

Andrew Georgiou

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Faculty of Health Sciences
The University of Sydney

A thesis in fulfillment of the requirements for the degree of Doctor of Philosophy
COMPLIANCE STATEMENT

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Andrew Georgiou
7 January 2009
Abstract

Computerised Provider Order Entry (CPOE) systems provide clinicians with the ability to electronically enter hospital orders for laboratory tests and services. CPOE is able to integrate with hospital information systems and provide point of care decision support to users thereby making a potentially significant contribution to the efficiency and effectiveness of care delivery. The evidence of the impact of CPOE systems on pathology services is not extensive and insufficient attention has been paid to their effect on organisational and communication processes. This thesis aimed to investigate the implications of CPOE systems for pathology laboratories, their work processes and relationships with other hospital departments, using comparative examinations to identify the tasks they are involved in and the particular needs the laboratories expect to be filled by the new system. This longitudinal study of a CPOE system was carried out over three years using multiple cases from a hospital pathology service based at a large Sydney teaching hospital. Multi-methods using quantitative and qualitative data were employed to achieve triangulation of data, theory and methods. The findings provide evidence of a significant 14.3% reduction of laboratory turnaround times from 42 to 36 minutes when laboratory data for two months were compared before and after CPOE implementation. The findings also reveal changes in the pattern and organisation of information communication, highlighting transformations in the way that work is planned, negotiated and synchronised. These findings are drawn together in a comprehensive organisational communication framework that is highly relevant for developing a contingent and situational understanding of the impact of CPOE on pathology services.
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<td>AHRQ</td>
<td>Agency for Healthcare Research and Quality</td>
</tr>
<tr>
<td>ANA</td>
<td>Anaerobic agar</td>
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<tr>
<td>AnAO₂</td>
<td>Anaerobic incubation</td>
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<tr>
<td>AP</td>
<td>Anatomical Pathology</td>
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<tr>
<td>APW</td>
<td>Alkaline Peptone Water</td>
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<tr>
<td>CDSS</td>
<td>Clinical Decision Support System</td>
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<td>CDT</td>
<td>Clostridium Difficile Toxin</td>
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<td>CHOC</td>
<td>Chocolatised Horse Blood Agar</td>
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<td>CMV</td>
<td>Cytomegalo virus</td>
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<td>CNAO₂</td>
<td>Aerobic special agar plate</td>
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<td>COAG</td>
<td>Coagulation testing</td>
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<tr>
<td>COP</td>
<td>Cysts Ova and Parasites</td>
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<td>CPOE</td>
<td>Computerised Provider Order Entry</td>
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<td>CSR</td>
<td>Central Specimen Reception</td>
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<td>DRG</td>
<td>Diagnosis Related Group</td>
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<td>ELISA</td>
<td>Enzyme-linked Immunosorbent assay</td>
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<td>EMR</td>
<td>Electronic Medical Record</td>
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<td>EUC</td>
<td>Electrolytes, Urea, Creatinine</td>
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<td>ESR</td>
<td>Erythrocyte Sedimentation Rate</td>
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<td>GRAM</td>
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<td>HSV</td>
<td>Herpes Simplex Virus</td>
</tr>
<tr>
<td>HUS</td>
<td>Haemolytic uraemic syndrome</td>
</tr>
<tr>
<td>IH</td>
<td>Iron Haematoxylin</td>
</tr>
<tr>
<td>ICT</td>
<td>Information Communication Technologies</td>
</tr>
<tr>
<td>LIS</td>
<td>Laboratory Information System</td>
</tr>
<tr>
<td>LJ</td>
<td>Lowenstein-Jensen media</td>
</tr>
<tr>
<td>MAC</td>
<td>MacConkey agar</td>
</tr>
<tr>
<td>MRN</td>
<td>Medical Record Number</td>
</tr>
<tr>
<td>MRO</td>
<td>Multi-resistant organism</td>
</tr>
<tr>
<td>MRSA</td>
<td>Methicillin-Resistant Staphylococcus Aureus</td>
</tr>
<tr>
<td>MTZ</td>
<td>Metronidazole</td>
</tr>
<tr>
<td>NHS</td>
<td>National Health Service (United Kingdom)</td>
</tr>
<tr>
<td>NIDDM</td>
<td>Non-Insulin Dependent Diabetes Mellitus</td>
</tr>
<tr>
<td>PAS</td>
<td>Patient Administration System</td>
</tr>
<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised Controlled Trial</td>
</tr>
<tr>
<td>ROTAG</td>
<td>Rotavirus Antigen</td>
</tr>
<tr>
<td>SM2</td>
<td>Special media for salmonella</td>
</tr>
<tr>
<td>SOS</td>
<td>Specimen Orderable Status</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>SPR</td>
<td>Specimen Reception</td>
</tr>
<tr>
<td>SPT</td>
<td>Specimen Tracking</td>
</tr>
<tr>
<td>SS</td>
<td>Salmonella shigella agar</td>
</tr>
<tr>
<td>STS</td>
<td>Socio-technical systems</td>
</tr>
<tr>
<td>STAT</td>
<td>Life threatening</td>
</tr>
<tr>
<td>TAT</td>
<td>Turnaround time</td>
</tr>
<tr>
<td>TB</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>TCBS</td>
<td>Thiosulphate cirate bile salts sucrose agar</td>
</tr>
<tr>
<td>UEC</td>
<td>Urea, Electrolytes, Creatinine</td>
</tr>
<tr>
<td>VZV</td>
<td>Varicella Zoster Virus</td>
</tr>
</tbody>
</table>
### Glossary

This glossary presents the key terms and formulations that appear in the thesis.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add-on</td>
<td>Additional assay performed on a previously analysed specimen.</td>
</tr>
<tr>
<td>Aliquot</td>
<td>Additional tube taken from specimen sample.</td>
</tr>
<tr>
<td>Architecture</td>
<td>Design and interconnection of a computer system’s hardware.</td>
</tr>
<tr>
<td>Asynchronous</td>
<td>Not occurring at the same time.</td>
</tr>
<tr>
<td>Audit trail</td>
<td>List of specified events that occurred in relation to a work process.</td>
</tr>
<tr>
<td>Blood collectors</td>
<td>Blood collectors are trained to draw blood for laboratory tests or for blood donations. They are also known as phlebotomists.</td>
</tr>
<tr>
<td>Case studies</td>
<td>Rich empirical descriptions of particular instances of a phenomenon.</td>
</tr>
<tr>
<td>Chi-square</td>
<td>A test statistic used to assess the statistical significance of unrelated non-parametric data.</td>
</tr>
<tr>
<td>Clinical Decision Support System</td>
<td>Access to knowledge stored electronically to aid patients, carers and providers in making healthcare decisions.</td>
</tr>
<tr>
<td>Commercial system</td>
<td>System software purchased from a software developer.</td>
</tr>
<tr>
<td>Component evaluation</td>
<td>An evaluation that looks at different features of a program or product.</td>
</tr>
<tr>
<td>Computer network</td>
<td>The interconnection between a group of computers.</td>
</tr>
<tr>
<td>Computerised Provider Order Entry</td>
<td>An electronic system that allows clinicians to electronically place orders eg, laboratory tests, medical imaging, diets or medications.</td>
</tr>
<tr>
<td>Consensus development panels</td>
<td>Consensus technique involving the organisation of meetings consisting of experts in a particular field.</td>
</tr>
<tr>
<td>Consensus techniques</td>
<td>Techniques used to obtain consensus about a certain subject or area.</td>
</tr>
<tr>
<td>Delphi technique</td>
<td>A consensus technique associated with questionnaires that are applied systematically.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
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</tr>
<tr>
<td>Determinism</td>
<td>Assumption that things are caused by some factor in a particular way.</td>
</tr>
<tr>
<td>Dimensional evaluation</td>
<td>An evaluation that considers different dimensions of the product eg, the reliability of a system as opposed to a component part of the system.</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>The extent to which a specific intervention does what it is intended to do.</td>
</tr>
<tr>
<td>Electronic Health Record</td>
<td>An individual patient’s health record in digital format.</td>
</tr>
<tr>
<td>Ethnomethodological studies</td>
<td>Investigations that look into peoples’ practices.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Determination of the quality, value or importance of something.</td>
</tr>
<tr>
<td>Formative evaluation</td>
<td>An evaluation conducted during the development of a program or product to provide information on the processes involved, often as a means of aiding the program’s success.</td>
</tr>
<tr>
<td>Grounded theory</td>
<td>A means of developing levels of understanding based on the systematic analysis of data.</td>
</tr>
<tr>
<td>Holistic evaluation</td>
<td>An evaluation that aims to investigate the program or product at an overall level.</td>
</tr>
<tr>
<td>Home-grown system</td>
<td>Systems developed within the hospital or clinical setting in which they are used.</td>
</tr>
<tr>
<td>Indicator</td>
<td>A statistic or unit of information which reflects the performance of a system.</td>
</tr>
<tr>
<td>Interface</td>
<td>The connection between two devices.</td>
</tr>
<tr>
<td>Interactionist studies</td>
<td>Studies that seek to understand how a phenomenon is seen by people.</td>
</tr>
<tr>
<td>Kappa statistic</td>
<td>A measure of agreement above and beyond that expected by chance.</td>
</tr>
<tr>
<td>Laboratory technician</td>
<td>Laboratory technicians carry out routine laboratory tests and other procedures.</td>
</tr>
<tr>
<td>Lamson tube</td>
<td>Pneumatic tubes which propel containers through a network.</td>
</tr>
<tr>
<td>Longitudinal study</td>
<td>Study carried out over a period of time.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td>Mann-Whitney U Test</td>
<td>Non-parametric statistical test for two unrelated samples.</td>
</tr>
<tr>
<td>Middleware</td>
<td>Bridging software between the Laboratory Information System and a laboratory analyser.</td>
</tr>
<tr>
<td>Multi-methods</td>
<td>Research using a variety of data sources and analysis techniques.</td>
</tr>
<tr>
<td>Observation</td>
<td>Data collection method based on the researcher viewing, listening and recording events.</td>
</tr>
<tr>
<td>Off the shelf</td>
<td>A product that has already been designed and made.</td>
</tr>
<tr>
<td>Pathologist</td>
<td>Medical practitioner who is recognised as a specialist in a pathology specialty.</td>
</tr>
<tr>
<td>Phlebotomists</td>
<td>See Blood collectors.</td>
</tr>
<tr>
<td>Qualitative research</td>
<td>Research undertaken in natural settings and is largely non-statistical.</td>
</tr>
<tr>
<td>Quantitative research</td>
<td>The numerical measurement and analysis of data.</td>
</tr>
<tr>
<td>Prospective study</td>
<td>Data collected over the forward passage of time.</td>
</tr>
<tr>
<td>Randomised controlled trial</td>
<td>The experimental manipulation of an intervention in a controlled setting using intervention and control groups.</td>
</tr>
<tr>
<td>Realism</td>
<td>Belief that there is an existing real world that is not dependent on our knowledge of it.</td>
</tr>
<tr>
<td>Reliability</td>
<td>Process of establishing that data analysis remains constant when reviewed by the same researcher (stability) or another researcher (reproducibility).</td>
</tr>
<tr>
<td>Retrospective study</td>
<td>Collection of data over past time.</td>
</tr>
<tr>
<td>Sample</td>
<td>Subset of a population.</td>
</tr>
<tr>
<td>Scientist (Laboratory)</td>
<td>Person with a science or applied science degree with subjects relevant to the field of pathology.</td>
</tr>
<tr>
<td>Socio-technical</td>
<td>Interdependence and interrelation of social and technical factors.</td>
</tr>
<tr>
<td>Structuration</td>
<td>The assertion that social structures are not separate from social actors but are rules and resources that are produced and reproduced by social actors as part of everyday existence.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------------------------------</td>
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</tr>
<tr>
<td>Summative evaluation</td>
<td>An evaluation conducted after the completion of a program.</td>
</tr>
<tr>
<td>Survey</td>
<td>A way of collecting information from a population sample.</td>
</tr>
<tr>
<td>Synchronous</td>
<td>Carried out simultaneously in real time.</td>
</tr>
<tr>
<td>Synoptic standards</td>
<td>The standardisation of laboratory reporting.</td>
</tr>
<tr>
<td>Technician</td>
<td>See Laboratory technician.</td>
</tr>
<tr>
<td>Theory</td>
<td>A frame of reference that aids our understanding of the world.</td>
</tr>
<tr>
<td>Triangulation</td>
<td>The use of multiple research methods as a validation and data analysis technique.</td>
</tr>
<tr>
<td>Validity</td>
<td>The soundness or rigour of a study.</td>
</tr>
<tr>
<td>Validity (external)</td>
<td>Extent to which research findings can be generalised to a wider population.</td>
</tr>
<tr>
<td>Validity (internal)</td>
<td>Extent to which the tool is actually measuring what it claims to be measuring.</td>
</tr>
<tr>
<td>Vendor system</td>
<td>A commercially made software system.</td>
</tr>
<tr>
<td>Venepuncture</td>
<td>The process required to obtain a sample of venous blood.</td>
</tr>
<tr>
<td>Workaround</td>
<td>A means of circumventing a recognised problem in the way a system works.</td>
</tr>
</tbody>
</table>
List of publications arising out of the research to date

Journal publications


Book chapters


**Presentations and posters**


Chapter 1  Introduction
1.1 Introduction

This chapter provides an introductory overview of the thesis beginning with an outline of the expanding role of Information and Communication Technologies (ICT) within healthcare. It identifies a series of organisational and communication issues that confront its implementation and diffusion – with particular reference to the role of Computerised Provider Order Entry (CPOE) and the potential benefits it holds out for healthcare services. It will also discuss the significance and potential role of CPOE systems in hospital pathology services and provide an explanation of the major obstacles and challenges they pose. The chapter will conclude with an outline of the aim and relevance of the thesis along with a description of how it is structured to achieve its aim.

1.2 ICT – a fundamental component of healthcare innovation

In the past computers and information technology consisted mostly of small and functionally-limited applications (Haux 2006) that were generally part of the “background” of medicine, found in financial offices or research facilities, or else in “niche systems” (Colleen 1994; Goodman 1998). ICT developments have infiltrated into virtually all parts of the healthcare system covering each point of the patient journey. It is hard to talk anymore about computers as just tools for carrying out tasks, rather they form the very environment (Kling 1996) in which healthcare is performed. In the last couple of decades ICT systems have been high on the agendas of healthcare systems across Australia (HealthConnect 2004), Europe (Department of Health 2002) and the US (Doolan & Bates 2002; Shekelle et al. 2006). In Australia, for instance, it has been
estimated that the total spending on ICT systems accounts for 1 to 3% of total healthcare costs, broadly equivalent to AUD$1-2 billion per year (Productivity Commission 2005).

Within today’s computer-dependent society, it is almost impossible to envisage any major healthcare initiative without an integral ICT component to underpin its implementation and development and to monitor its outcome. In Britain, the strategy undertaken by the National Health Service (NHS) Modernisation Agency and the NHS Improvement Plan (Department of Health 2004) to “transform” the health service were complemented by a multi-billion pound investment in ICT infrastructure (Humber 2004) aimed at improving patient care and increasing service efficiency and effectiveness. The program’s scope represents the largest single ICT investment in Britain to date (National Audit Office 2006). In the US and Australia, initiatives to improve the quality of healthcare (Kohn et al. 1999; Clinical Systems Strategy Unit 2001) and combat the high incidence of preventable errors has proceeded hand-in-hand with support to, and promotion of, new systems like CPOE that are designed to improve the quality and efficiency of the healthcare system (Sittig & Stead 1994).

Whilst there is enormous enthusiasm for the implementation of ICT, its diffusion and adoption within the healthcare sector has not achieved the same efficiencies and mostly lagged behind that of developments in other sectors (Shortliffe 1998). The problem is not limited to the healthcare sector. Heeks and Bhatnagar report on research into information systems in the British public sector which estimates that 20% of all IT expenditure is wasted (Willcocks 1994). They point to a yawning gap between the positive potential of information-age reform and the largely negative reality (Heeks &
Bhatnagar 1999). It is now generally recognised that the process of implementation of comprehensive ICT systems is ridden with risks and dangers (Berg 2001). The learning process has been long and difficult. In the 1990s a series of high profile and expensive healthcare system failures, which included the breakdown of the London Ambulance computerised system in 1992, and the failure of the Hospital Information Support Services attempt to link patient and clinical data in the 1980s (Beynon-Davies & Lloyd-Williams 1999; Jones 2004), led to a United Kingdom Audit Commission recommendation that computers and information technology must not be allowed to drive the process of information management, only to serve it (Audit Commission 1995).

1.3 The evaluation imperative

The risks of ICT failure are high (Birkmeyer et al. 2002; Georgiou & Westbrook 2006). In the US, Ash and Bates reported that investment in a CPOE system may be the largest single capital investment a hospital makes in a five-year period (Ash & Bates 2005). Other estimates from the US suggest that computerised systems can account for as much as 8% of an institution’s total budget (Anderson & Aydin 1997). Yet despite this, the overall benefits and costs of ICT systems are rarely assessed (Littlejohns et al. 2003) and the evidence of cost effectiveness remains poor (Wyatt & Sullivan 2005).

It is not surprising therefore that there is pressure on organisations to justify expenditures on ICT systems using evaluations of their impact (Anderson & Aydin 1997). Many leading commentators in health informatics have noted the importance of rigorous attention to evaluation as a key element underpinning the ability of health
informatics to contribute to scientific understanding and to the development of more effective clinical systems (Heathfield & Wyatt 1995; Heathfield & Buchan 1996; Friedman & Wyatt 1997; Ammenwerth et al. 2004). This is an essential component of the expansion of a culture that is capable of recording failures as well as successes and has the ability to generate results into testable hypotheses (Wyatt 1996; Georgiou 2005). It could be said to be an ethical imperative for health informatics (Gell 2001; Ammenwerth & Shaw 2005).

Over recent years, evaluation studies have become more widespread and are increasingly seen as an essential component of the implementation and operation of ICT in healthcare. There are also indications of a growing maturation (Ammenwerth & de Keizer 2005) and diversity in the use of evaluation methods and frameworks (Currie 2005). In their inventory of evaluation studies from 1982 – 2002, Ammenwerth and de Keizer were able to report a major shift in evaluation research published in medical informatics journals with an increase in studies looking at the impact of ICT on quality of care processes or patient outcomes (Ammenwerth & de Keizer 2005).

The increasing number and variety of ICT evaluation studies is welcome and encouraging. But in and of themselves, they do not demonstrate that the challenges of ICT have been significantly overcome. If anything, this growing number of studies has helped to focus greater attention on the difficulty and complexity of the task. This is highlighted by an Agency for Healthcare Research and Quality (AHRQ) report in 2006 which assessed an extensive evidence base of literature regarding the benefits and costs of ICT in various healthcare settings. The report concluded that:
“HIT [Health Information Technology] has the potential to enable a dramatic transformation in the delivery of healthcare, making it safer, more effective, and more efficient. Some organizations have already realized major gains through the implementation of multifunctional, interoperable HIT systems built around an EHR [Electronic Health Record]. However, widespread implementation of HIT has been limited by a lack of generalizable knowledge about what types of HIT and implementation methods will improve care and manage costs for specific health organizations. The reporting of HIT development and implementation requires fuller descriptions of both the intervention and the organizational/economic environment in which it is implemented (pages v-vi) (Shekelle et al. 2006).

The AHRQ report identified 70 studies that were developed within the same six institutions (usually with the enthusiastic involvement of technology champions) (Shekelle et al. 2006). These systems functioned well, within the confines of the working environment and culture of their respective institutions. Although this provided valuable evidence of the potential of ICT systems, it does place a major question mark over the transferability of their findings to other hospitals and settings.

1.4 Computerised Provider Order Entry systems

CPOE systems are currently being implemented in healthcare systems across Australia, Europe and the US (NSW Government Action Plan for Health; The Leapfrog Group for Patient Safety; Kohn et al.; Victorian Government Department of Human Resources; Humber 2004; Oacis programme 2005; Park et al. 2005). These systems allow clinicians to place orders directly into computers linked to databases containing patient-
specific clinical information and error-prevention software (Birkmeyer et al. 2002). CPOE incorporates a wide spectrum of computerised systems including laboratory and imaging investigation, clinical procedure and consultation ordering, electronic medication management with decision support, and clinical documentation systems (Handler et al. 2004). Viewed as an essential component for the electronic medical record (Hwang et al. 2002), they have been promoted for their potential to improve the quality of health and patient outcomes (Sittig & Stead 1994; Doolan & Bates 2002) along with greater efficiency of healthcare delivery (Mekhjian et al. 2002). Many of the initial studies of CPOE have focused on its ability to act as a tool to reduce medication errors in hospitalised patients (Birkmeyer et al. 2002). This evidence has been used by the Leapfrog Group (The Leapfrog Group for Patient Safety) (a consortium of private and public purchasers in the US) to advance the adoption of CPOE. According to their estimates, CPOE could prevent 500,000 serious medication errors if it was implemented across the US (Birkmeyer et al. 2002).

Despite the enormous support for CPOE systems, their implementation has been slow (Berner et al. 2005), with one US survey in 2002 estimating that it had approximately 10% market penetration (Ash et al. 2004). In the past six years a series of highly publicised failures and problems related to the implementation of CPOE have contributed to the diminution of initial enthusiasm. The decision of the Cedars-Sinai Health System in Los Angeles to remove its CPOE system in response to unanimous protest from its medical staff in 2003 (Berger 2004), led to renewed attention to the need to closely monitor the implementation process. In 2005 Koppel et al. found that a widely-used CPOE system facilitated 22 types of medication error risks including such things as fragmented displays that prevent a coherent view of patients’ medications and
inflexible ordering formats that generated wrong orders. The authors suggested that previous studies had focused on CPOE’s role in error reduction to the detriment of an examination of their role in error facilitation (Koppel et al. 2005). This work has been built upon by Campbell et al., who developed a categorisation scheme for 79 unintended consequences initially identified, which they then extended to 245 additional adverse consequences that were identified from their fieldwork (Campbell et al. 2006). The authors drew attention to the need for system developers and implementers to evaluate carefully these adverse consequences as a means to manage implementation and maintenance of CPOE projects (Campbell et al. 2006).

In 2005 a paper published in the US journal *Pediatrics* by Han et al. found an unexpected increase in mortality coincident with CPOE implementation (Han et al. 2005). The authors noted several limitations to their study, particularly the research design’s inability to lead to statements of cause and effect. The authors urged caution regarding the conclusions drawn from the study and observed that:

> “CPOE technology is still evolving and requires ongoing assessment of ‘systems integration’ and ‘human-machine interface’ effects, both predictable and unpredictable, on patient care and clinical outcomes” (page 1512) (Han et al. 2005).

Research evidence about the consequences and outcomes of CPOE continues to mount, enriched by attention to the various side effects and consequences of system implementation. However, the attention of the literature has tended to focus on high-impact and well-publicised issues like medication errors. This is often to the detriment
of other areas such as pathology laboratories and medical imaging, which together make up the great bulk of orders handled by the hospital and which are likely to be substantially affected by CPOE systems (Abelson et al. 2001; Georgiou et al. 2007).

1.5 The role of pathology laboratory services

Pathology can be described as the branch of medicine that deals with the nature, causes and processes of disease (McGrath 2003). Along with anatomy and physiology, it forms one of the basic disciplines of medicine (Deeble & Lewis-Hughes 1991). The Royal College of Pathologists of London describes pathology as the “hidden science that saves lives” (The Royal College of Pathologists 2000). Pathology permeates all branches of medicine helping physicians make decisions, usually behind the scenes, of everyday healthcare delivery (The Royal College of Pathologists 2000).

A pathology laboratory service includes many specialised departments containing highly trained teams of professional pathologists, laboratory scientists, technicians, computer staff, along with blood collectors, specimen reception staff, couriers and administration staff (Australian Institute of Medical Scientists 2005). Pathology laboratory services can also be distinguished by broad procedures usually divided up into separate departments (Deeble & Lewis-Hughes 1991; The Royal College of Pathologists 2000; Australian Institute of Medical Scientists 2005) including:

- Haematology, which assesses the number and function of various components in the blood. Haematology departments are involved in the study of blood, its cellular elements along with blood diseases and blood forming tissues;
• Blood Bank, which determines blood groups and tests for the presence of antibodies as a part of a patient’s screen, or in patients about to undergo surgical procedures which may require blood transfusions;

• Clinical Chemistry and Biochemistry, which measures levels of specific components of body fluids to assess the functioning of different body organs. Clinical Chemistry and Biochemistry analyse samples for their chemical, biochemical and hormonal components;

• Microbiology and Virology, which deal with the growth, isolation and identification of micro-organisms such as bacteria, fungi and viruses in body fluids, secretions and tissues;

• Anatomical pathology, which involves the investigation and reporting of tissue pathology, provision of autopsy services and cytological examination.

1.6 Pathology departments and health informatics

One of the defining characteristics of pathology is its contribution to the well-being of patients (Deeble & Lewis-Hughes 1991). Pathology laboratories consider clinical and pathologic data and integrate them within an ever-changing pathologic context and then transmit a meaningful answer back to the physicians and patient. In doing so pathology laboratories are not only dependent on IT systems to manage information (Pantanowitz et al. 2007) but also to translate data into clinically meaningful information (Hardwick 1998). According to Hardwick, clinical laboratories are often the “court of last resort” for diagnostic and prognostic information (Hardwick 1998).
Yet, despite the essential contribution to the effective prevention, detection and management of disease, pathology services are still widely perceived as a backroom function (Review of NHS Pathology Services in England 2006), with many people unaware of their vital, ongoing importance. There are many signs that this situation is changing, particularly with the emphasis on the role of pathology services in patient pathways, beginning with the selection of the most appropriate test or investigation, and proceeding to the interpretation and provision of clinical advice across clinical specialties (Review of NHS Pathology Services in England 2006).

Information Communication Technologies (ICT) have an important part to play in extending the role of pathology services beyond the basic request and reporting cycle. Pathology services are information-intense bodies (Connelly 1997). It is estimated that 70% of all the important decisions affecting a patient’s life involve a laboratory or pathology test, and pathology data represent an average of 70% of documents residing in electronic repositories (Becich 2000). This contribution illustrates the critical role that pathology information has in any consideration of cost effectiveness, patient outcomes and evidence-based medicine pursuits (McQueen 2001). It is not surprising therefore that computer systems have been used in clinical laboratories more widely than in any other area of medical practice (Paplanus 1985; Kaplan 1987) as part of core pathology laboratory functions reliant on the efficient management of information for patient care purposes (Travers 1997). In this sense, it is quite reasonable to view the clinical laboratory as not just an early adopter but a key exemplar of automation needs across the hospital (Lincoln & Korpman 1980).
Pathology departments are facing major challenges from new ICT developments and the advent of managed care approaches to healthcare delivery. Many healthcare experts, researchers, and leading laboratory scientists suggest the need for far-reaching changes in the way that pathology departments view their role and function (Vining & Braithwaite 1993). Some have pointed to these developments as evidence of a sea change away from the ancillary role of clinical laboratories in the past toward a more pro-active role in the improvement of patient outcomes (Plebani 1999; Plebani 2002). The *American Journal of Clinical Pathology* informatics supplement in 1996 asserted that pathology is at a crossroads: the choice is whether or not to accept an expanding role for pathology laboratories as recognised managers within integrated delivery systems of the pathology database (Friedman 1996). It is for this reason that many leading pathology commentators have advocated the innovative use of informatics as the means to creating a new alliance between clinicians and laboratory scientists to address patients’ real needs and improve medical outcomes (Plebani 1999).

The implementation of CPOE systems, with their enhanced information management and decision-support structures, provides the potential foundation for this “new alliance” that can transform the role pathology services play in the patient pathway (Mekhjian et al. 2002). The planning and implementation of CPOE systems needs to take into account how the technology will both affect and be affected by the organisation in which it is being installed (Wears & Berg 2005). This is important in pathology departments, which are made up of a diverse range of services, each with their own unique tasks and requirements (Review of NHS Pathology Services in England 2006). Yet there has been little investigation about the challenges that CPOE implementation poses to pathology services.
1.7 Aim of thesis

This thesis will draw upon organisational communication approaches as a means of exploring how the context of the organisation influences communication processes (Miller 2005). The advent of CPOE systems, together with their capacity to dramatically improve the quality and efficiency of information, is expected to have a major influence on the pathology process. Up to this point only a limited amount of research attention has focused on the impact of CPOE on pathology services, and even less consideration given to understanding the specific (sometime unique) organisational requirements of different pathology departments. This implies that the mechanisms that influence success or failure are not clearly understood or acted upon. ICT developments like CPOE provide major challenges to the way pathology laboratories function, relate and communicate (Barley 1986; Barley 1990; Aydin & Rice 1992). Identifying and understanding the mechanisms that impact on the success of these systems will help to maximise the effectiveness and value of these systems.

This thesis aims to investigate the organisational and communication implications of CPOE systems for pathology laboratories, their work processes and relationships with other hospital departments, using comparative examinations to identify the tasks they are involved in and the particular needs the laboratories expect to be filled by the new system. This study draws on lessons and evidence of previous research (qualitative and quantitative) and involves a multi-method assessment of the impact of these systems on pathology laboratory performance, an examination of their organisational dynamics and their contribution to the delivery of patient care. The study will also adopt a theory-driven approach as a means of guiding the research process and for comprehending the
importance of the findings. In this way the thesis aims to enhance the theoretical and empirical understanding of the topic and contribute to existing knowledge in this important area.

The thesis is structured in a logical framework which proceeds by chapter in the following way:

Chapter 2 presents a synthesis of the existing quantitative and qualitative evidence of CPOE systems and their organisational and communication implications for hospital pathology services. The chapter describes the major gaps in the knowledge base on this subject and outlines how this thesis aims to address these gaps.

Chapter 3 outlines the realist evaluation and multi-method approach adopted by the thesis. The chapter discusses existing approaches to the evaluation of health IT and the conceptual challenges involved, along with how it intends to deal with them.

Chapter 4 addresses the methodological approach adopted by the thesis. It describes the settings involved in the research along with the multiple research methods used for each of the chapters. The chapter also addresses key issues of validity, reliability and generalisability and how the study intends to address them.

Chapter 5 reports on the findings of the preliminary research stage of the study. The chapter identifies a set of emergent issues which affect the organisational communication functioning of the laboratory settings and develops these into an initial
theoretical framework which will shape and be shaped by the proceeding research findings.

Chapter 6 investigates the organisational and performance dynamics of the Central Specimen Reception (CSR) department, how its communication environment was affected by the altered circumstances brought about by the new CPOE system and how it dealt with the changes.

Chapter 7 compares the Clinical Chemistry and Haematology departments with particular reference to how the departments went about planning and controlling important processing tasks like add-ons and tracking in the face of changes brought about by the introduction of CPOE.

Chapter 8 continues the comparison between Clinical Chemistry and Haematology but this time investigates the temporal landscape of the departments with particular regard to the effect that the introduction of CPOE has on the synchronisation, scheduling and allocation of tasks.

Chapter 9 focuses on the Microbiology department to investigate the importance of hand-written clinical notes supplied by physicians to the processing of tests and to evaluate the implications of CPOE for this information exchange.

Chapter 10 uses the organisational communication framework, developed and refined in the preceding chapters, as a lens with which to investigate the impact of CPOE on the Blood Bank department.
Chapter 11 moves away from pathology laboratories to look at the effect of CPOE on the work and communication practices of the Emergency Department. This chapter provides a valuable case study with which to compare, contrast and test the findings from the previous chapters and the organisational and communication framework.

Chapter 12 will address the significance and meaning of the findings, their relationship to the aim of the research and the research questions that guided the study. The chapter will also evaluate the contribution of the realist and multi-method evaluation approach and the impact of the organisational communication framework to the development of the theoretical understanding of CPOE design.

Chapter 13 concludes the thesis with an appraisal of the implications of this research for the implementation of CPOE systems in hospitals, their impact on pathology departments and other hospital settings, and the contribution they can make to the improvement of patient care.
Chapter 2  Literature review
2.1 Introduction

The introductory chapter outlined the key contextual and background components of this study. It drew attention to the broad challenges confronting ICT in the healthcare system and identified how many of these issues are presently being faced by hospitals in the throes of implementing CPOE systems. The chapter also identified the contribution that pathology services make to the delivery of patient care, and highlighted the challenges (to work and organisational relationships) they face with the introduction of CPOE systems. This chapter aims to draw together what is already known about the impact of CPOE on pathology services. It will do this by reviewing and discussing the existing evidence in this area to identify the main factors provided by the evidence and highlight the deficiencies, drawing particular attention to areas of inconclusive and/or variable evidence.

CPOE systems can affect the clinical/pathology laboratory interface across a diverse range of areas, with significant benefits to the efficiency, effectiveness and quality of care. The pathology test process can be conceptualised in three stages (Georgiou et al. 2007) (see Figure 2.1) beginning with: 1) test ordering, which involves the physician or responsible clinician deciding to order a pathology test. It is followed by: 2) the test processing stage, which occurs within the pathology department. The process ends with: 3) application of pathology test results, which includes the actual delivery of results and subsequent actions that may impact on patient outcome. A further dimension of the process involves the flow of information across each of these stages. This is usually measured by turnaround time indicators that can be quantified using a range of measures including: a) laboratory turnaround times defined as time taken from...
receipt of a specimen in the laboratory to the time a test result is issued; and b) total
turnaround times defined either as the time a physician places an order or the time a
specimen is collected, to the time the test result has been issued or received by the
appropriate physician (Georgiou et al. 2007).

Figure 2.1: The pathology test order process

This chapter distinguishes between quantitative and qualitative studies. One section of
this chapter (see Section 2.2) centres on quantitative research and evaluation papers
relevant to the pathology ordering process that used experimental or quasi-experimental
study designs. It includes a summary of the measures of process and outcome that were
used, along with a description of their relationship to the pathology test ordering
process. A later section (see Section 2.4) of the chapter provides a review of qualitative
studies of CPOE. Because qualitative studies have broader and more general aims,
often identified with questions about what, how and why something is happening, this
section includes studies that may not have been exclusively concerned with pathology
services, but are nevertheless relevant to the pathology ordering process. Both the
quantitative and qualitative sections contain a description of the gaps in the literature
followed by an outline of the key research questions that this thesis will answer.
2.2 The impact of CPOE on pathology services – a synthesis of the experimental and quasi-experimental evidence

A systematic review undertaken by Georgiou et al. (Georgiou et al. 2007) reported on 19 evaluation studies of computerised pathology order entry systems published between January 1990 and August 2004 that used experimental or quasi-experimental studies including before and after and time series studies. The review identified 10 domains where CPOE systems have impacted on the test order process (see Table 2.1). These domains are associated with an array of measures that have been used to measure and monitor CPOE impact. For instance, the domain “Test volumes” can be assessed for a specified period of time by measuring the number of tests per patient per day, per physician, or by using patients grouped into Diagnosis Related Groups. The domain “Patient safety” may include a diverse range of measures including mortality rate, readmission rate or number of adverse events associated with the laboratory test process. The review found 39 indicators (applied by previous researchers in this area) that spanned all three stages of the process (Georgiou et al. 2007).

<table>
<thead>
<tr>
<th>Stage of pathology test ordering process</th>
<th>Domains of impact</th>
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<td>Physician decision to order</td>
<td>Test volumes</td>
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<td>Test costs</td>
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<td>Redundant test rates</td>
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<td>Work practices</td>
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<td>Test processing within the laboratory</td>
<td>Physician-laboratory communication</td>
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<td>Application of test results</td>
<td>Patient management</td>
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<td>Patient safety</td>
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<td>Time across previous stages</td>
<td>Turnaround times</td>
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Table 2.1: Domains of impact used to evaluate pathology CPOE systems (Georgiou et al. 2007)
Taken together these 10 domains provide a valuable framework to assess the impact of CPOE on the efficiency (value and efficacy of services in terms of cost, time and practice standards) (Scriven 1991; Potter 2000), effectiveness (the best possible outcome) (Potter 2000) and quality (ensuring that the right thing is done well) (Brook & Kosecoff 1988; Donabedian 1988) of pathology services. Figure 2.2 is a diagrammatic depiction of this framework. It identifies the interconnection of the various domains and their relationship to concepts of efficiency, effectiveness or quality (Georgiou et al. 2008).

Figure 2.2: Framework for assessing the impact of CPOE on pathology services

**Efficiency**

The most frequently used indicator of efficiency of the pathology test ordering process is turnaround time (Manor 1999). Clinical satisfaction with pathology services is often related to the timeliness of test results, because of their effect on treatment particularly in critical care settings (Howanitz & Howanitz 2001). Turnaround time can be defined using a variety of time points, including the times of requesting, collection, laboratory receipt, laboratory registration, laboratory reporting and clinician review.
There have been various studies that have measured the impact of CPOE on turnaround times. These include a study of laboratory turnaround time (from receipt in laboratory to time of dispatch of result) in an intensive care setting by Mekhjian et al. (Mekhjian et al. 2002) and total turnaround time (measuring time from request to the issue of a result) for tests in intensive care wards by Thompson et al. (Thompson et al. 2004), the emergency department (Guss et al. 2008) and surgical wards by Ostbye et al. (Ostbye et al. 1997). Each of these studies revealed turnaround time improvements after the introduction of a new CPOE system. Research undertaken by Westbrook et al. looked at data for 11 wards in a major Australian teaching hospital during a two-month period before and after system implementation (Westbrook et al. 2006). The study found a significant decrease in the mean laboratory turnaround time per test assay from 73.8 to 58.3 minutes with significant decreases in turnaround times for prioritised and non-prioritised tests as well as for tests performed during and outside business hours (Westbrook et al. 2006). A follow-up study two years after the implementation of CPOE found that significant improvements had been sustained with an average overall reduction of 12.6% (Westbrook et al. 2008).

While this evidence shows that CPOE can provide faster results to clinicians, a 1998 before and after study in the US compared the time physicians spent ordering in the three months before implementation of CPOE with a two-month period six months after implementation. The time spent writing orders rose significantly from 2.1% to 9.0% along with the time spent using the computer. The authors showed that some of this time may be recovered in other areas, for example less time taken to pre-schedule future tests or in travelling to patient locations (Shu et al. 2001). Ostbye et al. looked at telephone activity between the laboratory and a ward after CPOE implementation and
found no clear change in the number of calls from the ward, but a decrease in the number of calls from the laboratory to the ward after the system had stabilised (Ostbye et al. 1997). The statistical significance of these findings was not reported.

**Effectiveness**

Many CPOE studies involving pathology laboratories have concentrated on the impact on test volumes using a variety of measures including the number of tests ordered per patient, per admission or per physician. The results from these studies have been mixed. Most have reported an overall reduction of test volumes with CPOE (Mutimer et al. 1992; Tierney et al. 1993; Nightingale et al. 1994; Smith & McNeely 1999; Hwang et al. 2002; Neilson et al. 2004) although some (including two Australian studies by Westbrook et al.) reported no change (Westbrook et al. 2006; Westbrook et al. 2008). The exception was one US study which reported major increases of up to 50% in the average number of laboratory orders per patient after the introduction of CPOE (Kamal et al. 2002). However, this study did not provide a statistical measure of the significance of this result.

Redundant test rates (defined as unnecessary diagnostic tests) (Werner 1995) are often seen as a modifiable component of laboratory utilisation, (Isouard 1998; Bates et al. 1999; Isouard 1999) and as an important area for potential improvement using CPOE (van Walraven & Raymond 2003). One study by Bates et al. showed that CPOE led to a reduction in the redundant test rate (Bates et al. 1999), while Neilson et al. reported improvements in test ordering behaviour using CPOE reminders complemented by peer management (Neilson et al. 2004).
Other research has shown improvements in test order effectiveness drawing on the ability of CPOE decision-support mechanisms to bring about improved compliance with guideline advice (Smith & McNeely 1999), or order appropriateness (Nightingale et al. 1994). Fernandez Perez et al. reported on significantly reduced red blood cell transfusion rates and decreased transfusion costs from an intensive care unit using a CPOE decision support system (Fernandez Perez et al. 2007). Westbrook et al. showed that structured order screens and the manipulation of order sets enhanced the data provided to laboratories and the corresponding quality of test result information reported back to physicians, with potential benefits for patient care. The authors reported a significant improvement in the proportions of gentamicin and vancomycin specimens identified as peak or trough following system implementation. The previous paper-based order form resulted in many of these specimens being labelled as random because of insufficient information, thereby reducing the value of the results for patient care (Westbrook et al. 2006). A controlled before and after study using routinely collected data by Collin et al. found that CPOE was associated with a reduction in the proportion of outpatient appointments which ordered full blood counts, urea, and electrolytes and urine culture tests (Collin et al. 2008).

**Quality of care**

Research studies about the impact of CPOE on the quality of patient care have been less numerous. Indicators of the quality of patient care are difficult to quantify and require large sample sizes to detect significant differences (Georgiou et al. 2007). Moreover,
studies that look at indicators such as mortality rates and patient length of stay are prone to the effect of confounders, which can be difficult to control.

There are some studies that have examined the impact of CPOE on time to treatment and diagnosis (Kuperman et al. 1999; Smith & McNeely 1999) drawing attention to the interface between the time pathology laboratories issue reports and the accessibility and response to these results by physicians. Smith et al. measured the impact of a computerised decision support Laboratory Advisory System on the time taken to reach a diagnosis. They found that the time taken was one day for physicians that used the system and 3.2 days for those that did not (Smith & McNeely 1999). Kuperman et al. compared a computer system that automatically notified the responsible physician of a crucial condition via the hospital’s paging system. The authors reported a significant 38% shorter median time interval (1 hour v 1.6 hours) until an appropriate treatment was ordered when the automatic alerting system was used compared to when it was not used (Kuperman et al. 1999). A British study by Kilpatrick et al. investigated the impact of ward computers allowing access to laboratory results. It found large proportions (45% for accident and emergency and 29% for inpatient wards) of urgent laboratory test results were never accessed. Of those results never accessed, 3% were judged to require an immediate change of patient management (Kilpatrick & Holding 2001).

2.3 The gaps in the experimental and quasi-experimental literature

Overall, the research evidence using experimental or quasi-experimental studies of the impact of CPOE systems on pathology services is limited. It is concentrated in the US
and often based on the results of studies conducted from the same hospital as in the case of Brigham and Women’s Hospital in the US, which featured in four empirical studies, some 20% of those in this field (Georgiou et al. 2007). The potential problem with this is that evidence produced at one site may not be generalisable to others hospitals of different size, make up or history (Georgiou et al. 2007). Four of the major studies (Tierney et al. 1990; Mutimer et al. 1992; Tierney et al. 1993; Nightingale et al. 1994) on this topic are now over a decade old, and many are the product of pioneering studies using home-grown systems (Georgiou et al. 2007). This research may have played a major role in highlighting the enormous potential of order entry systems in the past, but today it is the “off the shelf” commercial systems which hospitals are more likely to encounter (Ash et al. 2003) and which have important implications for hospital work processes and relationships (Davidson & Chismar 1999).

Taken together, the indicators identified above provide an important framework for measuring the impact of CPOE. A limitation of previous studies has been that indicators are measured and studied in isolation, often disconnected from their interaction with each other (Georgiou & Westbrook 2006). For instance, the evidence about efficiency presented above shows that the savings brought about by CPOE in test turnaround time may compensate for the extra time it takes health professionals to enter test orders. This makes it important to maintain a holistic overview of the indicator measurements, understanding that the net effect of any particular implementation will be made up of a balance of positives and negatives, successes and failures (Pawson 2004).
It is also noticeable that the research in this area has concentrated on areas related to the health professional’s decision to order (test volumes, costs and compliance with guidelines) and the application of results (patient management, patient safety). There is a paucity of studies that have sought to quantify the impact of CPOE on work practices within the test processing stage (see Figure 2.1) of the pathology department (Georgiou et al. 2007). Generally, the literature on this topic shows scant regard to the inner workings of the pathology department. The literature indicates that pathology laboratories are more likely to be treated as a singular entity – “the department” – with little attention to the range of existing pathology laboratories, variation in their roles and the test processes they are involved in.

2.4 Research and evaluation studies using qualitative approaches

In 1994 Sittig included amongst his grand challenges for medical informatics, the need to “identify techniques to ease incorporation of information management technologies into the infrastructure of organizations” (page 413) (Sittig 1994). There is a growing field of research into CPOE systems incorporating organisational studies and qualitative approaches based on interviews, focus groups and observation. Some of the seminal work by Kaplan and Aydin in this area looked specifically at radiology and pathology laboratories to examine the potential of computer systems to act as catalysts for changing interactions within the hospital (Kaplan 1987; Aydin & Rice 1992; Aydin 1994). Their research was motivated by concern about the lack of attention to the ability of computer systems to affect the nature and definition of jobs and the work process (Aydin 1989; Barley & Kunda 2001).
There is now a greater perceived awareness about the nature and effect of organisational change (Aarts & Peel 1999). This is particularly relevant for CPOE when one considers that it is targeted for widespread application across a variety of settings and organisations with major implications for hospital-wide processes of order management, work organisation and departmental relationships (Sittig & Stead 1994; Ash et al. 2003; First Consulting Group 2003).

The conceptualisation of the order process

Pathology services are an integral part of clinical service delivery (The Royal College of Pathologists 2000). They consist of complex organisational structures with their own formalised rules, conventions and ways of working that have developed and evolved over time (Davidson & Chismar 1999). The changeover to physicians placing electronic orders represents a major structural change in work flows with major consequences for other hospital departments.

One of the underlying problems identified with CPOE systems is that they conceptualise the order process as essentially linear where physicians initiate orders which are then processed by nurses, pharmacists, pathology departments etc (Cheng et al. 2003). But the ordering process is far from linear; like patient care it is a product of collaboration across many professions. The source of clinical decisions may come from diverse influences and sources (Gorman et al. 2003). This potential discrepancy between the way CPOE conceptualises the ordering process, and the way it is carried out within hospitals, has prompted some to warn that CPOE implementation will have its ups and downs (Ash et al. 2005), and hospitals need to be prepared to expect the unexpected
(Dykstra 2002). This can include the appearance of unintended consequences which can have wide ranging effects on workload, avoidable error rates and communication channels across the hospital (Campbell et al. 2006). A usability evaluation which included a cognitive walk through of an emerging electronic laboratory order system in Holland by Peute and Jaspers, found 33 usability problems. The authors reported that 25 of these problems led to inefficient order behaviour, omissions and order errors (Peute & Jaspers 2007).

**Communication channels**

There is an underlying tension between the potential for computer systems to either decrease interpersonal interaction (eg, remote access to terminals may mean that clinicians spend less time with patients), or to promote integration with the ability to allow greater access to shared information (Aydin & Rice 1992). These tensions can lead to increased levels of task ambiguity, forcing staff to find new ways to incorporate changes into their daily work, possibly accompanied by either cooperation or conflict (Aydin & Rice 1992). In a case study using in-depth interviews at a private, urban acute care unit, Davidson et al. described how the structuring and formalisation of data and the need to integrate data with ancillary departments, created uncertainty about orders (Davidson & Chismar 1999). An Australian study based on focus groups and interviews carried out among physicians, nurses, managers and pathology staff regarding the impact of electronic ordering, found that while clinicians thought the CPOE system had improved levels of accountability and reliability, pathology scientists and managers felt that their previously existing work relationships and communication channels had been given inadequate attention (Georgiou et al. 2005). This situation has
the potential to cause major (possibly dysfunctional) shifts in relationships between departments and hospital staff (Ash et al. 2003; Ash & Bates 2005).

*Altered work practices*

A qualitative study carried out by Georgiou et al. looking at CPOE implementation at a major teaching hospital in Australia drew comparable conclusions to Davidson et al. The authors of the study described the initial confusion experienced by clinicians and laboratory scientists about where responsibility lay for the cancellation of unnecessary test orders (as in cases where a patient has been discharged or a test is no longer required) (Georgiou et al. 2007). Previously, when the laboratory carried out this function, it meant discarding the redundant hand written request. But with the new system a cancelled order needs to be performed electronically, otherwise it remains within the database listed as an unfulfilled (possibly pending) order. Clinicians and laboratory staff reported an initial period of task uncertainty about who actually performs this task. This uncertainty prompted the laboratories to establish a workaround procedure to check all outstanding orders and cancel them where necessary as a means of ensuring the integrity of their database. For the laboratories this was a way of compensating for the change in task responsibilities, even though it added to their workload (Georgiou et al. 2007). The authors reported on three distinct laboratory responses to these changes beginning with: a) efforts to increase clinical awareness; b) undertaking compensatory workarounds; and c) enforcing work practice and procedural rule changes (Georgiou et al. 2007).
Even routine test ordering processes can be disrupted by the new electronic system. For example, an add-on test refers to a situation where a clinician orders an additional test assay to be carried out on a specimen that has already been delivered to the laboratory. This used to be achieved by a phone call and a new hand-written request signed and faxed to the laboratories. However, with electronic ordering it was not immediately obvious how this procedure was to be carried out, or even if the new CPOE system is able to cope with the procedure. Georgiou et al. reported that the CPOE system did not have the capacity to distinguish add-on tests and created new test orders instead. This led to frustration in the laboratory because it was not clear if an order was for a new specimen or if it was meant to be an add-on to an existing specimen. Laboratory management responded by reinstating the pre-implementation status quo where physicians were required to phone and then fax signed hand-written requests for add-ons (Georgiou et al. 2007).

2.5 The gaps in the qualitative literature

The qualitative studies described above have been able to explore a range of issues and processes and have added new dimensions to the evaluation of CPOE systems. Many of their findings and conclusions are relevant and broadly applicable across hospital departments and hospital settings. But apart from some early pioneering studies (Kaplan 1987; Aydin 1994; Davidson & Chismar 1999) and some more recent studies (Georgiou et al. 2005; Georgiou et al. 2005; Georgiou et al. 2007; Peute & Jaspers 2007), assessments of the impact of CPOE on hospital ancillary settings like pathology laboratories using qualitative methods have been comparatively scarce. As in the review of experimental and quasi-experimental studies (see Section 2.2), the various
evaluation measures chosen have been dominated by a concentration on the physician’s
decision to order stage or test result application stage, instead of the in-laboratory test
processing stage (see Figure 2.1). The reasons for this are understandable – ultimately
the outcome of any CPOE intervention will be assessed in terms of its impact on the
delivery of patient care. But avoiding attention to the test processing stage runs the risk
of conflating the complex organisational structures and processes involved, missing
important details that can help to enhance the laboratory’s contribution to patient care.

The evaluation studies outlined above reveal a range of approaches that differ according
to the subject, target and purpose of the study, or even to the perspective and design and
methods employed (Ovretveit 2000). Obviously, the choice of evaluation approach will
be influenced by the question being asked. In the outline of efficiency and effectiveness
detailed earlier, the quantitative measures used are most suitable for establishing the
size, extent or duration of a certain phenomenon, generally to work out how much (if
any) of an effect was experienced (Stoop & Berg 2003). Qualitative research methods
including interviews, observations, user evaluations and document analysis, can help
not only to understand quantitative findings but also to comprehend what is happening
and why it is happening (Kaplan & Maxwell 1994). Whilst there are obvious
differences between the branches of research, the general absence of attempts to
synthesize quantitative and qualitative findings in this field is quite glaring. This is
despite the push from many health informatics researchers over the last decade for a
much broader view of ICT evaluation, one that is able to consider how technology is
 shaped by complex networks that combine technical and social elements (Stoop & Berg
2003; Aarts et al. 2004; Coiera 2004). This often involves using multi-method
approaches (Kaplan 1988; Stoop & Berg 2003; Westbrook et al. 2004; Georgiou et al.
2007; Westbrook et al. 2007) capable of taking into account the technical aspects of work together with the social, organisational, cultural and cognitive elements.

2.6 Research questions and aim

The foregoing review and discussion of the existing literature has highlighted several research problems and issues associated with the impact of CPOE on pathology laboratory services. There are major implications for the implementation of these systems and their consequences for work practices, organisational relationships and performance outcomes and patient care. To address these issues this thesis aims to investigate the organisational and communication implications of CPOE systems for pathology laboratories, their work processes and relationships with other hospital departments, using comparative examinations to identify the tasks they are involved in and the particular needs the laboratories expect to be filled by the new system. The study is a longitudinal one carried out over a three-year period during implementation of a CPOE system at a Sydney teaching hospital. It employs a multi-method approach that includes statistical analysis of relevant laboratory and hospital data alongside interpretive (Denzin 1978) and interactionist methods (Kaplan 1988) gathered from systematic observation of laboratory processes (Dingwall 1997) along with regular interviews/focus groups with key pathology laboratory-based and clinical informants. In accordance with its research aim, the study will answer the following research questions:

1. What is the impact of CPOE on key indicators of pathology laboratory performance (eg, test volumes, turnaround times)?
2. What is the effect of CPOE on the functioning and organisational dynamics of different departments of the pathology laboratory service?

3. What are the implications of CPOE on clinician/ward/laboratory relationships?

4. What are the implications of CPOE for the delivery of patient care?

5. What are the underlying mechanisms identified with the successful (or unsuccessful) functioning of CPOE systems within pathology services?
Chapter 3  Theoretical orientation
3.1 Introduction

In the opening chapter attention was drawn to the “evaluation imperative” (Rigby 2001) within health informatics. This imperative stems from the need to justify the huge ICT investments made in health, ensure the achievement of value for money, and the delivery of improved patient outcomes. In the last decade there has been a significant increase in the number of evaluation studies in health informatics (Ammenwerth & de Keizer 2005), a reflection of the increased priority given to ensuring safe and effective ICT design and implementation. These studies have broadened awareness of contrasting approaches to evaluation. They have also succeeded in identifying areas of ICT design and impact where greater research attention is required to aid decision-making and improve organisational development (Kaplan & Shaw 2004).

In a discussion of the practice of medical technology, Timmermans and Berg identify three distinct approaches – deterministic, social essentialist and technology-in-practice – to the design and implementation of technology in medicine (Timmermans & Berg 2003). According to the deterministic approach, technologies (such as ICT) are considered to have special effects that are connected to their inherent properties and design (Webster 2007). The deterministic approach grants very little attention to the context of technology use. Social essentialist approaches are sharply differentiated to deterministic approaches. Here, technology is perceived to be a blank slate which is interpreted and provided with meaning by agents (human beings). Technology-in-practice approaches on the other hand attempt to encompass the complex, open-ended and dynamic role of technology and its interplay with people, institutions and society (Webster 2007; Georgiou 2008). Whilst it is important to be mindful of the dangers of
oversimplifying broad and complicated approaches, the Timmermans and Berg categorisation is nevertheless a helpful way of introducing (and navigating around) the differences in attitudes and perspectives to ICT in healthcare.

The technology-in-practice approach is the one that most closely approximates the realist approach that will be used in this thesis. The strength of the realist approach lies in its ability to encompass contributions of each of the other approaches without compromising its own stated intentions. It occupies a middle ground, recognising both the fallibility of our knowledge of reality but also the importance and value of empirical experimentation (Bhaskar 1975; Danermark et al. 1997; Pawson & Tilley 1997; Van de Ven 2007). The realist approach can be identified by the following basic elements:

- There is a real world out there whose existence is not dependent on our knowledge of it. This real world is differentiated and stratified, made up of events, objects, material, and emergent products (Van de Ven 2007).
- Our knowledge of this world is theory-laden. The social sciences do not contain absolute, universal and error-free truths and laws (Sayer 2002).
- Our knowledge of complex reality demands the use of multiple perspectives. And robust knowledge is a product of theoretical and methodological triangulation (Van de Ven 2007).

This chapter aims to elaborate on these basic elements of realist evaluation in the context of a discussion of the relative strengths and weaknesses of major evaluation approaches within the health informatics field. The chapter will address what is meant by evaluation and describe the different ways of undertaking evaluation studies, and
how they have been utilised within health informatics generally, and more specifically in regards to CPOE. It will also discuss how realistic evaluation relates to socio-technical and multi-method approaches, in particular by dealing with the potential pitfalls of these approaches. It will conclude with an appraisal of the arguments both for and against theory-driven and realist evaluation approaches, along with an assessment of their potential contribution to building a solid evidence base for guiding the design and implementation of successful IT healthcare systems.

3.2 Evaluation methods and their use

Evaluation can be defined as the systematic determination of the quality, value, or importance of something (Scriven 1991). This can range from a program or product, to aspects or even components of the something in question (Davidson 2005). Evaluations are generally conducted either to identify areas for improvement or to provide an overall assessment (Davidson 2005). There are many study designs associated with different types of evaluation including before and after studies, retrospective or concurrent studies, audits or descriptive case studies (Ovretveit & Gustafson 2003). Within the health informatics discipline the dominant form of evaluation study has been quantitative (working with numbers and measurements) whereby elements of subjectivity are removed from consideration or attention (Moehr 2002; Mingers 2004) as opposed to qualitative (eg, working with text, focus groups, interviews etc) (Ammenwerth & de Keizer 2005). In their inventory of studies of information technology in healthcare for the years 1982-2002, Ammenwerth and de Keizer found that 83% (n=820) focused on quantitative methods and only 5% (n=44) on qualitative
methods, the rest (12%; n=119) used combinations of quantitative and qualitative (Ammenwerth & de Keizer 2005).

The Randomised Controlled Trial (RCT) is often referred to as the “gold standard,” or the best way of evaluating effectiveness and quality (Muir Gray 1997). RCTs focus on results and not just intentions or judgements (Stufflebeam 2001). They involve manipulating an intervention in a controlled setting with subjects randomly assigned to experimental and control groups (Chen 1990). RCTs are very highly regarded, so much so that within the research and evaluation literature the relative merits of other designs or methods are often judged by the degree to which they approximate an RCT (Chen 1990).

Evaluation studies can also be characterised depending on the nature of the study target or through the approach adopted. One of the most basic distinctions is between summative and formative evaluations (Scriven 1991; Stufflebeam 2001). A summative evaluation is conducted after completion of the program (ie, system implementation) (Scriven 1991). This type of evaluation seeks to make a determination about the overall quality or value of the evaluation program or intervention. It has been the one most often adopted for health information systems (Van Der Meijden et al. 2003). In contrast, a formative evaluation is conducted during the development of a program or product (Scriven 1991) to provide information on the processes involved, often as a way of influencing or assisting the intervention (Westbrook & Gosling 2002; Stoop et al. 2004).
It is also possible to categorise evaluations by the different factors under consideration. These can be categorised as dimensional, component-based or holistic. Evaluations which analyse the quality or value of different dimensions of the intervention may consider such aspects as the system’s reliability, ease of use or even its safety aspects. In contrast a component evaluation will look at the functioning of various instruments associated with the system such as keyboards, monitors, laptops or PDAs (Personal Digital Assistants). A third type of evaluation, termed holistic, seeks to study the subject from a number of different vantage points as a whole package and not through its separate dimensions or components. A holistic evaluation may be more appropriate when the quality or value of an intervention is experienced as an entire package, and it is not possible (or economical) to identify the separate parts (Davidson 2005). For instance, the impact of CPOE systems on patients in hospitals may be considered for their holistic impact on the process of patient care rather than in specific dimensional or component measurements.

### 3.3 Conceptual issues and controversies within evaluation studies

In a review of clinical decision support systems (a key part of CPOE systems) Kaplan found that most studies used either experimental or RCT designs to assess system and clinical performance (Kaplan 2001). Kaplan reviewed 27 studies (reported in 35 papers). She noted the limited methodological diversity with only six multi-method papers and three papers that used qualitative methods. The review also found few of the studies used a naturalistic design with real patients and there was little theoretical discussion of the issues and problems involved with clinical support systems (Kaplan 2001). Kaplan concluded that while RCT-type studies were valuable for measuring the
impact of a pre-specified effect, they explained little about the acceptability of clinical decision support systems and did not provide knowledge about why the system may be useful in one setting but not in another (Kaplan 2001).

It has often been noted that most evaluation studies within health informatics have focused on the function of the technology with scant regard to the organisational and contextual factors involved in the design, implementation and operation of ICT (Aydin & Rice 1992; Lorenzi & Riley 1995; Kaplan 2001; Snyder et al. 2006). Such studies often regard technology in a deterministic way – an objective and external force shaping human action, in which the optimisation of the technological artefact is the primary solution (Wears & Berg 2005). Comparatively less attention has been given to how human action may shape technology (Jones et al. 2004).

In 2006 a systematic review of health information technology on the quality, efficiency and costs of medical care carried out by Chaudry et al., reported on 257 studies, most of which addressed decision support systems or electronic health records. They found that 25% of the studies were from four academic institutions that implemented internally developed systems and only nine studies evaluated commercially developed systems. In one of their conclusions the authors remarked that the limited quantitative and qualitative description of the context of implementation process hindered informed decision making in this field (Chaudry et al. 2006). These results are mirrored by the systematic review of CPOE systems in pathology by Georgiou et al. discussed in Chapter 2, which showed that most studies of CPOE in pathology are concentrated in a few hospitals in the US, many with home-grown systems developed some time ago (Georgiou et al. 2007). There is also a paucity of research about organisational
questions, particularly those related to the inner workings and dynamics of the pathology department. This is a problem that is echoed in Kaplan’s and Shaw’s call for more attention to comparative and cross-cultural studies which can provide new insights about the impact of ICT on work and organisation (Kaplan & Shaw 2004).

Chaudry et al. drew particular attention to the difficulty in delivering research findings that are generalisable and transferable beyond the original study site (Chaudhry et al. 2006). Indeed one of the often stated weaknesses of quantitative approaches is that they encourage narrow evaluation perspectives, sometimes centring on just one aspect of the new system (eg, cost benefit) to the detriment of others (eg, risk and opportunity). This means that they are in danger of overlooking the broader hospital-wide objectives which the systems may affect, sometimes in unintended ways (Ash et al. 2004). Health information systems are no longer limited to one department but are now more likely to be integrated across departments and between organisations (Stockdale & Standing 2006). This means that the success or otherwise of a new CPOE system is often contingent on a number of contextual factors that cannot be easily controlled using quantitative evaluation designs and analytical techniques (Stoop & Berg 2003; Snyder et al. 2006).

These shortfalls of quantitative research have been the subject of rigorous and intense discussion within evaluation literature sources over a number of years. One of the most influential of these criticisms is presented by Cronbach who argues that experimental evaluations concentrate on achieving “internal validity” requiring the experimenter to show that the intervention (and only the intervention) led to the reported effect (Cronbach 1983; Pawson & Tilley 1997; Stufflebeam 2001). However, this is not an
easy thing to achieve, particularly as in hospital environments it is difficult (and
sometimes virtually impossible) to distinguish the “effect” caused by the system and the
“effects” caused by numerous other factors (Stoop et al. 2004). And even if the
researcher does succeed in isolating and controlling for the effect, it is not always what
is needed. According to Cronbach, the evaluation audience (say a hospital management
team preparing for implementation of CPOE) wants to know a lot more than whether or
not a program was properly controlled. They need to know will it work for them (in
their hospital). A concentration on “external validity” asks to what other groups,
settings and variables can the effect of the intervention be applied (Chen 1990).

Summative evaluation studies which gather evidence to test a causal hypothesis or
measure the attainment of specified goals, such as the time it takes to get a result from a
pathology department using CPOE, run the risk of being insensitive to other impacts of
the system, particularly any unintended impacts (Chen 1990). The potential for
unintended impacts (Ash et al. 2004; Koppel et al. 2005) on work organisation and
processes has been a major concern for CPOE planners over the last few years, leading
one researcher to advise implementers to “plan to be surprised” (Dykstra 2002).
Summative evaluations often assume a stable environment and do not work as well
when things are unstable and changing rapidly (Kaplan & Shaw 2004).

Chen, who is a leading contributor to the discussion, attempts to advance the issue
beyond the simple (and tribal) quantitative/qualitative divide. Chen argues that the
problem is more about the over-reliance of evaluation studies on a simple input/output
or black box type of evaluation (Chen 1990). This type of evaluation may provide a
valuable overall assessment about whether or not the program works, but fails to
identify the underlying causal mechanisms that generate effects, or any deficiencies of the program for future program improvement or development (Chen 1990). Chen provides an interesting medical example to amplify the point:

“As if a black box evaluation shows a new drug to be capable of curing a disease without providing information on the underlying mechanisms of that cure, physicians will have difficulty in prescribing the new drug because the conditions under which the drug will work and the likelihood of negative side effects will not be known” (page 18) (Chen 1990).

These black box approaches are usually characterised by their overarching adherence to a step-by-step cookbook method of doing evaluation applied uniformly to various programs without any concern for program content, setting, participants etc (Chen 1990). Chen’s criticisms echo some of the conclusions of the Chaudhry et al. systematic review of ICT system research, in particular the concern about the inability to identify deficiencies that can help develop and improve programs in other settings (Chaudhry et al. 2006). This line of argument has been developed by others, in particular Pawson and Tilley who, in their outline of realist evaluation approaches, strongly advise against basing evaluation on the question of whether or not programs work. For them, it is not programs in and of themselves that work, but the resources they offer to enable their subjects to make them work (Pawson 2004).
3.4 Socio-technical and multi-method approaches to health informatics

As was noted in Chapter 2, there has been a significant rise in the number of qualitative studies over the last decade. Many of these studies challenged some of the underlying assumptions of CPOE implementation drawing attention to the system’s “intrusiveness”, its effect on clinical work processes (Massaro 1993) and to “unforeseen consequences” often associated with its implementation (Dykstra 2002; Embi et al. 2004). These studies highlighted the interpretive, collaborative and reactive component of patient care processes, in contrast to the more rationalised and linear approaches that Wears and Berg suggest has tended to dominate the design and implementation of CPOE systems (Wears & Berg 2005). These studies also questioned the assumption that orders originate solely with a physician and are processed in clear sequential patterns (Gorman et al. 2003). Instead they highlight the complex and interdisciplinary inputs, diverse influences and individuals involved (Cheng et al. 2003). According to Wears et al., there is an underlying fallacy of linear models of healthcare organisations, which in reality are complex and tense social webs of alternately competing and cooperating groups (Wears & Cook 2005). Such considerations have prompted others to investigate how CPOE systems impact upon relationships within and between departments and professions (Aydin & Rice 1992; Davidson & Chismar 1999).

This increase in the number of qualitative studies of health information systems has gone hand-in-hand with an interest in a socio-technical approach to evaluation and research. This approach views social aspects (culture, values and politics) and technical elements (equipment, procedures and technology) as interdependent and interrelated (Coiera 2004; Whetton 2005). It is complemented by widespread interest in multi-
method approaches (Kaplan 1988; Stoop & Berg 2003; Currie 2005; Westbrook et al. 2007) that seek to combine aspects of both quantitative and qualitative evaluation as a way of resolving the longstanding debate about their respective value (Stufflebeam 2001). According to Stoop and Berg, the combination of methods provides evaluators with the ability to address the *what, why* and *how* questions that qualitative studies can provide, with the *size, extent* or *duration (how much)* questions provided by quantitative studies. Multi-method approaches would also seem to accord with Scriven’s description of evaluation as a “transdiscipline” that encompasses many disciplines and uses a specialised set of multidisciplinary tools for a wide range of applications (Scriven 2001; Stevenson & Thomas 2006).

There are, nevertheless, a number of problems and unresolved issues associated with socio-technical and multi-method approaches to evaluation. The term “socio-technical” was coined by the Tavistock Institute of Human Relations in Britain in the 1950s and sought to overcome technological determinism in organisation theory in favour of the need for consultation, innovation and flexibility in the design of work processes (Morgan 1986; Calhoun 2002; Westbrook et al. 2007). But understanding the interdependency of the social and the technical (Berg 1999) does not automatically solve the difficult task of reconciling the social, economic and technical aspects – a problem the Tavistock studies were criticised for underestimating (Calhoun 2002).

This is an issue alluded to recently in a paper by Coiera where he contends that socio-technical approaches should be more than a means of critiquing current practices and health information systems. Coiera expresses concern about an apparent imbalance in
the literature, and suggests that the time has come to put the technical back into socio-technical systems (STS) analysis:

“STS analysis can at its most extreme become a form of socio-ludditism, an anti-technology belief that because technology in human hands under-performs or misbehaves, it must be bad. Where once users were to blame when technology was not used the way it was designed, it now sometimes seems that technologists are to blame for not designing for all the ways in which their systems are misused” (page S99) (Coiera 2007).

On the face of it, the boundaries between what constitutes a social factor and what is technical may seem easy enough to decipher, but in reality the interconnections and relationships between the two are often disordered and complex. Within health informatics this apparent messiness lends itself to divergent opinions and approaches varying from the functionalist view that stresses the preponderance of the material artefact (eg, CPOE system) and views human agents as relatively passive players (Jones et al. 2004), to interpretivist approaches which sees our knowledge of reality as a social construction by human agents (Walsham 1993). Aarts and Gorman suggest that there is really no such thing as “the” socio-technical approach. They argue that different research traditions have different ways of looking at things, which together can provide complementary perspectives on the role of information technologies (Aarts & Gorman 2007).

There are also major difficulties with associated multi-method approaches that are meant to realise socio-technical evaluation goals. They sometimes have to contend with
stubborn obstacles that are part of an almost tribe-like mindset among advocates of contending methodologies. The use of multi-methods can produce confusing and possibly conflicting findings particularly as quantitative and qualitative methods are derived from different theoretical approaches to evaluation, reflecting different conceptions of what knowledge is and how it is generated (Chen 1990; Stufflebeam 2001; Kaplan & Shaw 2004). Different evaluation approaches contain philosophic differences (with major consequences about how knowledge is conceived and understood) that cannot be dismissed as a simple methodological divergence (Clarke 2006). In this situation health informatics evaluations may face the problem of trying to please everybody while satisfying none (Pawson & Tilley 1997).

3.5 Theory-driven evaluation – explanatory and realist approaches

Theory can be defined as a frame of reference that helps us to understand the world. It provides a guideline for analysing phenomena and comprehending the significance of research findings (Chen 1990). Theory involves conceptual and analytical processes for asking questions and providing answers (Pawson 2004) and can aid in helping to explain phenomena, why they exist and the way they operate (Layder 1998). Yet, the role of theory within evaluation is often contested and its value dismissed for promising much more that it delivers (Stufflebeam 2001). Scepticism about theory-driven approaches can come from both sides of the qualitative/quantitative divide. Positivist approaches to evaluation often view the role of theory as an imposition on their “value-free” objectivity (Long 2006). Meanwhile, interpretivist researchers argue that theory can be both a way of seeing and not-seeing, contending that human activity is not conditioned and does not proceed through a conscious use of theory. As Walsham
argues, there are no correct or incorrect theories, only different ways of viewing the world (Walsham 1993).

Theory has not played a dominant role in the health informatics evaluation field (Kaplan & Shaw 2004). In her review of literature on clinical decision support systems, Kaplan noted the lack of theoretical discussion of the issues and problems involved. This dovetailed with the absence of useful information about why the system may be useful in one setting but not in another (Kaplan 2001). Many of the evaluation texts and papers have tended to be method driven, concentrating on detailing the available tools of enquiry, often with little reference to theory (Friedman & Wyatt 1997; Ammenwerth et al. 2003). Chiasson et al. suggest that the dominant research issue within the health informatics field has tended to focus on whether or not the IT system works in a particular setting, rather than on attempts to account for the outcomes observed. This has contributed to the underutilisation of theory to explain changes and help to predict outcomes (Chiasson et al. 2007).

As Anderson et al. point out in Evaluating Health Care Information Systems, existing theoretical assumptions in evaluation studies always underpin orientations to change and research direction. And because of this it is important that evaluation researchers recognise the influence of their own and the organisation stakeholders’ underlying assumptions (Anderson & Aydin 1994). Anderson et al.’s point can be illustrated by considering the wide array of research, opinion pieces and guidelines about CPOE that currently make up the literature in this field. They come from a mixture of perspectives, some academic (Ash et al. 2003; Poon et al. 2004; Ash & Bates 2005), some management-based (Scalise 2002; Scalise 2003) and other policy-based (Scanlon 2004),

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each with their own perspective (and even prescription) about what is needed to achieve a successful application of CPOE. All of them provide some form of theoretical supposition about what needs to be done, how and when.

There are nevertheless some strong (and an increasing number of) advocates of theory-driven evaluation (Clarke 2006; Donaldson & Lipsey 2006; Long 2006; Walshe 2007), including in the health informatics discipline (Georgiou et al. 2005), who point to its ability to illuminate concepts that are critical to understanding complex situations (Brennan 2008). Their arguments reflect a desire to go beyond black box programs which eschew theory and provide little understanding of what happened and why, and are often of little assistance for future programs. Pawson claims that evaluation studies cannot avoid theory because by their very nature they seek to discover whether programs work. Programs are theories because in some shape or fashion they include the hypothesis that providing a set of people with a certain resource may change their behaviour. It follows therefore that evaluation is theory-testing (Pawson 2003).

Theory-driven approaches have major relevance for CPOE systems which are implemented in healthcare environments with pre-existing and prevailing social conditions. These social conditions are permeable and remain crucial to understanding the effect of the system. The capacity for change is sometimes only triggered in appropriate circumstances (Pawson & Tilley 1997), and may be unexpected. Accordingly, the task of evaluation is to gather evidence to see if the theory occurs as planned and, if not, then to amend it to account for the divergent outcomes (Pawson 2004).
Pawson and Tilley argue for a realist approach to evaluation which they summarise as the search for what works, for whom and in what circumstances (Pawson & Tilley 1997). It is an approach grounded in a distinctive model of enquiry (Bhaskar 1975; Sayer 2000; Mingers 2004) which seeks to identify the contextual (eg, local, historical or institutional) factors that may operate within different settings, in order to better appreciate the latent mechanisms (eg, social and technical) that can affect outcomes (eg, performance, organisational or clinical) (Georgiou et al. 2005). In this way evaluation theory can provide a solid guide for identifying which issues are most important, determining what method or methods are relevant to address them, and suggesting how to apply the best method or methods for dealing with them (Chen 1990).

The realist perspective about mechanisms and causality represents an important divergence from other evaluation approaches. For instance, the results of an experimental study may suggest that a CPOE system has attained its goal and therefore is working. But the results do not necessarily help to explain what it is about the system that made it work. To understand why the system works (or doesn’t work), it is important to search for the mechanisms which act in different contexts that were triggered to allow it to work. In this view, the causal claim is not simply about the regularity of patterns that may appear between separate things or events. It is about what an object is like, what it can do and from there, what it will do in different situations (Sayer 2002).

Within healthcare environments new information systems do not work merely because they have been constructed to do so. Systems are designed to enable people to make them work, and people may choose not to make them work, or they may find the
conditions not conducive to doing so. There is a complex range of contextual factors and triggers that will play their role. These triggers or mechanisms are not fixed. They may work in one situation and not another. They are contingent and depend upon the conditions in which they operate (Sayer 2002). The researcher’s role is to help identify and understand these mechanisms, outcomes and context. This approach can be defined as a generative conception of causality, in which causal powers reside not just in the ICT system, but in the organisational structures and social relations that are part of the wider social environment (Clarke 2006). Realist evaluation approaches to healthcare have appeared in a number of areas including nursing (McEvoy & Richards 2003), social work (Kazi 2003) and as a means of improving diffusion and dissemination of complex interventions (Greenhalgh et al. 2004).

Realist evaluation offers an important framework for the adoption of multi-method approaches, precisely because it can provide the theoretical basis for understanding and incorporating data from diverse sources. For social scientists such as Ackroyd, research incorporates phases and different types of activities that take prominence at different times. Particular methodologies and techniques are more useful for some functions than others, and so a combination of approaches may be necessary to provide a more comprehensive outcome (Ackroyd 2004). Ackroyd describes the use of different methods as akin to viewing the world through different instruments such as a telescope, an X-ray machine, or an electron microscope.

“Each reveals certain aspects but is blind to others. Although they may be pointing at the same place, each instrument produces a different, and sometimes seemingly incompatible, representation. Thus, in adopting only one method, one
is often gaining only a limited view of a particular research situation, for example attending only to that which may be measured or quantified; or only to individual’s subjective meanings and thus ignoring the wider social and political context” (page 182) (Ackroyd 2004).

3.6 Structure, agency and IT artefacts

How then do realist evaluations deal with the apparent dichotomy between the “social” and the “technical”? As mentioned earlier in this chapter, information systems evaluation approaches have tended to be dominated by functionalist and technical preoccupations about what is needed to make the system work “right”, with less attention given to the ideas, thoughts, opinions or aspirations of individuals (Mingers 2004). This approach tends to be top-down. Conversely, a bottom-up approach visualises the agent as central and seeks to explain phenomena in terms of the nature of human actors, who have a capacity for willed (voluntary) action (Scott & Marshall 2005). In opposition to the perception of people as passive agents in the face of technical or structural impositions, interpretivists contend that all knowledge is necessarily subjective and a social construction (Walsham 1993) thereby placing people at the very centre of investigation. This apparent dichotomy is an echo of the structure versus agency debate that permeates and often separates social scientists into contending sides. Needless to say, the contending views about structure and agency have wide ramifications for how studies are conducted and reported.

As a way of trying to bridge the social science divide, the social theorist Anthony Giddens devised the concept of structuration (Kouroubali 2002). Giddens argued that
agents and structures are presented not as two independent sets of phenomena but as a duality. According to this perspective the constitution of society and various structures (including the workings of a new IT system) is accomplished by its members, under conditions that are not necessarily wholly intended or comprehended by them (Walsham 1993; Jones et al. 2004). The structuration perspective has been widely employed by a range of information systems researchers (Orlikowski 1992; Walsham 1993; Orlikowski 2000; Jones et al. 2004) including some within the health informatics field (Davidson & Chismar 1999; McLaughlin et al. 1999; Kouroubali 2002).

The structuration approach to information systems research has been criticised for conflating agency and structure and failing to give due consideration to the impact of IT on human actions on the one hand, and inadequately accounting for the characteristics of material artefacts such as the software and hardware comprising the technology on the other hand (Jones et al. 2004). Orlikowski and Iacono contend that the impact of this conflation has led information systems research to fail to fully deal with the IT artefact (ie, those “bundles of material and cultural properties packaged in some socially recognizable form such as hardware and/or software”) (Orlikowski & Iacono 2001). Accordingly, this has led some to mistakenly accept IT artefacts as stable and independent resulting in a one dimensional view of the IT artefact as either an unfathomable black box, or vanished from view because of an overriding concern with how human agents perceive and socially construct their situation (Orlikowski & Iacono 2001).

A realist view of the issue of structure and agency aims to overcome conflation, arguing that the world is not directly produced or constructed by people, but is rather the
complex outcome of interactions between structural contexts (including those embedded in technology artefacts) and agents (people) (Carter & New 2004). While on the one hand structures depend on the activities and attitudes of individuals for their existence and persistence, the attitudes and actions of individuals cannot be explained or understood without reference to those very underlying structures and systems (Creaven 2000). In other words, people choose what they do, but they make their choices from a structurally and culturally generated range of options – which they do not choose (Carter & New 2004).

### 3.7 Conclusion

This chapter has identified and described a number of key orientations to evaluation. It has investigated the assumptions that underlie them and examined arguments about their relative strengths and weaknesses. The chapter drew upon the literature review in Chapter 2 to illustrate and discuss examples of the different approaches, to identify how they have been used and to discuss their relevance for health information systems evaluation, and for the implementation of CPOE systems. The chapter described the key features of socio-technical approaches and pinpointed a series of issues that impact on their utilisation within health informatics. This culminated in an outline of the major features of realist approaches to evaluation. Realist approaches seek to identify the contextual (eg, local, historical or institutional) factors that may operate within different settings, in order to appreciate better the latent mechanisms (eg, social and technical) that can affect outcomes (eg, performance, organisational or clinical). According to this perspective, theory can help identify important issues and determine appropriate methods for addressing them (Chen 1990).
The discussion also asserted the importance of distinguishing between structures and agents within health informatics research. This concept is founded on the understanding that the world is the complex outcome of interactions between structural contexts and people, which are dynamically shaped over time.
Chapter 4  Research strategy, design and methods
4.1 Introduction

The previous chapter outlined the theoretical orientation of the thesis. It addressed a number of different perspectives to evaluation and discussed their relative merits in relation to the literature on health information and CPOE systems. The chapter described the key features of the realist evaluation approach drawing particular attention to its emphasis on the contextual factors that operate within different environments and the latent mechanisms that can affect outcomes. It also highlighted the importance of a theory-driven and multi-method orientation to evaluation as a means of providing a more complete picture of the subject matter, and to improve understanding of what things influence the functioning of health information systems (Kaplan 2001; Ackroyd 2004). The chapter concluded that the choice of method is governed by what needs to be known and how best to find out (Danermark et al. 1997; Georgiou et al. 2005).

This chapter aims to outline the strategy, design and methods adopted by the research study. It will explain how this strategy supports the theoretical orientation of the thesis, meets its research aim and answers the research questions. The chapter also provides a summation of the key facets of the methods used and their applicability to the research topic at hand.

The chapter begins with a description of the facility where the research was undertaken along with the specifications of the CPOE system implemented across the hospital. The next section provides an overview of the research strategy adopted with a focus on the multi-case nature of the study and the research questions addressed by the respective case studies. The chapter then proceeds to outline the quantitative data collected in the
research study describing where and how the data were collected and the laboratory indicators that were measured. This is followed by a section on the qualitative research in the study, comparing the interactionist and ethnomethodological parts of the research. An additional section details the iterative consensus methods used to identify and define levels of agreement about clinical information. The proceeding section of the chapter outlines the sampling, analysis and theory development techniques employed. It is followed by a description of the triangulation methods and related validity and reliability checks that were used to ensure a high quality of research.

4.2 Research setting

This research was carried out between August 2005 and August 2008. It was centred on a pathology service located in a large 660-bed suburban tertiary hospital located in Sydney, New South Wales, Australia. The pathology service employs over 300 staff serving an Area Health Service consisting of seven hospitals and including a number of sites outside the Area Health Service boundary. Details about the make up of each of the pathology departments – Central Specimen Reception (CSR), Clinical Chemistry, Haematology, Blood Bank and Microbiology – are provided in each of the relevant chapters. The research also included a study of the 66-bed hospital Emergency Department (ED). This was made up of a total of 225 staff including 50 medical officers (16 staff specialists, 24 registrars and ten interns/resident medical officers), 130 nursing staff and over 40 clerical staff and ward orderlies.

The geographic area covered by the pathology service is some 6500 square kilometres with an estimated population of 1.33 million, representing 20% of the population of the
state of New South Wales (Sydney South West Area Health Service 2005). The population covered by the health service is ethnically diverse with large numbers of immigrants and high birth rates. Some 20% of the population is under the age of 15, and 17% over the age of 65. The area also includes some of the state’s poorest communities, ranked in the lowest Socio-Economic Indexes for Areas quartiles (Sydney South West Area Health Service 2005).

Health information technology from the Cerner Corporation (Kansas City, Missouri, USA) (Cerner Corporation) was chosen by the Area Health Service for implementation across the area. The Cerner Millennium Pathnet vendor system was introduced into the hospital in November 2005. This system automates clinical, financial and managerial processes for a range of pathology services including haematology, coagulation, chemistry, urinalysis, immunology and phlebotomy (Cerner Corporation 2008). In January 2006 it was replaced by the Cerner PowerChart (version 2004.01) electronic medical record and data repository (Cerner Corporation 2008). This integrated system allowed physicians and other authorised clinicians to electronically place orders for a range of items including pathology and radiology tests. The Cerner system replaced the existing Laboratory Information System (Hoslab) which had included an electronic results reporting feature that had been developed in-house.

Ethics approval for the period 2005 – 2006 was obtained from the Sydney South West Area Health Service Human Research Ethics Committee (SSWAHS HREC Western Zone) Project No. 2005/058 (see Appendix 1). Ethics approval for 2007 – 2008 was covered by SSWAHS HREC Western Zone Project No. 2007/077 (see Appendix 1). All potential participants were provided with information sheets describing the study
along with the confidentiality and consent requirements involved (see Appendix 2). All those that participated in the focus groups or interviews signed consent forms that indicated they had consented to do so (see Appendix 3).

4.3 The research strategy

4.3.1 Multiple case studies

This thesis employed a multiple case strategy to address its research aim. Case studies can be defined as rich, empirical descriptions of particular instances of a phenomenon that are typically based on a variety of data sources (Yin 1994; Eisenhardt & Graebner 2007). They look at the research topic within a real-life context. This is distinct from an experiment where context is deliberately removed so as to concentrate on a limited number of variables (Yin 2003). The value of the case study design is that it complements multi-method research approaches because of its reliance on several sources of evidence which converge in a triangulating fashion. The approach also benefits from the prior development of theoretical guides, which can be used to steer the process of data collection and analysis.

A multiple case study design involves research into a number of related cases. The choice of the cases is made on the basis of their specific purpose in the overall scope of enquiry. This is achieved through a replication logic whereby significant findings are tested and replicated with iteration. According to Yin, this process is analogous to one using multiple laboratory experiments whereby a significant finding in a single experiment is followed up by more experiments. The additional experiments may serve
to duplicate the results or possibly alter some conditions to see whether the findings are repeated (Yin 2003). For Yin the consequence of this approach:

“… is the development of a rich theoretical framework. The framework needs to state the conditions under which a particular phenomenon is likely to be found (a literal replication) as well as the conditions when it is not likely to be found (a theoretical replication). The theoretical framework later becomes the vehicle for generalizing to new cases, again similar to the role played in cross-experiment designs” (page 48) (Yin 2003).

The first stage of this thesis (reported in Chapter 5) begins with a description of each of the pathology departments. This is intended to provide an initial “literal” picture of the context and circumstances of each of the departments which can then be used to guide the study as well as to continue to test, replicate and refine its findings. It recognises that while the departments share many characteristics they also have their own unique role within the pathology service. In this way the aim of each case study serves its own purpose within the overall scope of inquiry (Yin 2003), but is also used to compare findings and to reach greater clarity about the applicability and generalisability of the findings. Table 4.1 lists the research questions of the project and identifies the case studies (along with relevant chapter) where they are dealt with. Hence, the performance indicators of pathology efficiency are presented as part of the case studies that examine Central Specimen Reception (Chapter 6), Clinical Chemistry and Haematology (Chapters 7 and 8) and the Blood Bank (Chapter 10). The organisational dynamics of the pathology departments are dealt with initially in the beginning phase of the study (Chapter 5) and then in each of the pathology department chapters that follow. The
Emergency Department (Chapter 11) is added to provide a clinical perspective to the impact of CPOE on department relationships across the hospital. The question of: a) the role that CPOE plays as part of pathology’s contribution to the delivery of patient care; and b) the underlying mechanisms associated with successful (or unsuccessful) CPOE implementation; are part of a synthesis involving all the case scenarios.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Case study (Research chapter)</th>
</tr>
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| What is the impact of CPOE on key indicators of pathology laboratory performance (eg, test volumes, turnaround times)? | Central Specimen Reception (Chapter 6)  
Clinical Chemistry and Haematology (Chapter 7 and 8)  
Blood Bank (Chapter 10) |
| What is the effect of CPOE on the functioning and organisational dynamics of different departments of the pathology laboratory service? | Pathology department – Phase I of research (Chapter 5)  
Central Specimen Reception (Chapter 6)  
Clinical Chemistry and Haematology (Chapter 7 and 8) |
| What are the implications of CPOE on clinician/ward/laboratory relationships?     | Pathology department – Phase I of research (Chapter 5)  
Central Specimen Reception (Chapter 6)  
Clinical Chemistry and Haematology (Chapter 7 and 8)  
Microbiology (Chapter 9)  
Blood Bank (Chapter 10)  
Emergency Department (Chapter 11) |
| What are the implications of CPOE for the delivery of patient care?               | Synthesis of all case study findings (Chapter 12) |
| What are the underlying mechanisms identified with the successful (or unsuccessful) functioning of CPOE systems within pathology services? | Synthesis of all case study findings (Chapter 12) |

Table 4.1: Research study questions and the relevant case study (and chapter) where data have been collected
4.3.2 Temporal research factors

Research settings vary widely according to various temporal contexts in which the research is undertaken. The significance of temporal factors to the design and undertaking of the research is often inadequately addressed or appreciated by researchers (Kelly & McGrath 1988). Their importance is explained by Kelly and McGrath in the following way:

“Some studies take place in a natural temporal context, in which processes are allowed to unfold at a natural rate; some take place in a temporal context that is experimentally contrived by the researcher. The choice of how to treat the temporal context of a study, which reflects the researcher’s temporal biases and assumptions, has far reaching effects on the information that can be derived from that study” (page 29) (Kelly & McGrath 1988).

Taken as a whole, this study is longitudinal because it follows its subject (pathology CPOE system implementation and operation) over a substantial period of time (three years) as a means of identifying changes caused by the system or the environment in which it is placed (Scriven 1991). Instead of a series of snapshots, the process is more akin to a motion picture whereby events are observed as they occur (Kaplan 1997). In this way the technology is assessed as a dynamic and emerging process rather than as a constant variable (Kaplan 2001).

The component case studies of the thesis utilise an array of temporal orientations depending on: a) the aims of the whole study and its individual components; and b) the
methods adopted to achieve these aims. Table 4.2 lists all parts of the research study along with their associated data collection timelines. A Gantt chart representation of this time frame is provided in Figure 4.1. The table and chart contain examples of summative evaluations that are conducted after the completion of a program (Scriven 1991). For instance, Chapter 8 of the study adopts a summative approach to measuring the impact of CPOE on turnaround times for laboratory tests across the hospital. It achieves this by comparing test turnaround times for a period of two months in 2005, before the system was implemented, with the same period a year later, after the system had been introduced. The advantage of this approach is that it can provide an assessment of the quality or value of the subject under evaluation (Davidson 2005).

The question of data collection also has important temporal implications. Prospective research can be defined as the collection of data over the forward passing of time, while retrospective research can be said to look backwards, collecting data from the past (Bowling 1997). In Chapter 6 unfulfilled test request forms (for blood collections that were not taken) were collected and retrospectively audited for the period September 2005 to March 2006 to monitor changes following the implementation of CPOE. In contrast to the retrospective audit of unfulfilled test request forms, Chapter 10 reports on a prospective monitoring of incoming telephone calls that was undertaken by the Blood Bank in 2008 to compare the impact of the new system on telephone communication channels. Even the issue of data analysis is loaded with temporal concerns. This is because measurements made of dependent variables (eg, turnaround times) require the introduction of an intervention, in this case, the implementation of a new CPOE system as the independent variable (Bryman & Cramer 1997). There is therefore a temporal
ordering of cause and effect (ie, the cause must come first) which is critical to drawing valid causal inferences (Kelly & McGrath 1988).

<table>
<thead>
<tr>
<th>Case study (Chapter)</th>
<th>Data collection timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathology department (Chapter 5)</td>
<td>August 2005 – April 2006: observation, interviews, focus groups, document examination</td>
</tr>
<tr>
<td></td>
<td>Telephone audit: 5-11 May 2005</td>
</tr>
<tr>
<td>Central Specimen Reception (Chapter 6)</td>
<td>November 2005 – October 2007: observation, interviews, focus groups, document examination</td>
</tr>
<tr>
<td></td>
<td>Hospital telephone communication logs: June 2005 – August 2006</td>
</tr>
<tr>
<td></td>
<td>Unfulfilled test request audit: September 2005 – March 2006</td>
</tr>
<tr>
<td>Clinical Chemistry and Haematology (Chapter 7)</td>
<td>August 2005 – February 2007: observation, interviews, focus groups, document examination</td>
</tr>
<tr>
<td></td>
<td>Add-on test analysis: 1 January – 31 December 2006</td>
</tr>
<tr>
<td>Clinical Chemistry and Haematology (Chapter 8)</td>
<td>August 2005 – May 2007: observation, interviews, focus groups, document examination</td>
</tr>
<tr>
<td></td>
<td>Laboratory test data: August – September 2005 and August – September 2006</td>
</tr>
<tr>
<td>Microbiology (Chapter 9)</td>
<td>Survey instrument pilot, refinement and administration (October 2006 – April 2007)</td>
</tr>
<tr>
<td></td>
<td>Expert panel 28 February 2008: observation, interviews, document examination</td>
</tr>
<tr>
<td>Blood Bank (Chapter 10)</td>
<td>May 2006 – August 2008: observation, interviews, focus groups, document examination</td>
</tr>
<tr>
<td></td>
<td>Telephone audit: 19 – 25 May 2008</td>
</tr>
<tr>
<td>Emergency Department (Chapter 11)</td>
<td>May 2006 – August 2006: interviews, focus groups, document examination</td>
</tr>
</tbody>
</table>

Table 4.2: Component parts of the research study with associated data collection timelines

Figure 4.1: Gannt chart representation of research study timeline. Vertical lines represent the changeover period to electronic ordering
4.4 Research methods

4.4.1 Quantitative data

One of the features of the realist multi-method approach, outlined in Chapter 3, is the understanding that the method chosen for evaluation is governed by what it is we want to know and how best to find out (Danermark et al. 1997; Sayer 2000; Georgiou et al. 2005). Tables 4.1 and 4.2 have already illustrated how the research questions of this thesis are connected to the study design adopted and to the choice (and temporal make up) of the corresponding data collection techniques. Six chapters of this thesis utilise quantitative data which are collected and used for a variety of purposes, including the identification and measurement of variables that have been affected by CPOE. Table 4.3 describes all the laboratory metrics along with their source, that are collected and analysed in the study. These include the use of telephone logs (Chapter 5 and Chapter 10) to monitor the impact of the new system on communications within the laboratory, performance indicators (eg, test turnaround times) to measure the efficiency of CPOE (Chapter 8), audits of unfulfilled requests (Chapter 6), add-on tests (Chapter 7) and a survey that was used as part of a consensus exercise to identify the importance of clinical notes provided by clinicians (Chapter 9).
<table>
<thead>
<tr>
<th>Laboratory metric</th>
<th>Data source</th>
<th>Laboratory and chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming telephone calls categorised by type</td>
<td>Prospective telephone call log</td>
<td>Central Specimen Reception (Chapter 5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blood Bank (Chapter 10)</td>
</tr>
<tr>
<td>Unfulfilled test requests</td>
<td>Retrospective audit of unfulfilled test</td>
<td>Central Specimen Reception (Chapter 6)</td>
</tr>
<tr>
<td></td>
<td>request forms</td>
<td></td>
</tr>
<tr>
<td>Incoming and outgoing calls</td>
<td>Hospital communication log</td>
<td>Central Specimen Reception (Chapter 6)</td>
</tr>
<tr>
<td>Add-ons</td>
<td>Laboratory information service</td>
<td>Haematology and Clinical Chemistry (Chapter 7)</td>
</tr>
<tr>
<td>Turnaround times</td>
<td>Laboratory information service</td>
<td>Haematology and Clinical Chemistry (Chapter 8)</td>
</tr>
<tr>
<td>Test volumes</td>
<td>Laboratory information service</td>
<td>Haematology and Clinical Chemistry (Chapter 8)</td>
</tr>
<tr>
<td>Levels of agreement about the importance of specified</td>
<td>Survey</td>
<td>Microbiology (Chapter 9)</td>
</tr>
<tr>
<td>clinical notes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3: Laboratory metrics, their data source, associated laboratory and chapter

Many of the chapters that separately report on the collection and analysis of the quantitative data include a hypothesis test (Argyrous 2000) about the effect of the CPOE system, eg, did the new system lead to improved turnaround times, or a greater volume of tests (Chapter 8)? Such analyses used performance indicators which can be defined as statistics, or other units of information that reflect, directly or indirectly, the performance of a system (Boyce 2002), and which can help to understand and improve the workings of a system (NHS Institute for Innovation and Improvement 2007). The indicator must be robustly defined, connected to an evidence base and accompanied by a solid rationale for its measurement and potential uses (Georgiou et al. 2008). Before and after studies using laboratory performance indicators have provided valuable evidence of the impact of CPOE on pathology services and can be used to monitor their ongoing effect (Mekhjian et al. 2002; Thompson et al. 2004; Westbrook et al. 2006; Westbrook et al. 2008).

In other instances, the collection of quantitative data can serve an important function in helping to identify, benchmark and monitor issues of concern. Telephone audits of the communication between the laboratory and the clinical ward (Chapter 5 and 10) can
help to understand issues that may be associated with CPOE, or arise as a consequence of its introduction. In such cases descriptive statistics that summarise the spread of the findings can be appropriate (Bland 1995). Succinct answers about cause and effect are not always easy to identify or obtain. Often statistical process control methods which assess common and special causes using statistical tools such as control charts, frequency plots and scatter diagrams, can also be appropriate and meaningful (Smith 1991; Thor et al. 2007; Georgiou et al. 2008). Each of the metrics used is described more fully in the relevant chapter along with accompanying details of the data collection and statistical analysis methods used.

There are a number of important factors that justify the utilisation of quantitative analyses using performance indicators. The first of these comes in the form of an imperative to carefully monitor the functioning of pathology services and the impact that CPOE may have on their operation. This is an important part of achieving the efficiency benefits associated with CPOE. The use of quantitative analyses based upon performance indicators encourages explicitness and clarity about what it is that is being attempted and what it wants to achieve (NHS Institute for Innovation and Improvement 2007). But it should also be noted that “indicators only indicate” and do not represent the complete picture of a system (NHS Institute for Innovation and Improvement 2007). They are only partial glimpses of the properties under investigation which may identify certain features of the concept being studied but may also vary according to the social setting (Pawson 1999). As Pawson points out:
“…the relationship between the two concepts will be influenced by a whole range of contextual features which are quite unrelated to the issue of how we have measured the variables” (page 64) (Pawson 1999).

### 4.4.2 Qualitative research

Qualitative research can be described as a means of investigating occurrences from the standpoint of those being studied using methods that are receptive and sensitive to the actual context of people’s situation (Spencer et al. 2003). Discussions about methods generally make a clear demarcation between the quantitative and qualitative aspects of the research. There are obvious reasons for this convention – not least being the need to provide clarity and explicitness. While this thesis adopts this convention, it is important to recognise that the concept of multi-method research lies not simply in the contribution both methods make separately but what they can contribute to each other (Georgiou et al. 2007). Multi-method approaches are based on an implied recognition of the complexity and multi-dimensionality of the subject of CPOE implementation.

**Interactionist and ethnomethodological studies**

According to Wolcott, qualitative research can be described as constituting various parts of a tree with branches (Wolcott 2001). Within this metaphoric tree, the branches which most closely approximate those used in this research study are: a) interviewing; b) observation methods; and c) examination of archival sources of data. These techniques correspond either to interactionist or ethnomethodological studies – the two perspectives most commonly adopted in qualitative studies of health information systems.
Greatbatch et al. 2001). Interactionist studies look at how information systems are seen by clinicians, healthcare professionals and managers, while ethnomethodological studies investigate the practices (as distinct from the perspectives) of people (Greatbatch et al. 2001).

Interviews are used widely in qualitative research for a range of research tasks and aims including how information systems are viewed and understood within healthcare settings. Generally, if you need to understand what people do, believe and think, it is usually a good idea to ask them (Murphy et al. 1998). Interviews can either be: a) structured, with pre-set questions, wording and pre-coded design; b) semi-structured (open-ended with no pre-coded response); or c) in-depth and probing where the order and phrasing of questions may vary according to the situation and respondent (Bowling 1997). Focus group research involves interviewing people in small groups which may have the advantage of a group dynamic or synergy amongst participants that stimulates discussion and provides greater insight (Kitzinger 2000; Krueger 2000; Ash et al. 2003). In this study semi-structured and in-depth interviews are used. In the initial phase of the research (outlined in Chapter 5) a round of interviews and focus groups was undertaken using a semi-structured format and then followed up in later sessions.

While interview and focus group research examine how people perceive a particular situation and how they make sense of their situation, they are less useful for identifying what people actually do or how they do it (Barley & Kunda 2001; Aarts 2005). Observation of people’s activities in everyday life, instead of just relying on what they say, can help to understand the context and situation they are involved in (Hammersley & Atkinson 1991). The combination of observation (or ethnographic methods) with in-
depth interviews can also be used as a means of identifying the way that work tasks are modified to suit the contextual setting (Berg 2001).

The respective chapters in which these techniques are reported are documented in Table 4.2. They include observation (non-participant), interviews, focus groups and document examination. These techniques are described in greater depth in each of the chapters. But as emphasised above, it is their interconnectedness, as described by Wolcott, which remains crucial:

“Researchers seeking a broader perspective do not venture out on branches that commit them to a single strategy (ie, to a study conducted solely through interviewing). They seek a coign of vantage that allows them a position from which they are able to draw on whatever combination of strategies seems appropriate” (page 88-89) (Wolcott 2001).

The predominant types and number of qualitative techniques used is represented in Table 4.4. The use of documentary sources (eg, laboratory collection forms or archival material) are reported and where appropriate, attached as an appendix to the study.
Summary of data collection

Table 4.4: Number of focus groups (and participants), interviews (and participants), observations (and hours), typed A4 transcript pages and word count, compared by pathology or clinical setting, recorded through each phase of the research.

<table>
<thead>
<tr>
<th>Pathology/Setting</th>
<th>Focus groups (no. of participants in each group)</th>
<th>Interviews (no. of interviewees)</th>
<th>Observations (no. of hours)</th>
<th>Transcript pages (typed A4)</th>
<th>Word count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Bank (Phase I)</td>
<td>2 (3,4)</td>
<td>10 (8)</td>
<td>4 (3)</td>
<td>29</td>
<td>9956</td>
</tr>
<tr>
<td>(Phase II)</td>
<td>2 (3,3)</td>
<td>8 (8)</td>
<td>12 (8)</td>
<td>24</td>
<td>9881</td>
</tr>
<tr>
<td>Haematology (Haem)/Clinical Chemistry (Clin Chem) (Phase I)</td>
<td>1 (5)</td>
<td>25 (6 Haem and 3 Clin Chem)</td>
<td>4 (2)</td>
<td>117</td>
<td>51,072</td>
</tr>
<tr>
<td>(Phase II)</td>
<td>1 (5)</td>
<td>31 (9 Haem and 3 Clin Chem)</td>
<td>6 (2)</td>
<td>115</td>
<td>57,840</td>
</tr>
<tr>
<td>Central Specimen Reception (Phase I)</td>
<td>1 (4)</td>
<td>12 (10)</td>
<td>6 (4)</td>
<td>52</td>
<td>18,545</td>
</tr>
<tr>
<td>(Phase II)</td>
<td>1 (3)</td>
<td>21 (9)</td>
<td>14 (8)</td>
<td>34</td>
<td>13,991</td>
</tr>
<tr>
<td>Microbiology (Phase I)</td>
<td>1 (5)</td>
<td>20 (11)</td>
<td>8 (12)</td>
<td>34</td>
<td>14,625</td>
</tr>
<tr>
<td>(Phase II)</td>
<td>1 (7)</td>
<td>7 (5)</td>
<td>5 (4)</td>
<td>12</td>
<td>6106</td>
</tr>
<tr>
<td>Emergency Department</td>
<td>6 (6, 5, 4, 3, 4, 4)</td>
<td>7 (3)</td>
<td>114</td>
<td>53,489</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16 (68 total participants)</td>
<td>141 (75)</td>
<td>59 (43)</td>
<td>531</td>
<td>235,505</td>
</tr>
</tbody>
</table>

Summarised briefly, the research study conducted 16 focus groups (involving 68 participants) and 141 interviews (75 participants). Of the focus groups and interviews, 46 were transcribed which resulted in 531 A4 pages and a total of 235,505 words. Interview and focus group sessions which followed a semi-structured format using an interviewer’s guide are reported in each of the chapters along with the list of questions asked. There were also 59 observation sessions which amounted to some 43 hours of observation. This does not count situations where observations were linked to the interview process as when participants demonstrated activities or the use of artefacts (eg, forms, screens, tools) to supplement their descriptions. This technique has been successfully applied by Weir et al. to help understand strategies that people rely on to organise their work (Weir et al. 2007).
4.4.3 Iterative consensus methods

Iterative consensus methods (Fink et al. 1984) are used in Chapter 9 to identify and define levels of agreement about: a) the effect of clinical notes supplied by physicians on microbiology test requests, on the choice, processing and interpretation of test results; and b) the potential impact of electronic ordering on the process of information exchange. The value of consensus methods is that they represent a means of dealing with situations where insufficient or contradictory information exists about a certain subject or area of study. According to Jones and Hunter:

“Consensus methods provide another means of synthesizing information, but are liable to use a wider range of information than is common in statistical methods, and where published information is inadequate or non-existent these methods provide a means of harnessing the insights of appropriate experts to enable decisions to be made” (page 376) (Jones & Hunter 1995).

The methods that are used for determining consensus include the Delphi technique, consensus development panels and nominal group processes (Bowling 1997). The Delphi method is often associated with postal questionnaires which contact a large number of people to obtain agreement on a particular topic in a systematic manner (Fink et al. 1984). Consensus development panels involve the organisation of meetings with panels of experts in a particular field. The nominal group is associated with a structured meeting which attempts to provide an orderly procedure, usually involving iterative summations of results and their presentation to participants for ranking and re-ranking (Bowling 1997).
There is no firm agreement about the validity and reliability of consensus methods, the value of the different methods or even the appropriateness of different statistical measures for quantifying consent (Bowling 1997; Holey et al. 2007). In many instances, different consensus methods using quantitative and qualitative techniques are used in conjunction to generate estimates of consensus and agreement (Bowling 1997).

In Chapter 9 a three-part consensus exercise is described using a combination of consensus techniques. This process is diagrammatically depicted in Figure 4.2, beginning with the drawing up, validation and piloting of the survey instrument, which included examples of clinical notes supplied by clinicians for microbiology stool and wound specimens. It then moves on to the administration of the survey to 22 laboratory participants that included 3 technicians, 16 laboratory scientists and 3 medical officers divided into <5 and >=5 years of experience. This part of the study included the analysis of results from the survey to identify impact ratings for each of the clinical notes. This generated a Kappa statistic to compare the amount of agreement between the three professional groups and between the different experience-level groups. The final part of the study involved the convening of an expert panel of seven participants which discussed and assessed the findings, and identified how electronic decision support in CPOE systems can improve pathology practice, rational ordering and patient outcomes.
4.5 Research design and development

The different aspects of data collection (along with their timelines) were outlined earlier in this chapter (see Table 4.2) and then described in relation to their respective research method (see Table 4.3 for quantitative data, and Table 4.4 for qualitative data). This section will explain the principles which underpinned the bringing together of the multiple data sources, along with the techniques that were used to validate and analyse the data. It then describes how the data were synthesised to produce a theoretical framework.

4.5.1 Data collection

Each chapter of the thesis reports on the combination of data collection methods that were used for each of the case studies. These were either reported individually for Central Specimen Reception (Chapter 6), Microbiology (Chapter 9), the Blood Bank (Chapter 10) and the Emergency Department (Chapter 11); comparatively for Haematology and Clinical Chemistry (Chapter 7 and 8); or as part of an initial evaluation study of all the pathology departments in Phase I of the research (Chapter 5).
Each chapter also contains a description of its data sources and database in line with Yin’s recommendation to “in principle” allow other investigators to review the evidence (Yin 2003). This research strategy aims to provide a “chain of evidence” that gives the reader an appreciation of how evidence was derived and developed right through to the chapter conclusions. This is an important reliability measure whose purpose is to ensure that another researcher hypothetically undertaking the study over again will arrive at identical findings and conclusions (Yin 2003).

This chain of evidence database was supplemented by a researcher’s log that was maintained through the course of the investigation (August 2005 – August 2008). The log collected notes from all interviews, focus groups and observation sessions. It recorded comments on all data sources (quantitative and qualitative) along with memos and reflections on the investigation process. It also provided an audit trail of the research study that documented decisions and recorded issues for follow up (Gifford 1998). The research log was kept electronically. All hand-written reports and notes were entered the same day or the day following each research encounter. Each log entry also provided a clear classification according to the research setting. This resulted in a readily accessible and flexible tool for reviewing and reflecting on the progress of the research (Hammersley & Atkinson 1991; Ash et al. 2003; Yin 2003). The research log recorded 203 entries and came to a total of 243 pages. Table 4.5 lists the different categories and the total number of entries made for each.
<table>
<thead>
<tr>
<th>Category</th>
<th>Number of entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Bank</td>
<td>13</td>
</tr>
<tr>
<td>Central Specimen Reception</td>
<td>17</td>
</tr>
<tr>
<td>Clinical Chemistry</td>
<td>15</td>
</tr>
<tr>
<td>Clinical wards</td>
<td>19</td>
</tr>
<tr>
<td>Documents/artefacts</td>
<td>8</td>
</tr>
<tr>
<td>Haematology</td>
<td>15</td>
</tr>
<tr>
<td>Hospital information department</td>
<td>10</td>
</tr>
<tr>
<td>Hospital ICT department</td>
<td>32</td>
</tr>
<tr>
<td>Microbiology</td>
<td>28</td>
</tr>
<tr>
<td>Pathology department (general)</td>
<td>46</td>
</tr>
<tr>
<td>Total</td>
<td>203</td>
</tr>
</tbody>
</table>

Table 4.5: Research entries for the period August 2005 to August 2008 categorised by department, ward and/or setting

### 4.5.2 Sampling methods

Sampling methods differ according to the approach and technique being utilised. Qualitative research has a greater emphasis on small samples that are contextually located and generally studied in depth. In contrast quantitative research is often focused on the presence of large and randomised samples where statistical significance testing aims to overcome context considerations (Miles & Huberman 1994). The sampling approach used for the qualitative section of the study was theoretical sampling. This means that the selection of cases was undertaken because of their analytical relevance rather than the need to establish frequency and distribution of the phenomenon (Glaser & Strauss 1967; Emerson 1981; Eisenhardt & Graebner 2007). Cases can be chosen either to replicate previous findings or to fill theoretical categories that include examples of contrast or polar opposites (Eisenhardt 1995). In this way the initial sampling decision prompted the search for cases where the emerging hypothesis could be scrutinised, contrasted and tested (Dingwall 1992; Murphy et al. 1998).
While theoretical sampling served as the guiding focus for the selection of cases (e.g., pathology departments and ward setting) and study participants, it is also important to address the role that other sampling methods played. Opportunistic sampling of participants was employed in situations motivated by constraints of time and accessibility (Quine 1998). Such situations are often the norm for researchers in busy hospital and pathology service settings. However, opportunistic sampling should not imply that the cases were chosen in an ad hoc or makeshift fashion. Rather, the adoption of opportunistic techniques requires careful consideration of all sampling decisions to ensure that they are made systematically with rigorous regard to the aims and questions of the research study (Murphy et al. 1998). In one case study (Chapter 11) chain referral sampling was used (Quine 1998). This technique involved using individuals as informants to direct the researcher to other potential participants but still within the theoretical aim of obtaining a cross section of participants from among physicians and nurses.

Closure was achieved when it became clear that sufficient information had been gathered for the phenomenon to be seen as “coherent” and “explicable” (page 548) (Green et al. 2007). This can involve one or both of the following options: a) a saturation point has been reached and no new material is emerging (Bowling 1997); or b) the iteration between theory and data is not producing any incremental new information and researchers are confronted with previously observed phenomena (Glaser & Strauss 1967).
4.5.3 Analysis

Different approaches to the analysis of qualitative data can be distinguished according to the level of data presentation and interpretation involved. Some presentations aim to present data without any analysis and with little interpretation; another approach sets out to provide rich contextual descriptions of the subject. This thesis utilised theory as a means of relating the data and concepts to form a version of reality (Strauss & Corbin 1990). In this process, data analysis is undertaken systematically and concurrently with data collection (Gifford 1998). It also requires the researcher to be close to and immersed in the data. Achieving immersion was facilitated by the research log (outlined above) which recorded reflections on the meaning and significance of the data, and provided a means of identifying emerging categories and themes, and developing theoretical hypotheses in the course of the research (Barley 1995). The research log also provided the basis for the follow-up of emerging ideas and the formulation of new questions to test them (Green et al. 2007).

The grounded theory approach (Glaser & Strauss 1967) aims to develop high levels of understanding of social phenomena based on the systematic analysis of data (Glaser & Strauss 1967). This is achieved by a process of constant comparison where data are compared for similarities and differences (Lingard et al. 2008). NVivo software was used to undertake an initial open coding of all interview and focus group transcriptions (Bazeley & Richards 2000). Axial coding was performed using grounded theory techniques (Glaser & Strauss 1967) whereby initial codes, indicators and concepts were exposed to more and more data, and then elaborated on, and transformed into robust
categories leading to more refined analytical levels relevant to the research question under investigation (Strauss 1987).

4.5.4 Theory development

There are two interrelated principles which underpin this study’s approach to the development of theory. They consist of: a) the use of theory as an “orienting concept”; and b) the use of a theory-building logic to the structure and development of the thesis. The use of theory as an “orienting concept” as outlined by Layder acknowledges that the prior existence of theory in our understanding of phenomenon should not detract from the essential aim of achieving empirically-anchored theory (Layder 1998). Layder explains the point in the following way:

“… it must be acknowledged that all research is to some extent influenced by theoretical assumptions and that it is better to deal with them openly and systematically in order that they do not unwittingly distort the data analysis or the ‘findings’ of the research. Secondly, and more importantly, as empirical researchers we should positively value prior theoretical ideas as a means of giving focus to data collection and analysis” (page 66) (Layder 1998).

The importance of this approach is that it emphasises the essential reflexive character of social research. Researchers are, after all, part of the social world being investigated. According to Hammersley and Atkinson, “this is not a matter of methodological commitment, it is an existential fact” (page 14-15) (Hammersley & Atkinson 1991).
Secondly, this thesis aims to follow Yin’s advice for developing robust and thorough theoretical understanding:

“… the sequence of chapters or sections will follow some theory-building logic. The logic will depend on the specific topic and theory, but each chapter or section should reveal a new part of the theoretical argument being made. If structured well, the entire sequence produces a compelling statement that can be most impressive” (page 154) (Yin 2003).

In this way the development of theory is not left to the end of the study, but is part of the ongoing process of induction and deduction of the research (Layder 1998). Theory is used to help design questions for study, guide the selection of data and its interpretation and formulate explanations about the causes or influences affecting the data (Reeves et al. 2008).

This thesis is thus designed in two phases: the first phase (Chapter 5) begins with a description of each of the pathology departments under investigation. From this initial investigation an evaluation framework is elaborated which is then developed in the subsequent phase where each department is investigated in depth. The logic of this process is that the evaluation framework is used as a theoretical guide to the thesis while also subject to development and refinement.
4.5.5 The quality of research

Triangulation

As outlined in Chapter 3, this thesis adopts a realist approach to its research aim. While realists acknowledge the existence of the real world they remain mindful that our understanding of that world is theory-laden and fallible (Bhaskar 1975). And since the real world is differentiated and stratified and made up of an assortment of events, objects, material and emergent products, it follows that robust knowledge should be a product of some triangulation across a range of perspectives (Van de Ven 2007).

Triangulation refers to the use of multiple research methods in research with the aim of elevating the researcher above the biases that emanate from single methodologies (Denzin 1989). Triangulation can include: data triangulation (different sources of data); theory triangulation (different perspectives to the same data source); investigator triangulation (different researchers) or methodological triangulation (using different methods) (Denzin 1978; Patton 1987; Bowling 1997; Fulop et al. 2002). Triangulation is used throughout this study and forms an essential element of the research strategy providing an important rationale for the use of multiple methods and the study’s theory-building logic. This is because triangulation (whether theoretical, methodological or data driven) does more than just validate claims, strengthen data sets or promote accuracy and unbiased measurement, it also provides a valuable contribution to data analysis, learning, and at times, even to altering perceptions and initial judgements (Hammersley & Atkinson 1991; Bloor 1997; Olsen 2004).
Validity

The study incorporates a number of different techniques that are used to underpin the quality of the research. This includes the use of respondent validation through feedback sessions with participants to enhance the validity of the data (Guba & Lincoln 1989). This technique is based on a recognition of the role of study participants who have additional knowledge of the context and other relevant events, that may not be available to the researcher (Hammersley & Atkinson 1991). Respondent validation can also help to contribute to the test of construct validity defined by Scriven as the ability of an instrument (eg, a test or an observer) to act “… as an indicator of the presence of (a particular amount of) a theoretical concept” (page 93) (Scriven 1991). For instance, in conjunction with the use of multiple sources of evidence, participants can help to decipher whether or not a selected measure of change did (or did not) reflect the type of change selected (Yin 2003). The use of numerous and expert opinions about phenomena from different perspectives can be an aid in limiting bias and increasing confidence in the data (Eisenhardt & Graebner 2007).

Finally, it is important to stress the importance of thoroughly examining and discussing existing literature for any conflicts with the emergent theory. This is undertaken within each chapter of the thesis. This involves exploring areas of similarity and contradiction along with the question – why? As Eisenhardt and Graebner point out, this exercise not only contributes to increased confidence in the findings but also forces researchers into a “… more creative, frame-breaking mode of thinking” (page 81) (Eisenhardt 1995).
4.6 Conclusion

This chapter has explained the strategy, design and methods used to address the aim of the thesis and each of its research questions. It began with a description of the health setting along with the component parts of the research. It explained some key demographic features of the setting and provided an overview of the technical features of the new CPOE system. The chapter then went on to describe the strategy adopted by the study. This consisted of a multiple case approach to provide rich, empirical descriptions of instances of a phenomenon (Eisenhardt & Graebner 2007). The temporal research aspects of the thesis were also explained with particular attention to the longitudinal design of the study and the varying timeframes and objectives (Kelly & McGrath 1988). The quantitative data used for different case study components of the research were identified along with their source and the laboratory metric that was employed. The qualitative data collected in the study were described and defined by their respective interactionist (how the phenomenon is seen by participants) or ethnomethodological (practices undertaken by participants) perspectives (Greatbatch et al. 2001). This section of the chapter also includes a description of the iterative consensus section of the thesis, explaining how it was used to obtain and define levels of agreement about the effect of clinical notes on the microbiology test process.

The design and development section of the chapter described the data collection and sampling methods adopted by the thesis along with the analysis techniques and the approach taken to the development of theory. The section underscored how theory development was an ongoing process which permeated the whole thesis beginning with the development of an initial evaluation framework in phase I of the research (see
Chapter 5), to serve as an important guide for the thesis, while itself subject to ongoing development and refinement. The last section of the chapter emphasised the techniques used to ensure the quality of research. This section showed how multi-method research designs can readily employ a number of triangulation methods (data, theory, researcher and methods) and are an important aid not only for the validation of research but also to its development and enrichment (Bloor 1997).

The following chapter will report on the first phase of the thesis, investigating the context and circumstances of each of the pathology department settings. The chapter will examine and contrast the different organisational requirements of the departments with the aim of developing an initial framework which will be used to guide the research through a process of intensive case study investigations of each of the departments.
Chapter 5  Organisational communication as an evaluation framework
5.1 Introduction

Previous chapters have provided an outline of the existing literature about CPOE and pathology services, identified the key questions and aim of the thesis along with a description of the methods and theoretical orientation adopted. This chapter details the findings from the first stage of research undertaken in the period prior to the installation of CPOE and the formative period following its implementation. A particular focus is placed on the identification of pre-existing social contexts within the study settings, comprising the underlying culture and ways of doing things, which can assist in explaining the CPOE system’s success or failure (Pawson & Tilley 1997; Alvesson 2002; Martin 2002; Ashkanasy 2003). The concentration on context is critical to helping to identify overt factors and latent mechanisms affecting the outcomes of CPOE systems. This is because the ability of CPOE to integrate successfully with existing work processes will depend on establishing the appropriate circumstances for it to do so (Pawson & Tilley 1997).

The aim of this chapter is to identify key issues which shape the organisational communication functioning of each of the five pathology department settings and to use these issues to develop a framework to provide an in-depth analysis and evaluation of the impact of CPOE. This framework will be progressively refined over the course of the study as a means of enhancing the clarity of the findings and intensifying the study’s focus. This technique is described by Hammersley and Atkinson as a “funnel” approach that is important to the generation and development of theory (Hammersley & Atkinson 1991). Layder, using a similar research model, describes it as an adaptive approach to theory development, whereby theory both shapes and is shaped by incoming evidence.
as a continuous part of the research process, rather than one left to a special juncture or point of time (Layder 1998).

The chapter will begin with a description of the organisational and contextual setting of each of the pathology departments. It will also identify emergent and recurring themes affecting the functioning of each of the departments and the impact of these on work processes. These findings are then discussed and developed into an initial evaluative framework that will steer the trajectory of the study while also being subject to ongoing refinement and development.

5.2 Methods

5.2.1 Research setting

The research was carried out across five departments of a pathology service based at a major metropolitan tertiary referral and teaching hospital in Sydney, Australia. The first stage of research included the period from August 2005 to April 2006. This corresponded to a period four months prior to implementation of the Cerner system and five months following the system changeover.

5.2.2 Qualitative data

Qualitative data were generated using focus groups, interviews and participant observation. Each of the focus group and interview sessions carried out before CPOE implementation used a semi-structured set of questions using an interview guide (see
Appendix 4) designed to investigate the context of the laboratory department along with participant expectations of the new system.

Emerging themes from the interview and focus groups were followed up by observation and interview sessions using formal and informal techniques. Several of the interviews were supplemented by observations that were embedded into the interview process, usually involving demonstrations and visualisations of any issues discussed (Weir et al. 2007). Many of the formal interviews and focus groups (usually those that were pre-arranged with participants) were transcribed. Additional and iterative interview sessions with participants were carried out in order to clarify issues, investigate the validity and relevance of emerging themes, and to follow up on any changes or developments.

In total, for the findings reported in this chapter, there were five focus groups undertaken involving a total of 21 participants, along with 67 interviews with 38 participants. Four of the focus groups and ten interview sessions were transcribed. One focus group was not able to be transcribed because of the poor quality of the recording. There were also 22 observation sessions of varying times that amounted to 21 hours in total. The number of interviews, focus groups, and observation sessions for each department are described below. Clinical Chemistry and Haematology are reported collectively because interview sessions were sometimes undertaken concurrently involving participants from both departments.
**Blood Bank**

Two focus groups were carried out in the Blood Bank. These consisted of three and four participants respectively, and included two hospital scientists and five technical officers. All of the focus groups were taped and transcribed, resulting in 29 transcript pages (A4 single spaced) and 9956 words. The focus groups were followed up by a series of ten interviews that included two Senior Laboratory Managers, two Hospital Scientists and four Technical Officers. Four observation sessions of work processes within the Blood Bank were undertaken to explore and understand issues that arose from the interviews/focus group sessions. These lasted from between 30 minutes to one hour each, totalling nearly three hours.

**Central Specimen Reception**

One focus group was held in Central Specimen Reception involving a Senior Manager, two Technical Assistants and a Data Entry Supervisor. Twelve additional interviews were also carried out with the above participants, along with other participants that included an Administration Officer responsible for data entry, two department managers and three Technical Assistants. The focus group and two interview sessions were taped and transcribed, resulting in 52 transcript pages (A4 single spaced) and 18,545 words. Six observation sessions were carried out in Central Specimen Reception lasting from between 30 minutes to one hour, and totalling over four hours.
Haematology and Clinical Chemistry

One focus group consisting of five Haematology hospital scientists was conducted. There were a further 25 individual interviews which included multiple interview sessions with nine senior laboratory scientists and managers including six from the Haematology department and three from the Clinical Chemistry department. Six of the interview sessions were taped and transcribed resulting in 117 transcript pages (A4 single spaced) and 51,072 words. There were also four formal observation sessions lasting between 30 minutes to an hour which totalled over two hours carried out across the two departments.

Microbiology

One focus group made up of four laboratory scientists and one laboratory manager was carried out in the Microbiology department. This was supplemented by a total of 20 interview sessions involving eleven participants that included two senior laboratory scientists, one laboratory business manager, three technical officers and five laboratory scientists. Eight observation sessions, each lasting an average of 1.5 hours (and totalling 12 hours), were also undertaken. Transcripts of the focus group and interviews resulted in 34 transcript pages (A4 single spaced) and 14,625 words.

5.2.3 Quantitative data collection

Blood Bank staff kept a log of incoming telephone calls for one centrally placed telephone extension for the period 5 – 11 May 2005, in order to monitor the number and
type of calls received according to a set of designated categories arrived at by Blood Bank management. The log recorded the time a call was received, the originating ward or location and the reason for the call, as listed in Table 5.1. The data were analysed using Excel software.

<table>
<thead>
<tr>
<th>Categories of reasons for calls to the Blood Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Wards ring up to order blood/platelets or fresh frozen plasma (FFP)</td>
</tr>
<tr>
<td>b) Wards ring up to enquire about the availability of blood product or validity of cross match</td>
</tr>
<tr>
<td>c) Wards ring up and ask for fresh blood product to be dispensed through the hospital pneumatic air tube (Lamson)</td>
</tr>
<tr>
<td>d) Wards ring up and ask for a derivative plasma product (eg, Albumin) to be dispensed</td>
</tr>
<tr>
<td>e) Wards ring up to confirm receipt of product</td>
</tr>
<tr>
<td>f) Other enquiries</td>
</tr>
<tr>
<td>g) Other phone calls (eg, personal)</td>
</tr>
</tbody>
</table>

Table 5.1: Reasons for telephone calls to the Blood Bank as recorded by Blood Bank staff in phone log

5.3 Results

5.3.1 Pathology departments – organisational and contextual settings

Central Specimen Reception

The role of the Central Specimen Reception (CSR) can be described as a receiving dock for pathology laboratory test samples. The department functions as an organisational hub and gatekeeper of the whole laboratory process (as depicted in Figure 5.1) whereby test orders and their accompanying specimens are received and forwarded to the appropriate laboratories. The department is also responsible for organising the
collection of blood from patients throughout the hospital. This involves the twice daily dispatch of a team of blood collectors to wards across the hospital to undertake blood collections requested by physicians, or other clinicians. CSR participants interviewed estimated that blood collectors account for some 60% of all blood sample collections across the hospital. The department is therefore considered to be an important component of overall laboratory efficiency and organisation.

Figure 5.1: The role of Central Specimen Reception in the pathology test process

CSR consisted of some 50 staff members (either full or part time), graded either as Technical Officers, Technical Assistants or Administrative Officers. Their tasks included ensuring that all specimens are accompanied by matching forms and the correct documentation. Prior to the introduction of CPOE, CSR staff time-stamped each test request on arrival and then distributed the specimens (with the accompanying hand-written request) to the appropriate laboratory for processing. CSR was also responsible for transferring the information from hand-written requests into an electronic form on the Hospital’s Laboratory Information System (Hoslab) after ensuring that patient details in the system matched those provided on the hand-written requests.
Clinical Chemistry and Haematology

From CSR, specimens are passed on to departments such as Clinical Chemistry and Haematology (see Figure 5.2). Clinical Chemistry involves the analysis of blood and other body fluids for chemical components. Haematology is the study of blood along with its cellular elements, and the diseases of the blood and blood forming tissues. Both departments are often regarded as the “frontline” of pathology services. As one Clinical Chemistry participant explained:

“I suppose a lot of haematology tests and a lot of chemistry tests become more frontline tests, so when the patient first presents they’ll do those tests as a baseline. UECs [Urea, Electrolytes, Creatinine] your full blood counts and maybe some coags [coagulation testing]. When they think – what’s going on, some ask for some more specialised tests – drug levels, serology, some microbiology if they think the infection is a concern. I suppose it’s the bread and butter of pathology tests, but also maybe kind of more frontline tests as a lot of generalised information can be gathered by the clinician on the patient’s status. Then they start specialising and get into the esoteric things if required” (Clinical Chemistry participant).
Both Haematology and Clinical Chemistry deal with a large proportion of urgent and life threatening (STAT) tests, the bulk of which emanate from critical care units and the Emergency Department where patient treatment is often reliant on urgent laboratory results. This makes issues like turnaround time (the time it takes for a test request to be processed and a result issued) a priority in organising how the laboratories undertake their work processes.

**Blood Bank and Microbiology**

While the Haematology and Clinical Chemistry departments rely on CSR to administratively process and forward pathology test specimens and orders as a first point of call, the Microbiology department and the Blood Bank operate their own reception functions separate from CSR (as depicted in Figure 5.3). This arrangement is linked to the specific work organisation tasks and needs of these departments.
Microbiology deals predominantly with diseases caused by infectious agents (e.g., bacteria, viruses, fungi and parasites). These agents require time to grow before an appropriate test result is available. For the Microbiology department the concept of timeliness has a specific context-dependent meaning different from other departments, like Clinical Chemistry, where the rapid processing of STAT (life threatening) orders is a regular component of their work.

The role of the Blood Bank is to provide compatible blood components for patients along with a range of tests, including blood grouping, antibody screening and identification and pre-transfusion testing. Accordingly, the Blood Bank is responsible for dispensing products provided by the Red Cross Blood Transfusion Service collected from blood donors. It uses laboratory testing procedures to ensure that the correct product is safely provided to clinicians and dispensed to the patient. According to one Blood Bank study participant:

“We in the Blood Bank are putting out a result, as every other pathology lab [laboratory] does, but we’re also dispensing a product…. [This means] we are interacting at a different level with the clinical areas” (Blood Bank participant).

The Blood Bank process begins with a prescription from a physician for a blood product which is communicated to the Blood Bank (traditionally by a transfusion request form, telephone call or fax). Any additional work required is then performed by the Blood Bank before being made available. The Blood Bank will then await a further communication from the ward asking for the product to be sent. In this way, the work
processes in the Blood Bank department straddle the three areas of pathology test process: order, processing and across to the application.

![Figure 5.3: The role of the Microbiology and Blood Bank departments in the pathology test process](image)

5.3.2 Issues of departmental integrity

Staff from each of the departments described key facets of their work that they considered important for the efficient flow and integrity of their output or product. The following section draws on three examples from CSR, Clinical Chemistry and the Blood Bank to illustrate these points.

Request and specimen congruence

Prior to the implementation of CPOE, CSR was responsible for checking that the hand-written request form which accompanied the test specimen contained the relevant information such as the patient’s Medical Record Number (MRN), and test order request, along with the correct specimen. This procedure was undertaken before the information on the request form could be transferred into the Laboratory Information System (LIS) also known as Hoslab. CSR blood collection personnel were also
involved in identifying any duplicate hand-written requests. Duplicates can often occur in busy ward settings or in those wards frequented by a number of clinicians, who may not be aware of what tests have been ordered previously. The process of identifying duplicate orders was described in the following way:

“When our collectors go [onto the wards] they pick up the forms … first they see which one is for am [collection], which one is for pm [collection], or which one is for another day. They’ll pick up today’s forms, and then they go through the forms and they’ll probably end up seeing that this person over here would have another form…. They’ll look at the test. If the test is the same as on the other form, then this will become a duplicate. If it is not the same then they’ll use it and attach it to the other form” (CSR participant).

CSR staff logged such request and order problems onto a Problem Specimen Report form (see Appendix 5) which specified the problem they encountered, the action they took and the outcome (if any) of their follow up. These reports were not filled out in all situations where problems were encountered. CSR staff explained that the forms were usually only completed for problems that had been the product of an enquiry from the ward about a missing test result, in which case the report forms acted as a record of action taken in case any follow up was needed. CSR staff also explained that the forms were more likely to be completed during times when the department was not busy. CSR management were able to provide a set of 90 forms for the period from December 2004 to October 2005 to the researcher for audit and analysis.
The analysis of the forms cannot be used as a valid measure of the size of the issue faced by the department, but it does provide an indication of the types of issues that the department was required to handle and how it dealt with them in order to maintain the integrity of the initial specimen reception phase of the test process. Figure 5.4 is derived from the data extracted from the CSR Problem Specimen Report forms. It shows that the major problem cases were for requests containing errors (n=35) and missing requests forms (n=25). Missing specimens occurred in 6 cases and specimens that contained errors in 14 cases. The reasons for these problems varied from problems with the labelling of forms, missing patient data to specimens with inaccurate information. Each problem was associated with a follow up procedure designed to remedy the problem leading to accurate specimen and request information.

Figure 5.4: Analysis of details appearing in CSR Problem Specimen Reports for the period December 2004 to October 2005
Efficient and robust tracking procedures

For the Clinical Chemistry department, tracking of tests was important:

“Tracking is a fundamental thing for [Clinical] Chemistry. We have so many specimens and aliquots [daughter tubes], and urines – all different specimen types, which we just need to know where they are … We just can’t line things up and put them in numerical order. So tracking and knowing where things are for retrieval and for safe storage is critical” (Clinical Chemistry participant).

The efficient tracking of specimens takes on special significance for Clinical Chemistry when it is confronted with a request from a clinician to add an extra test assay to a specimen that has already arrived in the laboratory. This is commonly referred to as an add-on. There are a number of reasons for add-ons: clinicians may request an additional test to a specimen to avoid subjecting the patient to an extra venepuncture. This situation is often the case with neonates or older patients where specimen collection may be difficult. In other cases it may be because physicians want to monitor a prior sample to compare post-surgical, post-medication or post-treatment results. In a lot of situations an add-on request can occur just because the medical officer has overlooked an important test. Situations like these may occur as a consequence of medical officer discussions with more experienced colleagues. As one Clinical Chemistry participant claimed:

“Sometimes to me it’s poor patient management. They just haven’t discussed what they’re looking for, and they’re adding on, not just one test, but 15 tests.”
How can you miss so many tests, you wouldn’t have [requested] in the first place?” (Clinical Chemistry participant).

Clinical Chemistry department procedures for handling add-on tests from the wards were often presented as an important measure of the integrity and efficiency of their work processes.

**Safety consequences**

The Blood Bank provides a valuable illustration of the safety concerns that underpin clear and efficient work processes. The department performs thousands of tests for blood groups and antibody screens in any given month. The process begins with a prescription from a physician for a blood product communicated by a transfusion request form, telephone call or facsimile. The department will then perform tests for blood groups and antibody screens and provide the appropriate product.

The Blood Bank has a responsibility to account for all the blood products that are provided to them by the Red Cross. This task involves strict inventory management and control measures and is vital to protecting the integrity of the blood product against potential contamination. As one Blood Bank officer remarked:

“…historically personnel in the Blood Bank labs [laboratories] have always been very meticulous and very careful and pedantic, I suppose about rules and regulations etc, but as we’ve got larger and larger it has just been impossible to keep that level of detail in the checking. We’ve had to accept that people make
mistakes and we try to [avoid] mistakes by utilising technology and equipment”
(Blood Bank participant).

**Temporal considerations**

The pathology test process model (test order, test process and test result) that has been used to describe pathology work flow also involves important temporal dimensions and considerations. These can vary across the departments, often reflecting their specific role and function within the hospital. While all the laboratories are charged with the responsibility to process tests and provide accurate results in the most efficient way possible, there are wide divergences in how they judge efficiency. Take for instance the following description from a Haematology department scientist of the differences between departments:

“The big difference between Haematology and the other departments – a lot of our work is STAT [urgent and life threatening] work, so the turnaround time is expected to be within the hour for the majority of the work. Biochemistry [Clinical Chemistry] have that issue as well”.

“Microbiology don’t have many tests that have to be done [with the same urgency]. Bugs take weeks to grow. They can see it and add a comment to each one, each day. There’s no rush to get through. I mean AP [Anatomical Pathology] speaks for itself. The specimens – the turnaround time for AP is generally at least a day for the quickest specimens” (Haematology participant).
Temporal issues can be expressed in many ways beyond the official turnaround time that is regularly monitored by pathology management. It can also be affected by other things such as the emergence of add-on tests:

“If there’s more add-ons, there’s more time spent looking for a sample, checking if there’s enough sample …” (Clinical Chemistry participant).

In this case, the actual tracking of tests described above can have an important temporal impact that turnaround time measurements may not be sensitive to. In other instances, temporal considerations may have nothing to do with the immediacy (turnaround time) of the test process or the organisational work process involved, as seen below in this description of how the new CPOE system is likely to be accepted:

“… but with anything new it takes time. You have to get used to everything. Retrain all our staff, and with that comes a lot of time and effort. There will be troubles along the way, definitely, but I definitely think we can go through it and make it better, and we’ll be fine with it” (Microbiology study participant).
5.3.3 Communication channels

Communication between wards and pathology laboratories can use synchronous channels where the exchange occurs at the same time (eg, telephone calls), or asynchronous channels where individuals are separated in time, (eg, an email message posted onto a system).

Synchronous communication channels

Each of the departments with specimen reception functions as a first port of call from the wards (ie, CSR, Microbiology, Blood Bank) described telephone communication as a key facet of their work. CSR for instance is often the department called when clinicians want to enquire about the status and results of their laboratory tests requests. As one CSR participant explained:

“... We get phone calls now [where] they might be chasing up where’s my results – ‘I don’t have my results’, ‘I want to add a test on’. Those calls [are forwarded] to the labs [laboratories responsible for the test processing]. We can do a certain amount of checking here, but then it will go to the labs for the results. We don’t handle results here” (CSR participant).

“... Doctors and nurses, when they ring up here, they expect us to answer all their questions. People here are not scientific officers, or hospital scientists who can answer their questions. When you transfer them to the laboratory they get really, really mad about it, they don’t want to be transferred” (CSR participant).
Not only is the department often the first point of call for clinicians enquiring about tests, it is also a source of many phone calls to clinicians chasing up missed specimen or request errors. As discussed earlier (see Figure 5.4), this can involve enquiring about a range of problems including missing patient identification data, incorrectly specified tests or even cases where forms have arrived unlabelled.

The Blood Bank process is also underpinned by a high reliance on communication using the telephone. This is described by Blood Bank study participants in the following ways:

“All our work mostly depends on phone calls” (Blood Bank focus group).

“Traditionally, in smaller labs [laboratories], ward staff will come down to pick up the blood that’s being issued. Here we rely on a Lamson pneumatic tube system to distribute blood around the hospital. Rather than dealing with one issue on one occasion we have to receive a phone call requesting the issue. We then have to go and prepare the blood product for issue in the Lamson system. We send the product and then we expect a phone call back from the ward to say that they’ve received the product, in case it has gone elsewhere. If we don’t get that phone call we’ve got to contact them and chase them up. It can be very time consuming as well” (Blood Bank focus group).

The importance of phone call communication to the Blood Bank is illustrated in Figure 5.5, showing the type of phone calls received and logged during a one week period between 5 and 11 May 2005. The total number of calls logged was 199 (mean per
day=28.4). Most calls involved a request to send blood products (n=42), order blood products (n=41), enquiries about the availability of the product (n=37) and other matters (n=36).

![Figure 5.5: Number and type of phone calls received by the Blood Bank during 5-11 May 2005 (n=199)](image)

**Asynchronous communication channels**

Telephone calls formed an important communication channel for departments that were either dedicated to (eg, CSR), or involved in specimen and order reception activities (eg, Blood Bank and Microbiology). The Microbiology and Haematology departments specified asynchronous communication via the provision of relevant and appropriate clinical information by physicians, as a key area affecting their efficiency.

Prior to the introduction of CPOE this meant the provision of a hand-written test request form sometimes including clinical notes, from the requesting physician. If clinical information is not included the request may be judged to be incomplete or inadequate.
and in need of some form of follow up, often requiring direct telephone contact with the requesting physician. This point was described by one participant in the following way:

“As a whole the request that we receive, we need to know what the specimen is. We need to know what they want us to do with it, and it needs to be legible, so it really is an error, because we have to use our time to verify what they actually want” (Microbiology focus group participant).

Clinical notes are very important to laboratory staff because of the role they play in setting the context for the test. Laboratory managers explained that this contextual information improves the laboratory’s input. For instance, it may help the pathology laboratory staff identify the need for more tests, or perhaps identify when a physician may have asked for an inappropriate test.

“They don’t tell us what they want and we process what we think. If we didn’t get the correct clinical details we may not necessarily make it up for the right thing …” (Microbiology focus group participant).

A salient example of this is for the disease tuberculosis, which the laboratory may not routinely test for unless it is either specifically requested, or when relevant clinical information is provided.

“There are times when we process a specimen, then they [clinicians] ring up and say: have you done TB [tuberculosis] on this? We say – well you didn’t ask for
They should have given us the clinical details that would have allowed us to do that” (Microbiology focus group participant).

The importance of clinical information was also underscored by the Haematology department. A clinical note supplied by a physician describing the patient's condition and/or current treatment will often impact on the decision about what test is required and even influence the interpretation of the test result.

5.3.4 Expectations

Many study participants expected the introduction of electronic ordering would alter the way that the department communicates with clinicians on the ward. Laboratory personnel would no longer be required to decipher hand-written notes, which most participants thought would significantly eliminate instances of unclear or illegible requests. In most cases their expectations and concerns were related to specific contextual features of their department’s functioning. The potential for more effective exchange of valuable and relevant clinical information was described by a Microbiology department participant thus:

“There should be some benefits to the laboratory, in that there will be less data entry, I guess. The patients’ demographics etc, will come across. There should be less confusion, as to what tests are requested by the medical staff. We are hoping to get a lot more clinical details…” (Microbiology focus group participant).
While most participants from different departments had high expectations of the new system’s ability to improve levels of efficiency, they also expressed concerns about its functionality and performance. For instance, participants from the Clinical Chemistry department described the importance of tracking procedures to monitor and retrieve specimens and expressed concern about the new Cerner system’s ability to perform this task:

“Cerner had nothing like that. They had a tracking system but you had to select the rack, and follow the next empty hole, and say – OK – I’m putting this tube into this spot, which works well at the final storage process, but [we] have requirements in between” (Clinical Chemistry participant).

For Blood Bank staff, the key area of impact was accuracy and accountability which many thought had important consequences for the quality of service delivered. As one participant noted:

“The accuracy thing is important, because sometimes we’ve had situations where our blood product will be received, or even transfused up in the ward, and the person who called for the products … they’ll say: I said I wanted [a particular product] … and [the] person who took the phone calls will say: no, she said [she] wanted this, and you’ve only got one word against the other, whereas if it’s ordered electronically then we and everyone can see, well this person ordered that. If the wrong products are issued, then at least they know it’s our fault because we issued the wrong product. It is in black and white what was ordered” (Blood Bank participant).
5.4 Discussion

5.4.1 The importance of context

The findings reported in this chapter highlight the following two important characteristics of the pathology departments:

- Organisational functions of the laboratories related to the receipt and traffic of specimens from different parts of the hospital.
- Scientific functions of the laboratory related to the type and volume of tests processed.

One of the distinctive organisational functions of CSR is its role as a dock for the receipt and transfer of laboratory samples. As depicted in Figure 5.1, this role meant that the department had an intermediary position between the actual test request made by clinicians and the test process stage. The findings highlighted the different reception functions of the departments, contrasting departments like Clinical Chemistry and Haematology whose receipt of orders and specimens is filtered through the CSR, with Microbiology and the Blood Bank which maintain their own reception areas requiring a regular level of contact with the wards and other clinical areas that generate requests.

The findings also revealed differences related to the scientific functions of the laboratories. For instance, both the Clinical Chemistry and Haematology laboratories are the ones most often associated with the “frontline” of pathology testing. There are similarities in the number of tests undertaken, with both receiving a large number of
urgent and life threatening (STAT) orders. But there are also important differences. Within Clinical Chemistry the test processing stage usually ends after the supply of results. But in the Haematology department, the test process does not necessarily end with the provision of an initial set of results. The department is often required to investigate further. The decision about what tests may be further needed is based on the initial test results or on patient information provided by the clinician or incorporated into the information system (Georgiou et al. 2007). In a similar fashion there are also important differences with the Microbiology department whose role is to deal with diseases caused by infectious agents. In contrast to the tight STAT time constraints encountered by Clinical Chemistry and Haematology, the concept of timeliness in Microbiology is very context-dependent. This is because an appropriate test result in Microbiology will only become available after they have had the time to grow the infectious agent.

Although it is possible to distinguish the scientific and organisational functions of the different departments, these functions should not be seen as mutually exclusive. The different scientific requirements involved will both affect and be affected by the organisational prerequisites. The Blood Bank provides a good example of this interdependence. The department not only dispenses products provided by the Red Cross Blood Transfusion Service, it also uses laboratory testing procedures to ensure that the correct product is safely provided to clinicians and dispensed to the patient (Georgiou et al. 2007). This means that the Blood Bank not only produces a test result in the same way that the other laboratories do, it is also required to dispense a product. Therefore, the Blood Bank, in collaboration with clinical staff, has an important organisational responsibility to ensure that patient details and specimens are correctly
detailed and labelled as a prerequisite to efficiently and safely fulfilling their scientific functions (Georgiou et al. 2007).

The contrasting organisational and scientific functions of the laboratories represent important contextual differences within and between the laboratories (Review of NHS Pathology Services in England 2006). This is important because the introduction of CPOE systems represents an organisational intervention whose design, implementation and utilisation will always occur within unique organisational contexts each made up of a multitude of factors (Snyder et al. 2006). The impact of a new system can vary considerably on different departments (Massaro 1993) and may dramatically affect the information environment of those involved, particularly as prior work patterns based on paper, verbal exchange, and manual methods are replaced with automated, computerised, and potentially less flexible systems (Weir et al. 2007).

This identification of important aspects of the context, or “granularity” (Kaplan 1987) of the pathology department provides the opportunity to locate the latent and generative mechanisms that may trigger (or inhibit) (Aydin 1989) the successful application and utilisation of the CPOE system. In doing so this section has laid the foundation for extending the research process to help understand the properties and surroundings required to enable subjects (clinicians, laboratory staff, information systems staff, administrators etc) to make them work, or what Pawson describes as the challenge to:

5.4.2 Generative mechanisms

Organising and planning processes

The findings presented in this chapter point to a number of work processes of intrinsic importance to each department’s functioning and output. For CSR, its “gatekeeper” role required it to ensure that each request was matched by an accompanying test specimen and relevant patient identification. The analysis of CSR Problem Specimen Reports outlined a series of potential problems (missing or error-laden forms or mismatched specimens) requiring follow up either by telephone to the ward to clarify test details, or cancellation of the test request.

For Clinical Chemistry, the organisational task of monitoring and tracking was described as an essential aspect of their throughput. The complexity of the test ordering process involving multiple test assays on blood samples means that the job of knowing where things are for retrieval and storage is vitally important. The department is also required to regularly deal with “add-on” requests from clinicians for additional test assays on already existing specimens (Georgiou et al. 2007). The add-on procedure requires the department to locate the specimen and reroute its pathway through the testing process using a series of administrative procedures. Similarly, Blood Bank staff underscored the significance of guarding the integrity of the blood products under their supervision, protecting against potential contamination while employing strict inventory control measures.
Another important theme to emerge from this phase of the research centred on the communication pathways within the laboratories and with other hospital departments and professionals. The actual ordering process itself can be conceptualised as part of a collaborative effort involving multidisciplinary groups (Gorman et al. 2003). Each department reported on one or many communication requirements that they considered to be important to their functioning. These requirements included synchronous channels where exchange occurs at the same time and asynchronous, involving different time frames as with a notice placed on a board (Coiera 2006). For CSR and the departments which maintained independent reception functions (Microbiology and the Blood Bank) communication patterns involved regular, and often intensive telephone contact with clinical staff. The reception areas are the first point of call for laboratory test enquiries from across the hospital. For the Blood Bank the telephone was considered to be a crucial part to virtually every aspect of the ordering, production and dispatch cycles of their work.

Communication pathways can also rely on asynchronous channels involving clinical notes and messages. Traditionally, the typical format through which this transfer of information occurs has been the hand-written test request form. Aside from their obvious clerical function, these forms can contain clinical notes containing important contextual data about patients that are conveyed between clinicians and pathology staff (Deeble & Lewis-Hughes 1991). The comments of participants reported above underscored the importance of clinical notes particularly for the Microbiology and Haematology departments because of their potential impact on the choice of tests.
undertaken, their urgency and even for interpretation of results. Indeed, as Hardwick points out, a key feature of the role of the pathology laboratories is to incorporate these notes into the process of providing clinically meaningful results to clinicians that can aid the dispensing of effective patient care (Hardwick 1998). The level and richness of information transfer within new CPOE systems and its ability to successfully replicate and enhance previous communication channels is therefore an important area of research.

**Temporal considerations**

Time considerations were the other element of the pathology departments’ work processes that featured strongly in the findings of this phase of the study. The concept of time took on contrasting emphases within the different departments. For instance, the Haematology and Clinical Chemistry departments emphasised the importance of life threatening (STAT) and urgent tests that they are routinely required to deal with. Turnaround time is a commonly used indicator of laboratory performance (Manor 1999), which can measure different aspects of the pathology process from the time a physician issues a request to the collection of a sample, to its arrival in the laboratory, its processing, right up to the time a validated result is issued (Georgiou et al. 2007). The timeliness of this process is also regarded as an important factor influencing physicians’ satisfaction with the pathology process, particularly as in some circumstances (eg, intensive care and emergency departments) it can have a major influence on the time to patient diagnosis or treatment (Howanitz & Howanitz 2001; Steindel & Howanitz 2001).
Temporal issues, however, are not always present in neat, easy-to-measure formats. Sometimes they can appear in the form of workarounds whereby new tasks are adopted to deal with unforeseen circumstances (Ash et al. 2003). For instance, as noted by one of the respondents, even a slight increase in the number of add-ons within the laboratory has the potential to trigger a series of other time consuming activities, including the task of finding the correct specimen for which an add-on is required. The additional time taken to undertake this task can have other consequences particularly if it leads to more calls from clinicians enquiring about the delays in order results (Georgiou et al. 2007).

Temporal issues can also take on different forms. Generally, we are accustomed to measuring time linearly in the form of a scale that indicates the length of behaviour, experience or action. But temporal issues can also take cyclical or spiralling formats that do not synchronise with other activities or timeframes (Hesse et al. 1988). For instance, a large factor in the Microbiology department’s conception of time is related to the time it may take for a culture to grow. Thus turnaround time for this department needs to be understood contextually. In other circumstances, the ability to successfully undertake tests is limited to a set time period, after which the specimen may lose its viability and is no longer accessible to the appropriate reagent.

5.4.3 Organisational communication as an evaluative framework

The discussion to date has enabled the identification of a set of latent mechanisms as illustrated in Figure 5.6, incorporating: a) organisational processes such as monitoring and tracking; b) communication processes including writing, phoning and messaging procedures; and c) temporal processes which can have either linear or cyclical formats.
Elements of each of the categories are featured across all pathology departments albeit in different and department-specific ways. The importance of the categories and their impact on the introduction of the new CPOE system will be explored in the following sections of this study.

While the different categories can be investigated as separate entities, it is also important to take into account their relationship to each other as a whole, comprising of an interdependent set of components and processes that interact over time (Eisenberg & Goodall 2004). Organisations are, after all, vehicles for converting inputs into outputs with formal requirements that involve aspects of information processing, communication, decision and control (Kimberly 1979; Beniger 1990). According to Euske and Roberts:

“… communication underlies most organizational processes, contributes to both the development and the enactment of structures, and is shaped by a number of organizational and individual characteristics, including size, department, autonomy, and upward aspirations. Without communication, organizing could not occur” (page 42) (Euske & Roberts 1987).
Information and communication processes are essential cornerstones of all organisational activities and consequently provide a valuable perspective with which to investigate and understand those activities (O'Reilly & Pondy 1979). This is particularly so in healthcare which consists of a collaborative set of actions that are underpinned by communication within and between members of specialised occupational groups for the coordination of patient care (Davidson 2000). So too with pathology services, which are information-intense units reliant on the efficient management and timely communication of relevant information to maximise the delivery of patient care (Review of NHS Pathology Services in England 2006).

The introduction of new information and communication technologies has major implications for pathology laboratories and their role in the delivery of healthcare. Fulk
and DeSanctis outline five features of new technologies, each of which has the potential to drive changes in organisational processes:

- Speed of communication and the efficient transfer of higher volumes of data
- Reduction in the costs of communication
- Rise in communication bandwidth allowing for more information down a common communication channel
- Vastly expanded connectivity
- Integration of communication with computing technologies allowing the linkage and storage of information across multiple sources (Fulk & DeSanctis 1995)

CPOE systems contain all of these elements. The evidence of their impact shows that they can alter the content and patterns of interactions between departments, resulting in both beneficial outcomes, such as increasing speed of communication, alongside possible detrimental outcomes, such as interdepartmental friction (Aydin 1989; Aydin 1994). They can also produce situations that affect communicative practices, such as the need to work collaboratively to sustain a common database (Aydin 1994) or to sustain previously existing data sources (Georgiou et al. 2007) (Davidson 2000).

The evaluative framework includes a temporal component recognising time as a crucial but often neglected component of organisational communications. According to Fisher, the failure to deal with temporal concerns is not due to simple disregard by researchers, but has more to do with the complexity and multi-dimensionality of the topic (Fisher 1978). Weir et al. provide a valuable description of its importance for pathology departments and its impact on organisational communication patterns:
“…all tasks have a **time component**, including when they are due, length of
time to complete the task (a test can be ordered, scheduling requires a 2-week
wait) or in the case of repetitive tasks (e.g., ordering monthly narcotics), the time
interval. Often everyone in the clinic knows the time component implicitly
because it is commonly held clinical knowledge (e.g., the time from a Coumadin
change to the next INR test). Time information is an integral part of interpreting
information and is always sought after if it is not available. When the
information is not so clearly known, such as how long it has been since a patient
has been called, or how many times a test has been repeated, then providers
often need to resort to verbal communication” [Emphasis in original] (page 69)
(Weir et al. 2007).

5.5 **Conclusion**

This chapter has established an evaluation framework based upon the key organisational
communication categories of: a) Organising, planning and controlling; b)
Communication networks; and c) Temporal considerations. These categories emerged
from the results of the investigation of the contextual setting of each of the departments,
which revealed similarities and dissimilarities between the pathology departments. In
some cases the differences were related to the different aspects of the department’s role
in the pathology test order process. For instance, those departments which had
specimen reception areas as a first point of call were also charged with “gatekeeper”
responsibilities. In other cases, the differences were associated with the scientific nature
of the work which affected the type of work, the nature of communication and
sometimes its temporality. Each of the laboratories reported on the importance of communication structures both within the department and across the hospital ward setting. These communication channels varied between the synchronous and asynchronous.

The value of exploring the contextual settings of each of the departments is that it has identified a series of mechanisms (albeit latent) that can be used to monitor, test and ultimately explain the effect of a CPOE system on work processes and outcomes. In some cases these mechanisms were common to each department. For instance, the change over to more asynchronous communication channels replacing hand-written paper requests is expected to have a major beneficial effect. However, the replacement of telephone call communication in situations such as the Blood Bank, may be more problematic. Similarly how the new system integrates with the organisational characteristics of the departments, such as how test specimens are tracked through the laboratory, is also an important latent mechanism. The findings also point to the importance of temporal factors in understanding departmental functions. This is because time is a critical ingredient of how departments organise, plan and undertake their work. Any disjunctions in this area are likely to have important (direct and indirect) repercussions.

The chapters to follow will utilise the framework (depicted in Figure 5.6) to explore the impact of CPOE, fully expectant that in the process the framework will itself be developed and fine-tuned. A series of case study exemplars will delve deeper into the impact of CPOE on, and across the pathology departments, with the aim of identifying key outcomes consistent with the research questions established by this research study.
Chapter 6 Central Specimen Reception – gatekeeper for the pathology laboratory service
6.1 Introduction

The preceding investigation of the different laboratory settings in Chapter 5 reported on the contextual backdrop of the pathology service. It drew attention to the contrasting scientific and organisational aspects of the pathology process which affect the way that work is undertaken. These findings led to the construction of an initial framework, focusing on the organisational, communication and temporal functions of the pathology service. This framework will be used as part of an in-depth examination of the impact of CPOE on each of the departments, beginning with the Central Specimen Reception (CSR) area of the laboratory service.

In Chapter 5 CSR was described as a receiving dock where laboratory test requests and specimens are received and forwarded on for processing. Prior to the implementation of CPOE this meant that the department was charged with the responsibility of ensuring that all details regarding the test were entered into the system. Blood collection personnel who worked within CSR identified and removed duplicate requests made in error by clinicians. The department also had the role of identifying “problem specimens” which, as described earlier, can include missing forms, request errors, missing specimens or even specimen errors.

It was noted that the organisational components of the department’s role were also closely aligned to its communication requirements. Hence, CSR (along with other departments with their own reception functions) regularly deal with a stream of telephone call enquiries from clinical staff. All of these organisational and communication factors are themselves subject to temporal requirements which in the laboratory environment are linked to issues like blood collection times, external
laboratory specimen dispatch and arrival times and urgent test requirements, all of which add their own level of complexity to the operating environment.

The aim of this chapter is to examine the impact of CPOE on CSR with specific regard to the performance and organisational dynamics of the department – what changed (and how much) with the new system and how were these changes negotiated and managed. The chapter is divided into qualitative and quantitative sections. This provides a means of highlighting key issues as identified by CSR participants and where possible, using performance metrics to measure and monitor them. The discussion section of the chapter addresses a series of emergent themes from both the qualitative and quantitative studies and the role they play in CSR work processes. These themes are then used to assess the communications environment in CSR, the effect of the new CPOE system, how the department dealt with the challenge of the new technology and how it negotiated its response. Finally, the chapter revisits the organisational communication framework outlined in Chapter 5 and uses the findings of this case study to consider its validity and refine its features.

6.2 Methods

6.2.1 Procedures

Two distinct parts of research are reported in this chapter. The first part involved the extension of qualitative work using focus groups, interviews and participant observation sessions begun in the period prior to the system changeover and CPOE implementation.
The second part identifies key metrics which are used to monitor the performance of the department.

**Qualitative methods**

In the period since the system changeover on 22 November 2005 until 29 October 2007, there were 21 separate interviews undertaken involving nine people. There was also one focus group held with three blood collection staff. The focus group and three of the interviews were taped and transcribed, resulting in 34 transcript pages (A4 single spaced) and 13,991 words. In addition 14 observation sessions lasting from between 15 minutes to one and one half hours were undertaken, resulting in over eight hours of observation. Interview sessions were often supplemented by observations embedded into the interview process. This involved the demonstration and visualisation of topics discussed (Weir et al. 2007).

**Quantitative methods**

*Telephone communications*

Hospital communication data logs listing the number of incoming and outgoing calls per month for all CSR phones and fax machines were obtained. These summaries were grouped into five quarters beginning in June – August 2005 and ending June – August 2006. This allowed a comparison of telephone call volumes for the period before and after the 22 November 2005 system changeover.
Unfulfilled test requests

All laboratory unfulfilled test request forms were collected and audited for the period September 2005 to March 2006. The number of unfulfilled test requests for each month was then compared with the total number of test requests for the same period to ascertain their impact relative to the total number of requests received as per the formula shown below.

\[
\text{Total n unfulfilled requests (given month)}/\text{Total n of requests (given month)}
\]

Data were entered into Excel and regular checks of 10% of all data entry were carried out to confirm accuracy.

6.2.2 Analysis

Statistical significance of differences were tested using the Chi-square test for independence with the Yate’s Correction for Continuity for 2X2 tables (Pallant 2001) using SPSS version 15 (SPSS 2007).

6.2.3 Performance measures

The total and average number of incoming and outgoing calls per telephone/fax line were analysed by three-month (quarterly) periods. The proportion of unfulfilled requests to the total number of tests over each month was also calculated. To aid the longitudinal overview of these data, the month of November (unfulfilled requests) and
the September-November quarter (telephone calls) were included as part of the pre-
implementation period. However, the Chi-square tests comparing types of unfulfilled
requests during the pre- and post- periods used 22 November 2005 as the delineator
date.

6.3 Results

6.3.1 Qualitative findings

Introduction of new system

In the initial months of CPOE implementation the laboratories confronted a transitional
period where hand-written requests and electronic orders were performed in unequal
proportions across the hospital. This situation severely affected traditional temporal
work processes and specimen delivery cycles, as described by one staff member:

“At times you don’t know where to start first. There’s the Lamson [pneumatic
tube for delivery of specimens] going and there’s full courier buckets [each with
alternate] arrival times … and sometimes in the morning it gets quite hectic”
(CSR participant).

This “interregnum” brought with it a period of uncertainty lasting several weeks
regarding who was responsible for identifying and stopping unintended duplicate
orders. Whereas previously, CSR staff were able to “weed out” duplicates (as described
in Chapter 5), the initial implementation period had blurred this area of responsibility.
This is because hand-written requests were now taken away from the ward to be
electronically entered elsewhere and then printed out as collection sheets for the blood collection rounds. Clinicians used to be able to check the laboratory order box to see if a test for a patient had been issued prior to a collection round. But this simple accountability procedure ceased and led to the situation described below:

“Now, of course the doctors don’t remember what they’ve written out, and they also want to make sure that they get things into the collection run, so they seem to be writing out more forms and they’re writing out ones for a number of days in advance” (CSR participant).

**Unfulfilled test requests**

CSR blood collectors perform two rounds of specimen collections per day (8.00am and 1.00pm). In the pre-CPOE period, this involved the blood collectors visiting a ward to access the hand-written requests (usually stored in a special filing basket or box). The collectors were required to check the details of the request, match the hand-written request with the patient, and then proceed with the collection. On occasions where the collector was not able to carry out the blood collection, an explanatory notation was made on the request form which was then returned to the CSR area. A test request could be unfulfilled for a number of reasons; it could be a duplicate test request inadvertently made for the same patient by different clinicians; it may have been cancelled by the clinician; or it may have been rescheduled because the patient was unavailable at the time. These unfulfilled requests were stored at the CSR for a period of several months and then destroyed.
This procedure changed with the implementation of electronic ordering. CSR introduced a “Central Specimen Reception Forms Manual” (see Appendix 6) to record all instances where a test request was unfulfilled. These forms asked the collector to record the details of the episode, including patient identification, ward and date, and to describe the reason for not collecting a specimen. The form provided the following choices:

1. Difficult collection
2. Patient refused
3. Patient unavailable
4. Patient aggressive
5. Patient not fasting
6. Other

The forms also required the collectors to record whether the collection was rescheduled or cancelled, along with the name of the responsible clinician. The data from these forms were then entered electronically into the CPOE system. A major reason for the introduction of the new procedure was to provide a level of accountability between the laboratory and the ward about the status of each test:

**Researcher:** “So you need to be able to record what was happening in case a doctor asks what happened to it?”

**CSR participant:** “... that’s exactly right, to find a reason why they cancelled … At least they see a reason, if we re-schedule they don’t see it. They just see that
there’s an order still pending, but they don’t see that we’ve re-scheduled. That’s more of a problem. And then they ring up and ask what’s happened to it”.

**Telephone calls**

In the two months following the system changeover, CSR participants commented that there had been a noticeable increase in telephone calls from clinicians. They believed this was due to clinician uncertainty about the status of laboratory requests along with unfamiliarity with the functioning of the new system:

“Initially, we had a lot of phone calls, just about how the system worked” (CSR participant).

And the reasons for this were put down to:

“… [clinicians] not knowing the system. We are the first point of call, obviously. We’ve had a lot of those, they’ve calmed down a little bit now” (CSR participant).

**Efficiency and accuracy**

CSR participants also reported on a number of improvements in the efficiency and accuracy of collection procedures. This was especially the case for blood collectors as described by the CSR manager:
“They would come in at 6 o’clock in the morning and head to their normal wards. There was no preparation prior to that, their trolley was ready. Off they would go on their run to whatever wards they were supposed to go. They come in now at 6 o’clock, they have to basically sort the collection print outs (it’s printed out at 5.30). They have to split it up, usually it comes out in runs, but they have to split the runs first of all, and the collector for each ward would split up their individual patients. So even though that seems to be more time consuming, when they get to the ward it’s a quicker process. In the ward, normally, prior to that they would have to get a form, they’d check the patients’ ID, collect it, handwrite it, so they have to handwrite everything” (CSR participant).

For the blood collection staff this was a preferable, more efficient way of operating:

“I like the system because when you collect, what you do is stick the sticker on straight away, whereas with [the] old system we have to write everything, the surname, the name, and their MRN [Medical Record Number], and sometimes we make a mistake writing the surname, especially with long surnames and middle names, and sometimes with the numbers as well. We’re just human beings who make mistakes, but with this new system it’s really, really good” (CSR participant).
6.3.2 Quantitative findings

The emergent themes reported from the qualitative research were then investigated through the use of quantitative measures.

**Telephone communication**

Table 6.1 shows the number of outgoing and incoming telephone and fax calls per quarter alongside their proportion to the total number of test requests for each period. The data shows that there was a dramatic rise in the in the number of outgoing calls from 2037 in June – August 2005 to 3061 in December 2005 – February 2006 and 5850 in June – August 2006. The corresponding figures for incoming calls was 1268 in June – August 2005, 4871 in December 2005 – February 2006, and 10,678 in June – August 2006. This pattern was also evident when the numbers of outgoing and incoming calls were compared as a proportion of the total number of requests for each period. Hence, in June – August 2005 the proportion was 0.02 and 0.01 for outgoing and incoming calls respectively. By the December 2005 – February 2006 quarter this had risen to 0.03 and 0.04 and by June – August 2006 to 0.05 and 0.09.

<table>
<thead>
<tr>
<th></th>
<th>No. total requests</th>
<th>No. outgoing calls (Proportion to total requests)</th>
<th>No. incoming calls (Proportion to total requests)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun-Aug 05</td>
<td>121290</td>
<td>2037 (0.02)</td>
<td>1268 (0.01)</td>
</tr>
<tr>
<td>Sep-Nov 05</td>
<td>121372</td>
<td>2872 (0.02)</td>
<td>4054 (0.02)</td>
</tr>
<tr>
<td>Dec 05 - Feb 06</td>
<td>111703</td>
<td>3061 (0.03)</td>
<td>4871 (0.04)</td>
</tr>
<tr>
<td>Mar-May 06</td>
<td>118290</td>
<td>6078 (0.05)</td>
<td>10683 (0.09)</td>
</tr>
<tr>
<td>Jun-Aug 06</td>
<td>125334</td>
<td>5850 (0.05)</td>
<td>10678 (0.09)</td>
</tr>
</tbody>
</table>

Table 6.1: Total number of calls per telephone/fax of incoming/outgoing phone calls and their proportion of total requests for the quarters June – August 2005 to June – August 2006 (pre-implementation quarters shaded)
Unfulfilled test requests

There were 4794 unfulfilled test requests for the period September 2005 to March 2006. Table 6.2 shows that the number of unfulfilled test requests rose sharply from 356 in the pre-implementation month of September 2005, to a peak of 1543 in December 2005, and then fell to 143 in March 2006. There was a similar trend in the proportion of unfulfilled test requests to total test requests, rising from 0.008 in September 2005 to 0.04 in December 2005 and then decreasing to 0.003 in March 2006. Chi-square tests with Yates correction for continuity were undertaken to statistically compare the data for each month with the one preceding it. The only month which did not record a significant change in the number of unfulfilled requests was the September – October 2005 period.

<table>
<thead>
<tr>
<th>Month</th>
<th>No. unfulfilled requests</th>
<th>No. total requests</th>
<th>Proportion</th>
<th>χ²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-05</td>
<td>356</td>
<td>42066</td>
<td>0.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct-05</td>
<td>323</td>
<td>39551</td>
<td>0.008</td>
<td>χ²=0.180; p = 0.67</td>
<td></td>
</tr>
<tr>
<td>Nov-05</td>
<td>395</td>
<td>39755</td>
<td>0.010</td>
<td>χ²=6.60; p&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>Dec-05</td>
<td>1543</td>
<td>38129</td>
<td>0.040</td>
<td>χ²=709.92; p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Jan-06</td>
<td>1234</td>
<td>36559</td>
<td>0.034</td>
<td>χ²=21.64; p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Feb-06</td>
<td>800</td>
<td>37015</td>
<td>0.022</td>
<td>χ²=94.99; p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Mar-06</td>
<td>143</td>
<td>42513</td>
<td>0.003</td>
<td>χ²=547.06; p&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.2: Number of unfulfilled requests (pre-implementation months shaded). Chi-square tests (with Yates correction for continuity) for each month are compared with the preceding month

The number of cancelled and rescheduled requests was also compared over the pre- and post-implementation periods as shown in Table 6.3. In the pre-implementation period, rescheduled requests amounted to 4% of all unfulfilled requests (26/698). This proportion rose to 24% of all unfulfilled requests (969/4096) post-implementation.
Cancelled requests fell from 96% of the total pre-implementation number (672/698) to 76% (n=3127/4096) in the post-implementation period ($\chi^2 = 142.9; \text{df} \ 1; \ p<0.0001$ (Yates correction)). There was also a significant decrease in the proportion of duplicate requests from 69% (484/698) to 35% (1448/4096) ($\chi^2 = 284.9; \text{df} \ 1; \ p<0.0001$ (Yates correction)).

<table>
<thead>
<tr>
<th></th>
<th>Pre-implementation</th>
<th>Post-implementation</th>
<th>Statistical test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of test requests cancelled</strong> (includes: Cancelled by clinician; Duplicate request; Patient or family refused; Patient discharged; patient deceased)</td>
<td>96% n=672</td>
<td>76% n=3127</td>
<td>$\chi^2 = 142.9$ (df 1) \ p&lt;0.0001</td>
</tr>
<tr>
<td><strong>Number of test requests rescheduled</strong> (includes Patient unavailable; Difficult collection; Patient did not fast)</td>
<td>4% n=26</td>
<td>24% n=969</td>
<td>$\chi^2 = 286.4$ (df 1) \ p&lt;0.0001</td>
</tr>
<tr>
<td><strong>Number of duplicate requests</strong></td>
<td>69% n=484</td>
<td>35% n=1448</td>
<td>$\chi^2 = 286.4$ (df 1) \ p&lt;0.0001</td>
</tr>
<tr>
<td><strong>Number of non-duplicate requests</strong></td>
<td>31% n= 214</td>
<td>65% n=2648</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.3: Comparison of cancelled or rescheduled and duplicate test orders as proportions of all unfulfilled requests. Chi-square test results contain Yates correction for continuity

### 6.4 Discussion

The results show dramatic shifts in the number of telephone calls and unfulfilled test requests from the period prior to the system changeover and extending some months later. These changes had an impact on the synchronous and asynchronous channels of communication with consequences for work processes in the department.
6.4.1 Synchronous communication

The results of the comparison of telephone calls revealed a major increase in the number of incoming and outgoing phone calls associated with the introduction of the new reporting system in November 2005 followed by the new ordering system in January 2006. This was particularly noticeable for the number of incoming and outgoing calls when considered as a proportion of the total number of requests received for each given period. This implies a rise in the level of activity within the department.

The findings from this case study contrast with those reported from a study undertaken by Ostbye et al. in Akershus in Norway, which found that the number of telephone calls from the intervention ward (with CPOE) did not show any clear change in calls after implementation and even began to experience a decrease after 11 weeks (Ostbye et al. 1997). However, other studies, not limited to pathology settings, confirm that changes in modes of communication brought about by the introduction of asynchronous CPOE order channels can indicate levels of disruption and dysfunction (Beuscart-Zephir et al. 2005). A study of a pathology order entry system by Davidson described how the generation of laboratory orders, although a routine feature of clinical practice, is nevertheless a procedure involving communication between a number of professions and departments and has the potential to disrupt existing patterns of communication (Davidson 2000).
6.4.2 Asynchronous communication

In the pre-implementation period the recording of a reason for an unfulfilled test request was generally *ad hoc* and inconsistent. This procedure was standardised after the introduction of the new results reporting system on 22 November 2005. The introduction of structured information allows clinicians to electronically monitor the status of requests. It also produces a higher level of CSR/ward accountability. However, the rise in the volume of telephone calls beginning with the system changeover (November 2005) followed by the new order entry system (January 2006) suggests that the phone was still used heavily by clinicians as a means of monitoring the status of test requests. This may have been in part a transitory phenomenon associated with the implementation period alongside initial unfamiliarity with the new system (Davidson & Chisman 1999).

While the proportion of unfulfilled requests increased dramatically following the system changeover on 22 November 2005, it fell after a few months to levels below those found previously. This initial rise was possibly caused by the instability associated with implementation. Davidson’s study in 2000 reported on a CPOE system with limited ability to consolidate orders which resulted in the issue of duplicate and overlapping orders. This situation caused friction between laboratory technicians and nurses about whose responsibility it was to consolidate such orders (Davidson 2000). On the other hand, the significant decrease in the relative proportion of duplicate requests points to the existence of a fundamental change associated with the new system. This supports existing evidence that CPOE can help to reduce the level of unnecessary and duplicate requests (Bates et al. 1999).
The fall in the number of cancelled requests as a proportion of all unfulfilled requests is more complicated. There are instances where it is obviously necessary to cancel a test request. Such an occasion occurs when a patient is discharged or a test request has been duplicated by mistake, or even when a physician decides to cancel a request. However, not all unfulfilled requests need to be cancelled. For instance, a patient may be temporarily unavailable or may not have fasted, or there may have been a situation where a collection was not possible. A patient may not be available for a blood collection for no other reason than they were undergoing treatment in another part of the hospital at the time. The decrease in the relative proportion of cancelled requests is therefore likely to be a consequence of the replacement of previous ad hoc monitoring systems with improved reporting structures associated with the new system.

6.4.3 Laboratory impact

CSR occupies a specific organisational role in the laboratory test process, sitting between the clinician’s decision to make a test request and the actual processing of the specimen (Georgiou et al. 2007). Its responsibilities include the need to maintain maximum levels of coordination (of information and specimens), as well as preserving the integrity of the test request. This in turn involves attention to accuracy and requires high levels of accountability and efficiency. The results of this study (as depicted in Figure 6.1) show that CPOE can impact on these areas of responsibility. This can occur through the introduction of structured ways of entering data which can lead to improved levels of coordination and accountability (Georgiou et al. 2008). It can also lead to changes in the efficiency of work processes, especially through its ability to reduce
duplication. However, these changes are not necessarily consistent. The increased levels of telephone and fax communication in the department associated with the arrival of the new system suggest that it may also severely affect work load levels.

![Figure 6.1: Impact of CPOE on Central Specimen Reception work process](image)

6.4.4 Organisational communication environment

In the previous chapter CSR’s role as a “gatekeeper” was described. This role ensures that each request is matched by an accompanying test specimen and relevant patient identification. CSR can be described as a de facto “guardian” of the test ordering process, charged with the responsibility of ensuring accuracy, efficiency and integrity of the specimen/order process. This forms an important part of the contextual background (Pawson & Tilley 1997) of the department with major implications for its mode of operation and performance. The department is the first point of call for clinicians enquiring about the status of test orders. This contact between the reception area, the other processing laboratories and the wards confirm that the ordering process is part of a collaborative effort involving multidisciplinary groups across the healthcare setting (Gorman et al. 2003), requiring extensive communication within and between specialised groups and departments to coordinate patient care (Davidson 2000).
Communication environment

Communication processes can be described as the social glue that fastens organisations together (Euske & Roberts 1987). This is because they play an essential role in helping people make decisions, and to comprehend, coordinate and control their environment (O'Reilly & Pondy 1979). Organisational functions and requirements can be severely affected by the introduction of a new ICT system whose functions may intrude on the way an organisation will undertake tasks such as information processing, communication, decision-making and control (Beniger 1990). Every new ICT implementation, upgrade or modification involves its own unique set of organisational challenges and underlines why organisational communications perspectives can contribute much to the study and evaluation of the impact of ICT systems. One such perspective outlined by Huber and Daft provides a valuable template (Huber & Daft 1987) with which to examine this environment through a consideration of the following factors:

1) Communication and information load (ie, the quantity, ambiguity and variety of information to be communicated).

2) Complexity (ie, the number of relevant actors or components, their diversity and interdependence).

3) Turbulence and the degrees of instability and randomness experienced.

The findings from this study, as summarised in Table 6.4, reveal that the introduction of the new CPOE system involved significant changes to the communications environment
of CSR affecting the information load and complexity of their work processes. The most basic indicator of the information load of an organisation is usually associated with the quantity of information received (eg, number of messages required). It also has the potential to introduce levels of ambiguity, particularly where there is a potential for multiple interpretations of a symbol or message (Huber & Daft 1987). This can trigger unintended shifts in authority, decision making, or role interactions (Barley 1986; Davidson 2000; Georgiou et al. 2007).

**Information load**

CSR participants reported that the new system had minimised data entry and enhanced the efficiency of their work processes, leading to greater levels of accuracy. However, in doing so the new system had also introduced its own new data gathering requirements associated with the recording of all instances where blood collection was unable to be performed. This new task may have added to the department’s workload even while improving the level of accountability for unfulfilled tests, particularly important for communicating the status of orders to clinicians. Other research in this field undertaken by Davidson refers to this issue as one of the major challenges for CPOE system designers, ie, how to balance the need for communication flexibility with the requirement for highly structured, systematic data (Davidson 2000).
Table 6.4: The impact and outcome of CPOE on information load, complexity and turbulence of the CSR environment

Complexity

The increased information load is closely associated with an increase in levels of complexity. Complexity can be monitored according to factors such as numerosity (number of components involved); the diversity of these components and their interdependence (Huber & Daft 1987). The findings revealed that not only had the new CPOE system introduced a new level of responsibility leading to increased levels of numerosity and accuracy, it had also increased the diversity and interdependency of relations, particularly through opening up a new electronic mode of communication with clinicians which allowed them to monitor test results.
**Turbulence**

Finally, this study detected an initial period of turbulence whereby the new system led to changes in work responsibilities and unpredictability. This occurred during the interregnum period where hand-written and electronic ordering existed simultaneously leading to: 1) levels of ambiguity about test order status; and 2) an increase in the number of duplicate orders. The department responded to this period of turbulence through the adoption of new negotiated roles of responsibility which included measures to ensure that all unfulfilled tests were accounted for and accurately recorded.

### 6.4.5 Limitations

The choice of performance indicators in this case, the monitoring of telephone/fax communications and unfulfilled orders can be affected by issues of data comprehensiveness and reliability. This study has endeavoured to offset these potential limitations through rigorous attention to the accuracy and completeness of the data, and through triangulation of methods using different data sources to identify and overcome potential deficiencies (Bowling 1997).

### 6.5 Conclusion

Communication between departments and individuals across the hospital setting may be all pervasive but are often overlooked, or taken for granted (O'Reilly & Pondy 1979). This chapter used performance metrics that monitored telephone and fax call traffic and the proportion of unfulfilled tests requests within the CSR department before, during
and after the implementation of CPOE, as a means of measuring changes in communication processes between the department and the rest of the hospital. It found that the total number of incoming and outgoing calls increased dramatically after implementation. While the number of unfulfilled test requests rose after the implementation of the new system, they fell after three months to below pre-implementation levels. There was also a significant change in the relative proportion of duplicate and rescheduled requests between the before and after periods, pointing to important changes in the way that CSR processes and manages test requests. Such performance metrics are valuable for identifying trends or potential problems.

The successful design of information systems in healthcare should be based on a robust comprehension of the practices in which the systems are to function (Berg & Goorman 1999). As amplified in this chapter, the processing of information can occur either synchronously or asynchronously. Inadvertent or unplanned changes in the mode of communication can have a major impact, leading to unintended consequences and possibly dysfunction, requiring early detection and response. This is particularly so for pathology laboratories whose contribution to the delivery of quality patient care relies on the efficient management and timely communication of relevant information (Review of NHS Pathology Services in England 2006).

Communication activities are used by organisations in the decision-making process, to help them control internal activities and to bring meaning to their environment (O'Reilly & Pondy 1979). In this context, the introduction of new technology (such as CPOE) can significantly affect key aspects of organisational structure and process (Culnan & Markus 1987; Davidson 2000). The organisational communication environment
(defined as information load, complexity and turbulence) (Huber & Daft 1987) is an important area of attention, not only because it provides an insight into how organisations plan and carry out their business but also as an important index of change. It is this environment that is most likely to be affected by new ICT systems like CPOE.

The study of CSR has provided the first setting for testing and refining the organisational communication framework set out in Chapter 5. The framework provided an initial perspective with which to view the challenges and changes brought about by the introduction of CPOE. This can be a valuable aid for the investigation of how an organisation negotiates, plans and carries out its activities and relationships in the face of major changes to pre-existing organisational practices. As Figure 6.2 illustrates, the investigation of CSR has also provided scope for the framework to be refined and sharpened, drawing attention to the importance of the communication environment of organisations and patterns of synchronicity.
This case study employed a multi-method approach incorporating both qualitative and quantitative methods as a means of exploring not only the size, extent and duration of the effect of CPOE, but also how the impact was perceived by participants. This was an important means of helping to explain why CPOE had the effect it did. The advantage of such an approach is that the different methods can be used to inform and validate each other. For instance, interviewing and observing participants can assist in the task of identifying indicators for measuring and monitoring effects, while conversely, the quantification of the size of the effect can in turn assist the process of generating issues for discussion and follow up.

The following chapters will extend the study to explore the factors highlighted here, this time including departments which (as identified in Chapter 5) have different organisational priorities, needs and tasks. This will allow the study to consider how the experience of the CSR relates to other pathology departments while simultaneously investigating new processes and tasks not present in the CSR environment.
Chapter 7 Clinical Chemistry and Haematology – organisational frontline of the pathology testing process
7.1 Introduction

The previous chapter investigated the impact of CPOE on the Central Specimen Reception (CSR) department, focusing on aspects of its “gatekeeper” responsibilities for ensuring the accuracy, efficiency and integrity of the laboratory test process. The organisational communication framework was used as a means of quantifying, assessing and explaining the changes brought about by the introduction of CPOE. This process was able to highlight relevant aspects of the framework to CSR function while also adding some new dimensions – effectively helping to test and fine tune the framework’s applicability. The chapter drew particular attention to the impact of the CPOE system on types of communication exchange (ie, synchronous and asynchronous) and its effect on the communication environment (information load, complexity and turbulence) of the department.

In this chapter the research focus moves to the Clinical Chemistry and Haematology departments, described earlier as the “frontline” of pathology testing. Between them, these two departments constitute a significant proportion of the pathology service’s workload. These departments are required to undertake a large number of urgent tests, sometimes involving life-threatening conditions. The initial phase of the research reported in Chapter 5, identified the role organisational factors such as the tracking, retrieval and storage of specimens played in the functioning of both departments. It also noted that while the Clinical Chemistry test process usually ends after the supply of results; within the Haematology department, the test processing stage may trigger the need for further tests. Processes such as add-on requests made by clinicians for additional test assays on existing specimens can have a major impact on laboratory
efficiency, and may be a consequence of poor laboratory/clinical communication processes. The aim of this chapter is to investigate the impact of CPOE on the organisational and communication make up of the Clinical Chemistry and Haematology departments, with particular reference to the effect of CPOE on issues such as add-ons and tracking.

The research in this chapter incorporates both quantitative and qualitative methods which are used to describe and explain the impact of CPOE on both departments, and where possible to quantify them using available data abstracted from the laboratory information system. The chapter incorporates a description of the methods used for this part of the research. It is followed by a report of the findings, drawing attention to areas of similarity and dissimilarity between the two departments. Emergent themes from the findings are then discussed and assessed in the context of the effect of the new system on the way Clinical Chemistry and Haematology operate. The chapter then proceeds to apply these findings to the organisational communications framework, drawing out the implications of the findings and modifying the framework accordingly.

7.2 Methods

7.2.1 Research setting

The setting for this section of the study was the Haematology and Clinical Chemistry departments of a pathology service based at a major Sydney metropolitan tertiary referral and teaching hospital. Both departments employ approximately 35 staff (including scientific, technical and ancillary staff). Clinical Chemistry would normally
process between 1200 – 1400 specimens per day from across the whole area health service and Haematology approximately 1200 specimens per day.

### 7.2.2 Procedures

The study adopted a formative design (Scriven 1991) with the objective of investigating the introduction of the new system in the course of its preparation and implementation during 2006. Qualitative and quantitative methods were used to study both departments. The qualitative methods incorporated focus groups, interviews and participant observation as a means of understanding the influence of social and organisational factors and how users perceive and experience the system (Kaplan & Maxwell 1994).

#### Qualitative methods

The study included one focus group consisting of five Haematology hospital scientists and a series of individual interviews involving twelve senior laboratory scientists and managers from the Haematology (n=9) and Clinical Chemistry (n=3) departments. There was a total of 31 interview sessions carried out. Interviews were carried out systematically over the course of the study and were often repeated for clarification purposes. This process provided the researcher with the ability to investigate the relevance and validity of emerging themes. Six of the interview sessions were taped and transcribed. This resulted in 115 single spaced A4 pages and 57,840 words. Research notes of all interviews and the focus group were recorded in a log with memos reflecting on the data and the research process.
There were six formal observation sessions lasting between 10 minutes to an hour and
totalling two hours, carried out across the two departments. These were supplemented
by observations that were embedded into the interview process (Weir et al. 2007). This
usually involved demonstrations and visualisations of issues discussed. Notes from all
the observation sessions were recorded in the researcher’s log.

Quantitative methods

An add-on test can be defined as an additional assay performed on a previously
analysed specimen (Melanson et al. 2006; Georgiou et al. 2007). As explained in
Chapter 5, an add-on test can occur for a number of reasons, ranging from a physician
seeking to avoid an unnecessary venepuncture on a patient, or because they needed to
compare results over time, or even as a result of having previously forgotten to order a
test. All add-on tests for the pathology department that came from the hospital site
under investigation were identified and abstracted from the laboratory information
system for 2006. Table 7.1 lists associated variables that were also used in the data file.
Table 7.1: List of variables associated with add-ons extracted from the Laboratory Information System

Figure 7.1: The distinction between a specimen, test and add-on test

Pathology laboratory data can be categorised either by: 1) the number and type of tests associated with the specimen; or by 2) the specimen taken from a patient following a laboratory request. This distinction, as portrayed in Figure 7.1, is important to the two types of analysis of add-on data. The first type of analysis compares the number of add-on tests as a percentage of all tests undertaken by the laboratories. Whilst the laboratory information system extract was able to provide the total number of add-on tests it was
not possible to analyse this alongside the total number of tests for the associated period. In order to report the percentage of add-on tests to the total number of tests it was necessary to make an estimation of the number of tests. An analysis of the number of tests per specimen carried out for the August/September period in 2005-2007 revealed that a median of 11 tests was carried out per specimen (see Appendix 7). This allowed an estimation of the percentage of add-on tests to all tests across the hospital using the following formula:

\[
\frac{N \text{ add-on tests}}{(N \text{ of specimens} \times 11)} \times 100
\]

The second type of analysis compares the number of add-ons as a percentage of the number of specimens where an add-on was requested. This was calculated using the formula shown below:

\[
\frac{N \text{ of specimens which had one or more tests added}}{\text{Total n of specimens}} \times 100
\]

The percentage of add-ons was compared by each month of 2006, and then by patient type (day, emergency, inpatient, outpatient) and laboratory (Clinical Chemistry and Haematology).
7.3 Results

7.3.1 Qualitative results

The Clinical Chemistry and Haematology departments account for the great bulk of tests carried out by the pathology service. A large proportion of test requests are marked as urgent or life threatening tests from critical care units and the Emergency Department, for which efficient and effective organisational practices are vital. Two organisational factors featured prominently in the study findings after the introduction of CPOE. One involved the issue of “middleware” which was described as the software interposed between the laboratory analyser and the Laboratory Information System (LIS [also referred to as Hoslab]), as a means of bridging the gap. The other issue that featured prominently was that of add-ons, described in Chapter 5 as a request for an extra test assay to be added to an already existing specimen sample. These two recurring themes are reported on below with reference to the contrasting experiences of the two departments.

Middleware communication

Both Haematology and Clinical Chemistry utilise middleware. For Clinical Chemistry it was described as a communication interface between their department analysers and the LIS for result interpretation and handling. The Haematology department’s middleware has a different emphasis related to the task of validating test results:
“85% of our work gets validated by [pre-defined software] rules so there’s no lab [laboratory] intervention. It goes through the machine, the rules in place look at the instrument errors, the patient’s previous results and then makes the results available to the clinicians at the other end. 15% of that, we have to have an intervention in before they’re available to the clinician. It’s identifying that 15% and processing them that the middleware helps us with” (Haematology participant).

The issue of middleware and how the new electronic ordering system replaced or handled the existing middleware was therefore an important one for both departments with major work flow implications on the ordering of tests and the upload of results from analysers to the LIS patient files.

**The development of the Specimen Orderable Status (SOS) system**

A vast amount of specimens pass through different laboratory processors. As a consequence of this, the efficient and safe monitoring and tracking of specimens is a vital component of laboratory functioning. This figured prominently in both departments’ planning and preparation for CPOE:

“We identified this issue on probably day one of the whole Cerner project back in 2002” (Clinical Chemistry participant).

“The previous sample tracking system within the laboratory was a home-grown system that complemented Hoslab. It allowed laboratory staff to scan the
laboratory number and then provided them with information about what processes the specimen had been through, what further processes and remaining tests needed to be undertaken and where the specimen had to be stacked at the appropriate analysing resource or stored (final storage)” (Clinical Chemistry participant).

The pathology department was forced to negotiate the addition of a new program, “Specimen Orderable Status” to compensate for the loss of previous system functionalities. Participants explained that with the previous system the task of changing aspects of the software was relatively straightforward. This was because they had a much greater level of control and dealt with personnel that were familiar with their needs. Under the new Cerner system it involved a lot of negotiation and effort:

“It was a complicated thing to get this SOS program written because the Cerner tracking solutions weren’t going to be the entire answer for us. Their final way of storing things, and their way of reading tests off labels in order to know where they go in the lab [laboratory] weren’t going to work for us, and coming from a computerised system, which did work for us, we weren’t going to go backwards” (Clinical Chemistry participant).

Within Haematology, the experience of the new system was expressed in a different way:
**Senior Laboratory Scientist:** “We had middleware previously and we’ve lost that functionality. We do not have middleware at this point. We still have those manual processes we discussed prior to even going online”.

**Researcher:** “So you actually have to go through it all yourself?”

**Senior Laboratory Scientist.** “That 15% we have to find, identify, and process”.

**Researcher.** “So how do you find 15%?”

**Senior Laboratory Scientist.** “With the SOS program. So every time a specimen comes off a machine, any automated piece of equipment we have, as it comes off, we need to have the barcode read through the SOS program and it indicates to us whether the results have been validated or not. So when they haven’t been validated, which is that 15%, we then need to go into Cerner and see why not, and then perform the manual validations. We then go back into SOS to see that it has actually happened” (Haematology participant).

Figure 7.2 provides a screenshot view of the SOS that was introduced into the new Pathnet system. The screen differentiates between the “Service Resources” (laboratory instruments and work areas) that each specimen is designated to travel in order of priority. It also provides a report of the specimen’s “Status” (completed or not) and “Laboratory status” (physical location in the laboratory). “Aliq” indicates if an aliquot (daughter tube) is required. “Collected” refers to the time the specimen was scanned into SOS, an important feature for Haematology which needs to complete its testing procedures within certain time frames. SOS took the place of two previous Hoslab applications, Hoslab Specimen Reception (SPR) (Figure 7.3) and Hoslab Specimen Tracking (SPT) (Figure 7.4). SPR was used by Clinical Chemistry to direct specimens
to appropriate analysers in order of priority. SPT was used after each specimen was finished at each analyser/work area. It determined the next rank/location of the specimen according to priority along with a rack position for easy location.

![Order View Program](image)

**Figure 7.2:** Screenshot view of Specimen Orderable Status developed in Cerner Pathnet after introduction of CPOE
Figure 7.3: Screenshot view of the previous Hoslab Specimen Reception system
Add-ons

For Clinical Chemistry the add-on procedure is a regular (although not always welcome) part of their work. Because of the potential knock-on effect that rises in the volume can cause, the add-on is often talked about within the department as a key indicator of laboratory workload and efficiency. It was not unusual for many Clinical Chemistry participants to describe the situation with additional add-ons as a potential “nightmare”.

Figure 7.4: Screenshot view of the previous Hoslab Specimen Tracking system
There were a number of possible reasons identified by participants that could lead to an add-on request from a physician:

- **Precious sample:** Often it is difficult and traumatic to obtain blood specimens from a baby or frail patient. In such situations physicians prefer to issue an add-on request on an already existing specimen.
- **Medication monitoring:** The physician may want a test performed on a sample taken before a medication was provided as a way of monitoring the medication’s effect.
- **Timing:** For clinical reasons, a test is required from a sample taken at an earlier point in time, possibly as a consequence of the results from the original request.
- **Convenience:** It may save time, because another specimen does not need to be drawn.
- **Wrong information:** Physicians are unsure about test ordering procedures and processes, or may have ordered the wrong test.
- **Missed test order:** A physician may have inadvertently forgotten to ask for a test. An add-on may also occur after further consideration and/or consultation with colleagues. For instance, an inexperienced clinician may have neglected to issue a test request that a senior clinician decided needed to be made.
- **Communication patterns:** Inadequate communication or awareness about what has been, and what hasn’t been ordered, may lead to extra add-on tests.

When a clinician wants an add-on test from a blood specimen that has already been sent to the laboratory they are required to complete a request form and fax it to the laboratory. This pre-implementation system was maintained after the introduction of
the new system. For the laboratory the task of adding-on a test was described in the following manner:

“… well, the sample has probably already been processed, so it means that you’re double handling the sample, and … there have been occasions when we’ve had three add-on requests on the one patient. That means that you’re not only handling it twice, you’re handling it three or four times, so what happens is you’ve done your initial analysis of the sample, so it has gone through, and it has gone into what we call our Z rack, which is the tracking rack – the storage rack. You then have to go and find the specimen … We’ve got something like 54 racks of 200 specimens, or something, so there’s a lot of specimens in there. Then you’ve got to look at when the original request was done, so you can actually add the test on, because some tests you can’t add on because they have to be separated immediately, or they’re only stable for like, you know, about a day or something” (Clinical Chemistry participant).

The issue of add-ons is a regular feature of operation procedures within the Clinical Chemistry department. This is because the department incorporates a very large catalogue of tests. Add-ons were less an issue for the Haematology department, which has a smaller catalogue of tests. Haematology participants said that most add-ons to their department were immunology-related. Add-ons can also be very time consuming. There are many issues that need to be considered for an add-on, these include the amount of time elapsed since the specimen was taken, and whether there is actually enough of the blood specimen left to carry out the test. Some tests like erythrocyte sedimentation rate (ESR) which are used to detect and monitor the activity of
inflammation, are time-dependent and need to be undertaken within four hours (unless refrigerated).

With the introduction of the new CPOE system both departments felt that add-on numbers had escalated. Haematology participants reported that their add-on rate increased nearly six-fold from 4 to 5 a day to 20 to 30. For both departments it meant a huge increase in workload which senior laboratory management estimated was in the vicinity of over 10%. Initially, the issue of add-ons was linked to “teething problems” such as in situations when clinicians were not aware that they were still required to issue a formal hand-written request for an add-on, and that it could not be performed electronically. But soon it was realised that the add-on issue was connected to design features of the new system:

“In Cerner, unless there’s a result available you can’t even see that it was collected. Previously, we had a thing called “to follow”, so as soon as it was booked in, the doctor could see all the tests that were ordered. Now they can’t easily see that, or the education is such that they don’t know where to go to find that information. We found a lot of the add-ons were the tests that we hadn’t completed yet, so we would waste probably five or ten minutes on each one, trying to work out – do we have a specimen to add it to. Then when we get to the point of adding it – oh, it was already ordered, so we couldn’t add it. Then we must ring and tell them that it was already ordered” (Haematology participant).
7.3.2 Quantitative results

Add-on tests as a percentage of all tests

There were a total of 66,340 add-on tests for the 483,752 specimen requests undertaken across the hospital for the year 2006. Table 7.2 shows that 52.2% (n=34,644) of those add-ons involved the Clinical Chemistry department and 17.1% (n=11,362) the Haematology department. Table 7.3 lists the add-ons for both departments compared by the type of patient episode involved. The majority of add-ons came from inpatient episodes 77% (n=26,698) and 67% (n=7599) for Clinical Chemistry and Haematology respectively, followed by 12% and 27% from day cases.

Based upon the calculation of a median number of 11 tests per specimen request, the percentage of add-on tests to total tests for the year 2006 was 1.3% as per the calculation shown below:

\[
\frac{66340}{(483752*11)} \times 100 = 1.25
\]

Table 7.4 compares add-on tests for Clinical Chemistry and Haematology as a percentage of each departments’ total test count. The percentage for Clinical Chemistry and Haematology was 1.5 and 0.6 respectively.
<table>
<thead>
<tr>
<th>Patient type</th>
<th>Day only</th>
<th>Emergency</th>
<th>Inpatient</th>
<th>Outpatient</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Chemistry</td>
<td>4195</td>
<td>3155</td>
<td>26698</td>
<td>596</td>
<td>34644</td>
</tr>
<tr>
<td></td>
<td>12.1%</td>
<td>9.1%</td>
<td>77.1%</td>
<td>1.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Haematology</td>
<td>3015</td>
<td>602</td>
<td>7599</td>
<td>146</td>
<td>11362</td>
</tr>
<tr>
<td></td>
<td>26.5%</td>
<td>5.3%</td>
<td>66.9%</td>
<td>1.3%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Table 7.3: Number of add-ons for Clinical Chemistry and Haematology by type of patient episode in 2006

<table>
<thead>
<tr>
<th>N of add-on tests</th>
<th>Estimated total n of tests</th>
<th>Add-on test % of all tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Chemistry</td>
<td>34644</td>
<td>212744*11</td>
</tr>
<tr>
<td>Haematology</td>
<td>11362</td>
<td>169834*11</td>
</tr>
</tbody>
</table>

Table 7.4: Add-on tests for 2006 in Clinical Chemistry and Haematology as a percentage of all department tests
Add-ons as a percentage of all specimens

Add-ons can also be measured as a percentage of all specimens as shown in Table 7.5. This reveals that the lowest add-on percentage was 3.3 in January and the highest of 3.9 occurred in May. The average monthly add-on percentage for the year was 3.5. Figure 7.5 compares the monthly percentages with the mean. It shows that the April – July period and the November – December periods were above the 2006 average.

<table>
<thead>
<tr>
<th>Month</th>
<th>No specimens where add-on was requested</th>
<th>Total number of specimen</th>
<th>% of add-ons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 06</td>
<td>1187</td>
<td>36559</td>
<td>3.25</td>
</tr>
<tr>
<td>Feb 06</td>
<td>1210</td>
<td>37015</td>
<td>3.27</td>
</tr>
<tr>
<td>Mar 06</td>
<td>1447</td>
<td>42513</td>
<td>3.4</td>
</tr>
<tr>
<td>Apr 06</td>
<td>1184</td>
<td>34932</td>
<td>3.39</td>
</tr>
<tr>
<td>May 06</td>
<td>1609</td>
<td>41385</td>
<td>3.89</td>
</tr>
<tr>
<td>Jun 06</td>
<td>1432</td>
<td>39388</td>
<td>3.64</td>
</tr>
<tr>
<td>Jul 06</td>
<td>1521</td>
<td>41840</td>
<td>3.67</td>
</tr>
<tr>
<td>Aug 06</td>
<td>1512</td>
<td>44106</td>
<td>3.43</td>
</tr>
<tr>
<td>Sep 06</td>
<td>1505</td>
<td>43579</td>
<td>3.45</td>
</tr>
<tr>
<td>Oct 06</td>
<td>1383</td>
<td>42172</td>
<td>3.28</td>
</tr>
<tr>
<td>Nov 06</td>
<td>1613</td>
<td>42093</td>
<td>3.83</td>
</tr>
<tr>
<td>Dec 06</td>
<td>1387</td>
<td>38170</td>
<td>3.63</td>
</tr>
<tr>
<td>Total</td>
<td>16990</td>
<td>483752</td>
<td>3.51</td>
</tr>
</tbody>
</table>

Table 7.5: Percentage of the number of specimen add-on requests to the total number of specimens received by each month of 2006
Figure 7.5: Comparison of the percentage of add-ons for each month of 2006 compared by mean percentage (3.51%) across the whole year

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Chemistry</td>
<td>Day only</td>
<td>1416</td>
<td>38212</td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>594</td>
<td>10689</td>
<td>5.56</td>
</tr>
<tr>
<td></td>
<td>Inpatient</td>
<td>4992</td>
<td>159498</td>
<td>3.13</td>
</tr>
<tr>
<td></td>
<td>Outpatient</td>
<td>228</td>
<td>4345</td>
<td>5.25</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7230</td>
<td>212744</td>
<td></td>
</tr>
<tr>
<td>Haematology</td>
<td>Day only</td>
<td>1578</td>
<td>33930</td>
<td>4.65</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>666</td>
<td>9910</td>
<td>6.72</td>
</tr>
<tr>
<td></td>
<td>Inpatient</td>
<td>5500</td>
<td>123842</td>
<td>4.44</td>
</tr>
<tr>
<td></td>
<td>Outpatient</td>
<td>115</td>
<td>2152</td>
<td>5.34</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7859</td>
<td>169834</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.6: The number of specimen add-on requests for inpatient, outpatient, day and emergency patients as a percentage of the total number of requests received in 2006 for Clinical Chemistry and Haematology
Comparison of add-on percentages for the different patient types (day cases, emergency, inpatient and outpatient) were calculated using the number of specimens where an add-on test was made as a percentage of the total tests for each patient type, as reported in Table 7.6. The figures show that for Clinical Chemistry and Haematology the greatest percentage (5.6 and 6.7 respectively) of add-ons occurred for emergency patients and the lowest percentage (3.1 and 4.4) was for hospital inpatients.

7.4 Discussion

7.4.1 Pathology test processing and the management of information

The preceding chapter on Central Specimen Reception (CSR) described its position as the receiving dock for laboratory specimens – the first point of call from the test order stage. In contrast Clinical Chemistry and Haematology are firmly embedded in the pathology test processing stage, as shown in Figure 7.6. This means they share a series of tasks such as accessioning, specimen preparation, sample distribution, test analysis and result verification. According to Hardwick and Morrison, the tasks associated with the pathology test processing stage are intrinsically connected to the flow of information (Hardwick & Morrison 1990), and therefore to the Laboratory Information System (LIS). The pathology department LIS can be described as at the centre of most pathology laboratory functions including work flow management, specimen tracking, data entry and reporting, interfacing with other systems, archiving and inventory control (Pantanowitz et al. 2007). Information and the capacity to receive, process, and communicate it in a timely and accurate manner are crucial organisational functions. This connection suggests that in order to understand how the pathology department
responds to challenges, like the introduction of a new CPOE system, it is necessary to examine how laboratory information is obtained, processed, and transmitted (O'Reilly & Pondy 1979).

Figure 7.6: Key components of the Clinical Chemistry and Haematology test process

The findings in this chapter highlight the fundamental connection between the organisational and communications aspects of the pathology work process. Prior to the introduction of CPOE both Clinical Chemistry and Haematology operated middleware systems which added functionality to their existing LIS and helped facilitate result handling, tracking specimens and storage (Pantanowitz et al. 2007). Clinical Chemistry utilised middleware for result interpretation, tracking and handling of test specimens. For Haematology, middleware played an autoverification role which incorporated checks on reference ranges, quality control, critical values, delta checks, dilution needs, instrument flags and laboratory review policies (Pantanowitz et al. 2007). There is also an interconnection between the middleware and add-ons because, as the situation in Clinical Chemistry reveals, the ability to track specimens plays a critical part in how add-on requests are handled.
Middleware also plays an important intermediary role in the laboratories, helping to bridge any shortfalls between the information system and the processing and output of results. The middleware in Clinical Chemistry remained operational with the introduction of CPOE, but not so in Haematology, where it failed. The pre-existing tracking system was a home-grown one that operated in conjunction with the LIS, and was used by both departments in different ways and for different purposes. The new Cerner Pathnet system did not replicate this role. This situation required the laboratories to undertake a complex set of negotiations with the software vendor (Cerner) to build an addition to Pathnet – Specimen Orderable Status (SOS) – to compensate for this lack of functionality. The results show that new CPOE systems may involve new ways of planning and organising the laboratory test order process. They also reinforce the point that new technology needs to be implemented in the context of existing systems and social practices (McLaughlin et al. 1999), many of which may be the legacy of a previously existing organisational communication environment.

7.4.2 Add-ons – an organisational and communication indicator of laboratory functioning

The request for add-ons by clinicians is a regular and frequent aspect of the work of the Clinical Chemistry department. It also features in the work of the Haematology department albeit with a different level of intensity. The quantitative findings showed that the Clinical Chemistry department during the year 2006 accounted for 52.2% and Haematology 17.1% of all add-on tests across the hospital. The highest volume of add-on tests was from inpatients, 77.1% and 66.9% respectively for Clinical Chemistry and
Haematology. But when add-ons were considered as a percentage of all specimens, the Emergency Department (ED) recorded the highest percentage – 5.6% for Clinical Chemistry specimens, and 6.7% for Haematology.

Laboratory staff participants drew attention to many of the potential reasons for add-ons. These varied from situations involving precious samples (eg, neonates or fragile patients where additional venepunctures are avoided), medication monitoring, timing or convenience. Clinical Chemistry and Haematology considered these reasons to be appropriate and valid. Other reasons for add-ons included where physicians initially forgot to ask for a test, or as a consequence of inadequate information about what tests had already been ordered, can be classified as “avoidable”. Table 7.7 lists the reasons for add-ons according to the two categories “Valid” and “Avoidable”. Based on this table it is reasonable to expect a higher add-on percentage for departments like ED. The ED is involved in the process of establishing a diagnosis and is therefore likely to ask for additional tests in the light of emerging findings. Timing is also a crucial factor in the ED patient care process (Handler et al. 2000; Handler et al. 2004; Institute of Medicine 2007) with obvious consequences for the ordering of add-on tests, particularly in urgent cases where an existing specimen may be readily available for laboratory testing.
Table 7.7: Reasons for add-ons differentiated according to the categories “Valid” and “Avoidable”

<table>
<thead>
<tr>
<th>VALID</th>
<th>AVOIDABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precious sample</td>
<td>Wrong information</td>
</tr>
<tr>
<td>Medication monitoring</td>
<td>Missed test order</td>
</tr>
<tr>
<td>Timing</td>
<td>Communication patterns</td>
</tr>
<tr>
<td>Convenience</td>
<td></td>
</tr>
</tbody>
</table>

Add-on tests are time consuming and costly (Melanson et al. 2004; Melanson et al. 2006) and a potentially inefficient process. For Clinical Chemistry it means extra time taken up with finding the original sample requiring an add-on and ascertaining the validity and suitability of the sample. While existing research about laboratory add-ons is sparse, it does suggest that the procedure may comprise approximately 1% of the daily test volume (Melanson et al. 2004; Melanson et al. 2006). Melanson et al.’s comparison of add-on testing for one week in Clinical Chemistry laboratories of two large academic medical centres in the US, reported 1.5% and 0.7% of add-on tests as a percentage of daily test volumes for each site. The corresponding figures from this study were 1.3% across the whole hospital, 1.5% for Clinical Chemistry and 0.6% for Haematology. These figures appear broadly comparable to Melanson’s findings (Melanson et al. 2006). Melanson et al. also reported that the percentage of add-on requests on inpatients, ED and outpatients was 73.3%, 18.6% and 5.9% respectively (Melanson et al. 2006). The Clinical Chemistry figures for this study are 77.1%, 9.1% and 1.7% respectively for inpatients, ED and outpatients, and 12.1% for day cases (see Table 7.3). Although the inpatient percentage is roughly comparable, the other areas are not. However, because the US hospital figures do not include day cases, comparison of findings across the countries may not be appropriate.
In this chapter the measurement of the impact of add-ons is presented in two ways: i) add-on tests as a percentage of all tests; and ii) add-on tests as a proportion of test specimens. The value of the former metric is that it is straightforward and provides a readily accessible indicator of the level of add-ons. Its disadvantage is that it may be less sensitive to the impact of add-ons on the laboratories. The number of tests linked to a specimen varies significantly across the whole spectrum of test panels and diagnostic procedures. A more sensitive measure of the impact of add-ons to the laboratories needs to take into account the number of times the laboratory may be required to chase up and find a specimen, as provided in the indicator of the number of add-ons as a percentage of specimens received. Hence, it is valuable to know that while 3.5% of all pathology specimens had an add-on (see Table 7.5), the equivalent figure for ED specimens to Clinical Chemistry was 5.6% (see Table 7.6).

It may be that in the long run the new CPOE system may help to alleviate the burden of add-ons to Clinical Chemistry and Haematology. However, as this study revealed, participants believed that the number of add-ons had escalated after the introduction of CPOE. Although the data for add-ons pre-implementation were not available, the 2006 figures presented in this chapter do not show any marked change over the year. It is likely that the measurement of add-on data does not adequately reflect the impact of the new system. For example, add-on data (as recorded in the information system) only includes instances where an add-on was performed. It does not include situations where an add-on test was made incorrectly (eg, duplicate test order) or could not proceed (eg, specimen time limit exceeded). In these situations the add-on test order would have been cancelled after a laboratory phone call consultation with the ward. A previous study (that involved the author of this thesis) into the effect of a newly-introduced
CPOE system in an Australian hospital described widespread uncertainty about add-on procedures among physicians and laboratory staff, leading to an increased number of telephone calls across the laboratory – ward interface (Georgiou et al. 2007). This suggests that the reports of increased workload and add-ons may have been a combination of many of the organisational and communication teething issues (as described in this chapter) that were associated with the system changeover.

7.4.3 The organisational communication aspect of management

The organisational and communications framework developed previously has some distinct features that are readily applicable to both the Haematology and Clinical Chemistry departments. The communication environment described in Chapter 5 addressed issues of information load, complexity and turbulence (Huber & Daft 1987). From this perspective it is clear that the issue of add-ons not only led to a perceived increase in information load (eg, quantity of add-on requests) but was also responsible for higher levels of information turbulence and instability, sometimes caused by clinical unfamiliarity with the new system. Similarly, the issue of middleware and tracking had important repercussions for the communication environment. Both departments utilised middleware as an important intermediary role in the laboratory. Clinical Chemistry required a system that could readily provide them with relevant information about the status of the specimen and the further processes needed to be undertaken. They found their communication environment de-stabilised by the failure of the new CPOE system to replicate the previously existing tracking functionality. Haematology, which used middleware to validate test results, had to replace that functionality by a manual
process, thereby causing a major change to the organisational and communication environment.

The findings from this chapter have also helped to underscore the relationship between communication and standard management functions. The standard functions of management could be described as: a) planning b) organising c) staffing and d) controlling (Fayol 1967; O'Reilly & Pondy 1979). Each of these functions is associated with its own communication corollary. Within this template, planning involves seeking information about the current situation and using it to help forecast and predict the course of future events. Organising incorporates the process of arranging people and resources using established communication channels. Staffing includes communication tasks involving the management of human resources and controlling involves information exchange to coordinate organisational resources (O'Reilly & Pondy 1979).

O'Reilly and Pondy’s template can be matched with the issues that emerged from this chapter’s description of Clinical Chemistry and Haematology, as depicted in Figure 7.7. For instance, the issue of tracking of specimens is critically important for the planning and functioning of the laboratory. The middleware function, which helps the departments to monitor the status of the specimens and validate the results, is important to the planning and organisation of their work. The ramifications of the failure of middleware to connect with the new CPOE system in Haematology had significant implications for staffing and management of resources with obvious implications for controlling laboratory functions. Similarly, the sudden and unexpected escalation of add-ons reported by participants after the implementation of CPOE resulted in
significant changes to the way that the Clinical Chemistry department was able to plan and organise its resources as well as affecting staffing and control over resources.

Figure 7.7: The management process as an organisational communication concern

7.4.4 Limitations

This study focused on the circumstances, dynamics and complexity of two departments in one hospital. The advantage of such comparisons is the richness and granularity the research findings provide. The generalisability of the findings may be offset by factors unique to the study site that may not be replicated in other settings. The descriptive statistics outlined in this chapter provide a valuable overview of the depth and nature of the add-on issue. This analysis would have been strengthened by the addition of pre-implementation data, which would have allowed tests of the significance of the perceived changes. Unfortunately, prior to the introduction of the new CPOE system these data were not systematically monitored. The availability of these data in the new CPOE system is a potentially positive factor, offering the department the opportunity to identify and plan their response to changes in add-on numbers and providing a valuable benchmark for future follow-up research.
7.5 Conclusion

This chapter sought to investigate the impact of CPOE on the way that the Clinical Chemistry and Haematology departments operate. It concentrated on the issues of add-ons, tracking and other laboratory processes as a means of extending the previously developed organisational communication framework. The results drew attention to the issue of middleware, described as software that bridges the gap between the Laboratory Information System and the laboratory analyser. Middleware is an important component of the organisational and communication set up of the laboratory, with major implications for the successful introduction of CPOE. In this chapter the contrasting departmental experiences with middleware were described. In Haematology the existing middleware failed to fit with the new system, and the department was forced to revert to manual methods of validation. In Clinical Chemistry, the middleware tracking function remained operational but required some adaptation and addition to the Cerner system in order to replicate the previous tracking role. Finally, the examination of the issue of add-ons found that while they are an expected and everyday aspect of the Clinical Chemistry (and to a lesser extent Haematology) work flow, the frequency and volume of add-ons is an important measure of the laboratory – ward communication interface. With the introduction of a new electronic ordering system, the burden of add-ons may increase because of the changes in previously existing ways of communicating between wards and laboratories.

The findings described in this chapter also underscored the relationship between basic pathology laboratory processing functions and the communication process. This chapter was able to draw out connections between components of the laboratory process such as accessioning, preparation, analysis, distribution and verification of tests with the
task of exchanging information and communicating to wards and across the hospital. Finally, the chapter was able to draw attention to the standard management functions (ie, planning, organising, staffing and controlling) and connect them to major organisational communication concerns from the findings. For instance, the chapter noted: i) the perceived increase in the burden of add-ons; ii) the need to modify tracking arrangements; and iii) the failure of previously existing middleware, which had direct consequences for how the departments were able to plan, organise, staff and control their work environment. In doing so, we are now able to refine the organisational communication framework with the addition of the key management functions as depicted in Figure 7.8.

![Figure 7.8: The contribution of Haematalogy/Clinical Chemistry case studies to the organisational communication framework](image)

The comparison of the experiences of the two laboratories during the implementation period in this chapter has been valuable. By drawing attention to some of the common issues confronted by both Clinical Chemistry and Haematology, the study has also been
able to contrast differences and nuances and provide a more holistic contextual
explanation of the effects of CPOE (Georgiou et al. 2007). It has also proven useful as
a replication tool to test the validity and reliability of findings as they apply in different
settings (Yin 2003). In the proceeding chapter, the comparative analysis of the two
departments will be extended to explore the importance of temporal factors on
laboratory functioning and the impact CPOE has on these.
Chapter 8  Clinical Chemistry and Haematology
departments – the effect of CPOE on the
temporal landscape
8.1 Introduction

The previous chapter investigated the way that CPOE affected the way that the Clinical Chemistry and Haematology departments organise and plan their activities. It drew attention to the issues of add-ons, test specimen tracking and middleware in the laboratory, to highlight the connection between laboratory functions and the communication process, particularly in the way that the laboratory plans, organises and controls its organisational work flows.

In this chapter the research focus remains with Clinical Chemistry and Haematology departments but this time deals with the temporal dimensions of their functioning and the effect of CPOE. Both departments are required to plan their activities around the fulfillment of urgent (sometimes life threatening) test requests usually measured in strict turnaround time (TAT) targets from the time of collection to results notification. The laboratories are also faced with other important time-dependent constraints that may be cyclical or spiraling (Hesse et al. 1988) and are bound by contextual, organisational, biological or other temporal factors such as test specimen viability or test reagent availability. These constraints can be severely affected by the implementation of a new system which may impose new (potentially dysfunctional) time cycles and pressures. The aim of this chapter is to: i) compare test turnaround times for a selection of key laboratory tests before the introduction of CPOE, with those one year later as a key efficiency indicator of the impact of CPOE; and ii) undertake qualitative and quantitative research to identify the different components of both departments’ temporal functioning, particularly on how the new system either accentuated or detracted from previous organisational communication arrangements.
The chapter will begin with an outline of: i) the temporal components of Clinical Chemistry and Haematology functioning, and the impact of CPOE; followed by: ii) a quantitative comparison of turnaround time data before and after the implementation of CPOE. The discussion section will address key issues that arise from the analysis of turnaround times. It will then draw on the qualitative findings as a means of explaining the temporal components of the laboratories’ organisational workload. The conclusion will address how these findings relate to the organisational and communication framework adopted by this study and identify key implications for the design and implementation of CPOE systems.

8.2 Methods

8.2.1 Qualitative analysis

As in the previous chapter, the setting for this section of the study was the Haematology and Clinical Chemistry departments. The design of the chapter was formative (Scriven 1991) with the objective of investigating the introduction of the new CPOE system in the course of its preparation and implementation between August 2005 and May 2007. Qualitative and quantitative methods were used to study both departments. The qualitative methods were identical to those described in the preceding chapter using focus groups, interviews and participant observation as a means of understanding the influence of social and organisational factors and how users perceive and experience the system (Kaplan & Maxwell 1994).
8.2.2 Quantitative data collection procedures

Laboratory turnaround times were analysed using a before and after design. Data relating to a broad selection of high volume Clinical Chemistry and Haematology discrete test assays that had been completed within 24-hours of specimen collection were extracted for two months (August to September 2005) before the implementation of the Cerner Millennium PowerChart (version 2000.01) and compared with an equivalent dataset in the same two months (August to September 2006) one year after. The range of test assays chosen for analysis was estimated to make up over 85% of all Clinical Chemistry and Haematology tests (Westbrook et al. 2006). A list of the extracted data fields is provided in Appendix 8 while Appendix 9 lists all the test assays chosen for inclusion in the dataset for analysis. The 24-hour limit on test assays was imposed to limit the effect of extreme outliers. Data were abstracted from the previously existing laboratory information system and then linked with corresponding fields from the new Cerner system. This involved the use of linkage methods to match laboratory test identifiers with admission dates and laboratory test order and collection times to validate the linkage (Lam et al. 2008).

8.2.3 Outcome measures

Laboratory turnaround time was defined as the time from receipt of a specimen in the laboratory to availability of a test result (Georgiou et al. 2008). Total turnaround time was defined as the time a specimen was collected from a patient to the time a result was made available (Georgiou & Westbrook 2006). The turnaround time data were also stratified by inside office hours (8.00am to 5.00pm) and outside office hours (5.01pm to
Potassium and haemoglobin test assays were compared over the two years using a numerator of the total number of test results with a turnaround time within 60 minutes, and a denominator of total number of results received for each test, compared by office and non-office hours (Australian Council on Healthcare Standards 2004). The median number of tests per patient episode was used to compare differences in test volumes (Bates et al. 1997; Westbrook et al. 2006; Georgiou et al. 2008).

Add-on test analysis was carried out on the add-on database reported in Chapter 7. An add-on time was defined as the difference between the add-on request time and the time of specimen collection. The add-on times were then categorised into those that fell <=4, >4 & <=8 and >8 hours after specimen collection.

8.2.4 Data analysis

The Mann-Whitney U Test was used to compare turnaround times and the number of tests per episode for 2005 and 2006. This test compares differences between independent groups on a continuous measure (Pallant 2001). It uses a comparison of medians by converting scores to ranks across the two groups and then evaluates whether the ranks differ significantly (Pallant 2001). It is considered to be the non-parametric analogue of the two sample t-test (Bland 1995), appropriate in situations such as turnaround time monitoring where data are not normally distributed (Hawkins 2007; Georgiou et al. 2008). The Chi-square test for independence (Pallant 2001) was used to compare the proportion of potassium and haemoglobin tests that fell within or without
the <=60 minute range for total turnaround times during office hours and non-office hours.

8.3 Qualitative results

8.3.1 Turnaround times

Timeliness is an essential component of both the Haematology and Clinical Chemistry’s work. This was highlighted in Chapter 5 where turnaround time was described as a key indicator of laboratory efficiency, often the benchmark of laboratory performance. It is not surprising therefore that the effect of the new CPOE system on turnaround times was a major issue within the laboratory:

“At the moment we get 90% of our work turned around in four hours. That’s 90% of all chemistry requests turned around in four hours. Considering we only do some tests once every two weeks it is not a bad effort. I don’t know whether that’s going to be possible with the new system” (Clinical Chemistry manager).

Traditionally turnaround times are defined as the time in which it takes a pathology laboratory to process a specimen and provide a result. Different measurements can be used for different aspects of the laboratory process eg, from the time a test specimen is collected to the time a result is issued (total turnaround time), or from the time the specimen arrives in the laboratory to the time a result is issued (laboratory turnaround time). The choice of turnaround time measurement will be shaped by the different processes involved. Total turnaround time measures may incorporate the transport (eg,
air chute or courier) time taken to bring the specimen to the laboratory. Different arrangements may in turn be shaped by the hour of the day a test is ordered and the blood collection rounds. In Chapter 6 it was reported that blood collectors perform two rounds of specimen collection per day, one at 8.00am and another at 1.00pm. The laboratory 24-hour service is divided into office (8.00am – 5.00pm) and non-office hours (5.01pm – 7.59am). These times have a bearing on staff availability and organisational flow. As a Haematology participant explained:

“Even the effect of time from the point of view if you’re a clinician and you’re ordering something, you have the option to tick ‘life threatening’. You have the option to tick ‘urgent’ [which] … has a time within it where we would be expected to produce a result” (Haematology participant).

8.3.2 The temporal maze

Temporal considerations embedded in the laboratory process

The temporal flow of the laboratories is shaped by factors that go beyond the achievement of optimal turnaround times. As one Clinical Chemistry participant announced, it is like a “maze”:

“Time is in the time of the sample. Time is in the time of the viability of the re-agents, not the tests [but] the actual viability of the re-agents that you use to do the test. That’s another time, and it acts on the actual tests. Some kits have got
a six to eight week life span, so you’ve got to time your samples, so you store them. OK, I’ve got enough to do a run” (Clinical Chemistry participant).

Haematology participants reported similar temporal considerations driven by guidelines which require Haematology tests to be concluded within four hours of collection, or else separated and frozen within two hours, which then lengthens the time allowed for processing for up to a week in some cases, and a month in others. This temporal consideration requires a very strict accounting of test collection time. It takes on special significance when clinicians order add-on tests (defined and discussed in the previous chapter) which may be for specimens whose integrity has expired. As one Haematology participant explained:

“...We have a number of time-dependent tests and usually they’re the ones [doctors] want, so if I’ve ordered a full blood count, [and] I want an ESR [Erythrocyte Sedimentation Rate] added, well an ESR means you … want it in four hours if it is not refrigerated. Well, we don’t refrigerate them straight away because there are so many of them; we need to do other things, so we just set four hours on those, and so we’ll get an add-on in the system and then we go back to the specimen to see how old it is and then contact the doctor to say it was too old. There’s a whole process involved in that” (Haematology participant).
Temporal considerations from the organisational context

Both the Haematology and Clinical Chemistry laboratories are also subject to a complex array of organisational factors and procedures that affect the temporal flow of the laboratory process. Both laboratories are required to service several hospitals across a large metropolitan area. These hospitals have different levels of laboratory capacity. Some periphery hospital laboratories (Hospital laboratory A and B) do not carry out coagulant testing while others (Hospital C, D and E) do so only in urgent cases. In order to ensure the efficiency and effectiveness of this process the laboratories operate a processing cycle which was described in the following way:

“So, for example, [the central laboratory site] … is built for 24/7; there’s a calendar in the system. [Hospital laboratory B] and the rest of those labs, there’s a calendar that says: between 7am and 11pm all the tests that they can do that are dictated as being urgent will be directed to their work lists and all the rest come to us. Outside of those 11pm till 7am everything gets directed to our work list” (Haematology participant).

This arrangement directly impacts on the issue of test validity because the laboratories are required to function within a temporal cycle requiring the freezing and transport of a specimen.

“Ideally, we don’t want them to have to [freeze a sample], because that again, adds more work at the small labs [laboratories], but it also then means that the
sample might be delayed, because it needs to be frozen, so it may miss a courier because they’ve had to separate it…

So that’s why these four hours become sort of important, and so to miss a courier means that they might have to do extra work on site, or in the case of [Hospital A], they may need to send it off in a cab at some cost, for just one or two specimens, to ensure the integrity of that specimen” (Haematology participant).

8.3.3 The impact of electronic ordering

The temporal, organisational and scientific considerations were among the most complex areas for planning and implementing the new CPOE system. As a Clinical Chemistry senior scientist manager said:

“We did try to flowchart all the processes in the lab [laboratory]. It was a horrendous exercise; interesting, but trying to flowchart all the processes and the different types of timeframes involved was a massive effort. We had to do it to try and build a new system. It brought home to me how complex the labs [laboratories] are because it’s not just a matter of several coming in, the tests gets done end of story; it’s just so many factors and levels” (Clinical Chemistry participant).

In the previous chapter (Chapter 7), the role of middleware for both the Clinical Chemistry and Haematology departments’ ability to track and monitor specimens was described. The chapter revealed how both departments (motivated by different
organisational requirements) negotiated the addition of a new software program to compensate for a loss of tracking and monitoring functionality. The findings of this chapter reveal a temporal dimension to this issue. This point is amplified in the following data using two exchanges taken from different points of the study. The first exchange which occurred in April 2006 a few months after the implementation of the new system, explains the importance of time in the test process. The second exchange occurred in May 2007 over a year later. It explains how temporal factors influenced the design of the software additions to the system. The juxtaposition of the two quotes helps to illustrate not only the importance of the temporal issues but also their impact on the communication process and the change it required in the new CPOE system.

**Researcher:** “I understand that the big problem with COAG [Coagulation] testing is time. The suitability for testing is limited, and that’s created a big problem now”.

**Senior Scientist-in-charge:** “That’s a huge problem”.

**Researcher:** “Why is that?”

**Senior Scientist-in-charge.** “In our previous system, it identified to us quite clearly, when we logged a specimen in, about how old the specimen was. So when the specimen got here, we logged it in, and we knew that this was three hours. We’d have four hours to complete some of the tests, so we could fast track that one through the system. At the moment in Cerner, when we zap it here, it just logs it into the lab” (April 2006).

* * *

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**Senior Scientist-in-charge**: “We originally built SOS [Specimen Order Status] for a couple of reasons, and one of them was to allow us to find where specimens were at any given time, just by zapping the barcode reader and bring it up and it will tell us that it had been ordered whatever it happens to be. Then we added the use of finding those specimens that … needed validation and the third thing we added was a clock that would tell us how long since collection”.

**Researcher**: “So you added a clock?”

**Senior Scientist-in-charge**: “Yes. So suddenly, on this SOS we can see the lab [laboratory] number; you can see the patient details; all the tests that are ordered; the status of those tests and also the time since collection, all in one place. In Cerner you can’t see it all in one place. So I can pick up a tube number and I can see everything that’s been ordered” (May 2007).

### 8.3.4 Quantitative results

Comparisons of test data for the period of 2005 and 2006 are detailed in Table 8.1. They show both the total turnaround time (time of collection to result) and in-laboratory turnaround time (time from specimen arrival in laboratory to result). For the pre-CPOE period of August/September 2005, the number of tests included in the sample was 362,728. In the August/September 2006 sample the number of tests was 396,878, and electronic ordering was being used for 75% of all laboratory orders across the hospital. The median total turnaround time fell by 9 minutes (11.7%) from 77 in 2005 to 68 in 2006 (p<0.001; Mann-Whitney U Test). For in-laboratory turnaround time, the median fell by 6 minutes (14.3%) from 42 in 2005 to 36 in 2006 (p<0.001: Mann-Whitney U Test).
Test). The number of tests per patient episode increased by 9.1%, from 22 tests per patient episode in 2005, to 24 in 2006.

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPOE coverage</td>
<td>0</td>
<td>75%</td>
</tr>
<tr>
<td>N test assays</td>
<td>362728</td>
<td>396878</td>
</tr>
<tr>
<td>Total TAT</td>
<td>Median 77</td>
<td>Median 68</td>
</tr>
<tr>
<td></td>
<td>Mann-Whitney U Test P&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>In-laboratory TAT</td>
<td>Median 42</td>
<td>Median 36</td>
</tr>
<tr>
<td></td>
<td>Mann-Whitney U Test P&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Tests per patient episode</td>
<td>N patient episodes 3967 4662</td>
<td>Median 22 24</td>
</tr>
<tr>
<td></td>
<td>Mann-Whitney U Test P&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.1: Comparison of turnaround times (total and in-laboratory) and test numbers per patient episode before and after the introduction of CPOE

Turnaround times are also compared for potassium and haemoglobin test assays for which rapid turnaround time is an important factor in patient diagnosis and care. Table 8.2 shows that there was a significant increase in the proportion of both tests completed within (or equal to) 60 minutes one year after the introduction of CPOE. For non-office hours the proportion <=60 minutes rose from 32.5% to 45.3% for potassium, and 62.2% to 70.6% for haemoglobin. In office hours, the proportion rose from 14.1% to 30.9% for potassium and 37.8% to 61.4% for haemoglobin.

<table>
<thead>
<tr>
<th></th>
<th>2005 % (n)</th>
<th>2006 % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium &gt;60 mins</td>
<td>67.5% (4993)</td>
<td>54.7% (5125)</td>
</tr>
<tr>
<td>Potassium &lt;= 60 mins</td>
<td>32.5% (2402)</td>
<td>45.3% (4243)</td>
</tr>
<tr>
<td>Chi Square</td>
<td>Chi-Square=2.835 df=1 p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Haemoglobin &gt;60 mins</td>
<td>37.8% (2651)</td>
<td>29.4% (2645)</td>
</tr>
<tr>
<td>Haemoglobin &lt;=60 mins</td>
<td>62.2% (4355)</td>
<td>70.6% (6335)</td>
</tr>
<tr>
<td>Chi Square</td>
<td>Chi-Square=1.249 df=1 p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Total TAT Non-office hours 5.01pm – 7.59am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total TAT Office hours 8.00am – 5.00pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium &gt;60 mins</td>
<td>85.9% (8030)</td>
<td>69.1% (7769)</td>
</tr>
<tr>
<td>Potassium &lt;= 60 mins</td>
<td>14.1% (1315)</td>
<td>30.9% (3466)</td>
</tr>
<tr>
<td>Chi square</td>
<td>Chi-Square=8.053 df=1 p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Haemoglobin &gt;60 mins</td>
<td>62.2% (5488)</td>
<td>38.6% (4189)</td>
</tr>
<tr>
<td>Haemoglobin &lt;=60 mins</td>
<td>37.8% (3336)</td>
<td>61.4% (6659)</td>
</tr>
<tr>
<td>Chi Square</td>
<td>Chi-Square=1.082 df=1 p&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.2: Comparison of the percentage of potassium and haemoglobin turnaround times >60 minutes and <=60 minutes for office and non-office hours in 2005-2006
Across all laboratories, the greatest proportion of add-on tests was requested within four hours from the time of specimen collection, as shown in Table 8.3. However 27.9% of tests were requested after 8 hours.

<table>
<thead>
<tr>
<th></th>
<th>&lt;= 4 hours n (%)</th>
<th>&gt;4 &amp; &lt;= 8 hours n (%)</th>
<th>&gt; 8 hours n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Bank</td>
<td>6 (1.9%)</td>
<td>3 (1.0%)</td>
<td>302 (97.1%)</td>
</tr>
<tr>
<td>Clinical Chemistry</td>
<td>20293 (58.6%)</td>
<td>7362 (21.3%)</td>
<td>6951 (20.1%)</td>
</tr>
<tr>
<td>Haematology</td>
<td>8183 (72.1%)</td>
<td>1254 (11.0%)</td>
<td>1920 (16.9%)</td>
</tr>
<tr>
<td>Microbiology</td>
<td>1234 (23.5%)</td>
<td>371 (7.1%)</td>
<td>3657 (69.5%)</td>
</tr>
<tr>
<td>Serology</td>
<td>7832 (54.9%)</td>
<td>912 (6.4%)</td>
<td>5529 (38.7%)</td>
</tr>
<tr>
<td>Total*</td>
<td>37548 (57.1%)</td>
<td>9902 (15%)</td>
<td>18359 (27.9%)</td>
</tr>
</tbody>
</table>

* Missing data (n=531)

Table 8.3: Number (and percentage) of add-on tests for pathology departments within time brackets of <= 4 hours, >4 & <= 8 hours and >8 hours

8.4 Discussion

8.4.1 Turnaround times

The results presented in this chapter reveal significant decreases in turnaround times (both in-laboratory and total) following system implementation. For total turnaround times the decrease of a median of 9 minutes represented an 11.7% reduction, while for in-laboratory turnaround times, the decrease of a median of 6 minutes represented a 14.3% reduction. These findings should also be viewed in the context of a significant increase in the number of tests ordered per patient episode, which during the same period rose by 9.1% from a median of 22 in 2005, to 24 in 2006. The proportion of potassium and haemoglobin tests which were processed within 60 minutes increased in the post-implementation period. This increase in the proportion of potassium and haemoglobin tests processed within 60 minutes occurred during both office and non-office laboratory hours.
Laboratory performance and clinical satisfaction with pathology services is related to the timeliness of test results. This is because turnaround times can affect the time to patient diagnosis and/or treatment (Howanitz & Howanitz 2001; Review of NHS Pathology Services in England 2006). Turnaround time is also one of the main issues that laboratories are likely to receive complaints about (Valenstein 1989). It is therefore regarded as a key indicator of the impact of CPOE on pathology service efficiency and often the most readily accessible to laboratory managers because of the role turnaround time measurements play as part of performance monitoring (Georgiou et al. 2008; Georgiou et al. 2008). As noted in Chapter 2, there are several studies of CPOE performance using turnaround times that have reported significant decreases (Mekhjian et al. 2002; Thompson et al. 2004; Westbrook et al. 2006; Georgiou et al. 2008) including a recent Australian study which found significant improvements in turnaround times 12 and 24 months following system implementation (Westbrook et al. 2008).

The provision of faster test results has contributed to changes in clinical reasoning processes. In many cases a laboratory result may be available to a physician even before the end of an examination, and can thus affect a physician’s decision in real time, and need not wait until the next available examination time (Plebani 1999). Moreover, laboratory data no longer just confirm or deny previously obtained clinical data, but become an integral part of patient management with the potential for improvements in medical outcome (Plebani 1999) and for the efficient passage of patients through the system (Forsman 1996).
The monitoring of turnaround times can be influenced by a number of intervening factors that are likely to impact on the results. These include the time of day a test was undertaken which may account for varying levels of staff availability, eg, office and non-office hours; the type of test taken which can affect processing time frames; and even the stated urgency of the test (eg, requests from critical care wards). As with any measurements using indicators the results are not always conclusive but open to levels of uncertainty (NHS Institute for Innovation and Improvement 2007). It is important therefore to understand the strengths and weakness of the data and not to assume that the indicator automatically qualifies as an objective measure of performance (Boyce 2002). Indicator data provide information about selected segments of reality, which may be misleading if viewed individually and not in conjunction with other parts of the system (Georgiou et al. 2006; NHS Institute for Innovation and Improvement 2007).

There are a number of caveats associated with the monitoring of turnaround times. Turnaround time measurements are predominantly performed as indicators of laboratory efficiency and seldom in terms of how they may impact on broader health outcomes (Review of NHS Pathology Services in England 2006). The association between shorter turnaround times with improved patient outcomes remains unclear (Garg et al. 2005; Westbrook et al. 2006). A British study looked into the impact of ward computers which allowed access to laboratory results and found that a large proportion (45% for accident and emergency and 29% for inpatient wards) of urgent test results were never accessed, and of those, nearly 3% were judged to require an immediate change in patient management (Kilpatrick & Holding 2001).
One of the factors which makes the impact of turnaround times difficult to decipher is the lack of consensus about the level of acceptable turnaround time (Hawkins 2007). Part of the problem exists in the very make up of turnaround times. A turnaround time includes a number of sequential steps, each with a minimum or fastest time possible. As Hawkins explains, if a centrifuge is set to ten minutes spinning time, centrifugation can take no less than ten minutes and may take longer if there are delays (eg, balance problems) (Hawkins 2007). This means that normal distributions of turnaround times are rare and are likely to vary considerably across sites according to different laboratory operational procedures and processes. This is why health monitoring agencies such as the Australian Council on Healthcare Standards monitor turnaround times using numerators of the total number of test results within a specified time period, (eg, potassium results less than 60 minutes during office hours) and a denominator of the total number of requests for the relevant test received by the laboratory (Australian Council on Healthcare Standards 2007; Georgiou et al. 2008). Results based on these indicators were presented above.

The importance of identifying the multiple layers of the temporal setting was highlighted by the qualitative findings of this chapter. These findings show that the laboratories integrate different levels of temporal coordination into their work. While laboratory participants were well aware of the importance of optimising the provision of results, they also were able to identify other temporal factors which shaped their work. In some cases this included laboratory procedures related to the processing and viability of test specimens or availability of test reagents. The analysis of add-on time categories from Table 8.3 revealed a large proportion of add-on tests for Clinical Chemistry and Haematology that fell eight hours and beyond. For Clinical Chemistry the figure was
20.1% and for Haematology it was 16.9%. The figures highlight the magnitude of the temporal issue, particularly as it is quite likely that a proportion of those tests (especially for Haematology) may be approaching their specimen viability limit. In other cases, the temporal coordination requirements may include organisational factors such as the synchronisation with temporal patterns of satellite laboratories, or even just with the daily blood collection rounds across the hospital.

8.4.2 Temporal coordination

In his work investigating nosocomial patterns of time, Zerubavel observed that hospitals are one of the few organisations that operate around the clock, seven days a week, and 365 days a year, that are not driven primarily by considerations of productivity and profit (Zerubavel 1979). As a consequence of this, Zerubavel observed that the provision of healthcare must involve a level of temporal coordination among staff (Zerubavel 1979). Some aspects of this temporal coordination, contained in the findings of this chapter were related to laboratory processes such as the viability cycle of test specimens, or the life span of test reagents. In other instances this coordination was related to organisational factors and procedures which affect the flow of work. The need to coordinate Haematology process flows with the work of smaller satellite pathology laboratories which do not operate on a 24/7 time frame is a salient example of an organisational factor which affects work patterns and the timeliness of the processing cycle. Similarly, decisions about freezing samples to prolong their viability are important temporal considerations for the laboratory. Bardram’s work on temporal coordination describes time as one of the scarcest work practice resources.
Organisations are involved in a constant endeavour to prioritise and organise their time because of its implications for how work activities are coordinated (Bardram 2000).

Turnaround time indicators monitor time from a linear-vectoral perspective (Zerubavel 1979) according to a series of events measured to seconds, minutes, hours, days, years, etc (Adam 2004). According to Zerubavel this is a traditional “physicomathematical” perspective to time, but there are also qualitative dimensions to time (Zerubavel 1979) which make it a much more multiplex entity. For instance, time can also be conceived of as part of a timescape that affects organisational functionality and includes everyday notions such as tempo (eg, the pace and intensity of activity), or patterns (the periodicity of events), sequence and synchronisation of events (Adam 2004). Each of these dimensions of the organisational timescape are identifiable in the Haematology and Clinical Chemistry laboratory, from the need to clearly organise the sequence, tempo and synchronisation of the test ordering process as a means of coordinating testing from satellite laboratories, to the need to ensure specimens are processed according to cyclical patterns enforced by the viability span of the specimen or the availability of the appropriate test reagent.

8.4.3 The impact of ICT on temporal coordination

The findings presented in this chapter also highlight the importance of temporal considerations on the implementation, usability and performance of the newly installed CPOE system. One of the areas where the impact on temporal coordination was felt was with the tracking and monitoring functionality of the new system. For instance, one of the shortfalls that laboratory participants identified in the new system was its inability
to tell the laboratory how much time had elapsed since the blood sample (time of venepuncture) had been taken, and to identify the precise rack and storage location the specimen was supposed to be located. Not only did the addition of the Specimen Order Status (SOS) software into the system help the laboratories to coordinate the sequential processing of specimens, including those that may need to be stored for future testing, it also provided them with a electronic means to manage the different *timescape* requirements involved in the laboratory process.

This change in the way that the laboratories were forced to deal with the new temporal circumstances suggests that new CPOE systems do not simply save time leading to reduced turnaround times and more efficiency, but also have the potential to affect the coordination of temporal practices (Wajcman 2008). The laboratory experience in this study suggests that electronic systems can play an important mediating role in temporal coordination and the determination of what event occurs when in relation to other activities and actions, as part of the synchronisation, scheduling and allocation of activities (Bardram 2000).

**8.4.4 Limitations**

This study focused on the circumstances, dynamics and complexity of two departments in one hospital. The advantage of such comparisons is the richness and granularity the research findings provide. However, the generalisability of the findings may be offset by factors unique to the study site that may not be replicated in other settings.
8.5 Conclusion

The aim of this chapter was to investigate the temporal dimensions of the Clinical Chemistry and Haematology departments through a quantitative comparison of test turnaround times before and after the introduction of CPOE and a qualitative exploration of the different components of the new system, paying specific attention to whether it accentuated or detracted from previous organisational communication arrangements.

The measurement of laboratory performance is heavily dependent on the monitoring of turnaround time. This is regarded as an important index of efficiency and effectiveness and therefore an important indicator of the impact of CPOE in the laboratory and its contribution to clinical care processes. However, there are a number of difficulties involved with the measurement of turnaround times, including some levels of uncertainty about the comparability and generalisability of the measures. Turnaround time measures consist of a number of sequential steps (eg, processing characteristics) which may vary across hospitals and even departments.

The findings in this chapter pointed to the existence of what Adam described as a timescape in the way that organisations undertake their business (Adam 2004). The understanding of time should go further than the linear-vectoral perspective of its functionality (eg, seconds, minutes, hours etc), to incorporate qualitative dimensions such as the need to achieve synchronisation, scheduling and allocation of activities. This was highlighted by the temporal impact of CPOE implementation, which forced the laboratories to respond to deficiencies and changes in the way they tracked and
monitored specimens. This situation led the department to introduce and develop new tracking software into the CPOE system as a means of improving the ability to organise work.

The findings also add a new level of detail to the temporal component of the organisational and communication framework (see Figure 8.1), in particular the role of coordination in helping the laboratories to monitor, access and control specimens and tests. These factors are interconnected with other components of the framework, for instance, coordination of the laboratory is an intrinsic component of the organising, planning and control functions because a temporal dysfunction can be expected to have an immediate effect on how work is carried out. Temporal coordination also plays a role in the communication processes of the laboratory, particularly as a means of ensuring that information is exchanged at the right time and in the right place – an important factor when considering whether information exchange is going to be synchronous or asynchronous (Georgiou et al. 2007).
All of the above factors have important design implications for CPOE systems, which like many new technologies, do more than just save time, but also affect the way tasks and work activities are understood. New technologies do not just help organisations do what they did previously, only faster, they actually change the way things are done (Wajcman 2008). The temporal coordination of work activities in the laboratory is therefore likely to have major repercussions on the design and use of CPOE systems (Bardram 2000). The next chapter will expand the study of organisational communications in the laboratories, this time concentrating on the Microbiology laboratories and the effect that clinical notes supplied by physicians on test requests have on the test process. It will also consider the implications that the information exchange between clinicians and the laboratory may have on the design and implementation of CPOE.
Chapter 9 The exchange of patient-oriented clinical information across the Microbiology laboratory – ward interface
9.1. Introduction

The previous chapter investigated the temporal dimensions of the Clinical Chemistry and Haematology departments and drew attention to the *timescape* in which both laboratories went about their work (Adam 2004). This included considerations ranging from the processing of laboratory tests measured in seconds, minutes and hours; to qualitative factors involving organisational and laboratory operation cycles. The chapter emphasised the significance that these temporal factors have on the synchronisation, scheduling and allocation of tasks within the laboratories and hence their importance in the development and implementation of new CPOE systems.

This chapter moves to the Microbiology department and the exchange of patient-related clinical information between the ward and the laboratory. Traditional paper order forms, where pathology test requests are completed by clinicians, are an important connection between clinicians on the ward and the laboratories, and can have a major impact on the number and types of tests ordered (Deeble & Lewis-Hughes 1991). The supply of clinical information adds value to the laboratory process, providing a contextual setting with which the laboratory can contribute to the effectiveness of test requests and to the management of patients and the outcomes of their care (Panteghini 2004). The chapter aims to: a) identify what effect clinical notes supplied by physicians on microbiology test requests have on the choice, processing and interpretation of test results; and b) assess the potential impact electronic ordering may have in the effective and efficient communication of clinical notes across the laboratory – ward interface.
The chapter begins with a description of the consensus techniques (involving quantitative and qualitative methods) used to undertake the study. The results of a survey involving Microbiology department technicians, scientists and medical personnel, about the impact of a specified list of clinical notes found on hand-written requests for stool and wound specimens, are then presented. These results are compared for differences among professions and levels of experience. The clinical notes were sorted into a series of categories reflecting similarities and properties eg, abscesses, infections, ulcers etc. Clinical notes with high levels of agreement were then presented to an expert panel for review and comment about the impact of the notes on the microbiology process, their potential effect on patient care and the design implications for CPOE systems. The chapter concludes with an assessment of how these findings contribute to the organisational and communication framework and the role they can play in optimising the impact of CPOE systems.

9.2 Methods

An iterative consensus technique (Fink et al. 1984) involving a selection of laboratory technicians, scientists, managers and medical staff within the Microbiology department was used to identify the impact that clinical notes (supplied by physicians on test requests) have on the choice, processing and interpretation of tests. The study was carried out in three parts: part i) the development of a survey instrument to identify the significance of clinical notes on the laboratory test process; part ii) the administration of the survey and collation of results; and part iii) an expert panel of microbiology staff to discuss the findings of the survey and their relevance in improving pathology practice, rational ordering and patient outcomes.
Part i) Development of a survey instrument

A survey instrument was developed from a list of clinical information supplied by clinicians for test requests for stool and wound (including swabs or aspirate material from wounds such as ulcers, abscesses, postoperative wounds, pus or exudates) specimens (Prgomet et al. 2008). The clinical notes were identified from a retrospective audit of all hand-written Microbiology department requests received during a four week period (n=9431) in the month of May 2005. The study defined “clinical information” as any patient-related clinical information written on the pathology form by the requesting physician. It found that wound samples contained clinical information in 322 (64.3%) of 501 requests, while stool samples had clinical information in 129 (34%) of 379 requests (Prgomet et al. 2008). The data extracted from Prgomet et al.’s study identified 50 discrete examples of stool specimen notes and 86 wound specimen notes. Senior laboratory personnel classified each of the clinical notes according to whether they fell into the categories: antibiotics, diarrhoea, infection, parasite, rotavirus or other category for stools; and abscess, genital, Multi-Resistant Organisms (MRO), ulcer/boil or other for wounds. Table 9.1 outlines the number of times and percentage of total stool and wound notes where the categories appear.
<table>
<thead>
<tr>
<th>STOOLS</th>
<th>Number of notes that fell into category (% of total stool notes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotics</td>
<td>3 (6.0%)</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>19 (38.0%)</td>
</tr>
<tr>
<td>Gastro</td>
<td>2 (4.0%)</td>
</tr>
<tr>
<td>Infection</td>
<td>2 (4.0%)</td>
</tr>
<tr>
<td>Other (Traveller, Clinical note, organisation)</td>
<td>18 (36.0%)</td>
</tr>
<tr>
<td>Parasite</td>
<td>2 (4.0%)</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>4 (8.0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WOUNDS</th>
<th>Number of notes that fell into category (% of total wound notes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abscess</td>
<td>18 (20.9%)</td>
</tr>
<tr>
<td>Genital</td>
<td>2 (2.3%)</td>
</tr>
<tr>
<td>MRO</td>
<td>3 (3.5%)</td>
</tr>
<tr>
<td>Other</td>
<td>13 (15.1%)</td>
</tr>
<tr>
<td>Ulcer/Boil</td>
<td>50 (58.1%)</td>
</tr>
</tbody>
</table>

Table 9.1: Categories of stool and wound notes compared by the number and percentage of times they appeared in the Prgomet et al. study

The survey instrument for wounds (see Appendix 10) and stools (see Appendix 11) were drafted to investigate the impact of the different examples of clinical notes on the processing of tests and/or their interpretation. The survey was piloted and refined during a three-month period between October – December 2006 in consultation with the laboratory business manager and three other microbiology professionals.

**Part ii) Administration of the survey instrument**

The surveys for wounds and stools were finalised and administered on 14 February 2007 to 22 microbiology personnel. Participating staff were chosen on a purposive basis (Bowling 1997) to include those directly involved in the processing of test specimens along with a cross section of professional groups involving different levels of experience. Survey respondents included eight that fell in the category of <5 years experience and 14 in the category of 5+ years experience. There were three respondents with technical qualifications, 16 with scientific degrees and 3 with medical degrees.
The survey was accompanied by a letter from the department business manager (see Appendix 12) which explained the purpose of the survey. Survey respondents were asked to indicate whether the clinical note affected the processing or interpretation of the test by specifying the codes outlined in Table 9.2.

<table>
<thead>
<tr>
<th>Processing</th>
<th>P</th>
<th>(plates changed or added)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>(tests added such as microscopy, stain etc)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>(comment eg, specimen unsuitable)</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>(other differences)</td>
</tr>
<tr>
<td>Interpretation</td>
<td>I</td>
<td>(interpretation changed as a result of clinical notes)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>(comment about the culture)</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>(suggest treatment due to clinical notes)</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>(other interpretations)</td>
</tr>
</tbody>
</table>

Table 9.2: Codes for microbiology clinical notes study

All surveys were completed within two months of distribution. The results of the survey were then entered into a spreadsheet for analysis and comparison. A clinical note was deemed to have an effect on processing if it contained any of the processing codes listed in Table 9.2. Each note was assigned an impact rating (presented as a percentage) as a means of identifying the level of agreement amongst survey respondents about the impact of the note on the test process. This rating was calculated using the following formula where $v_{ei}$ represents a recorded impact on the laboratory processing of a microbiology test.

$$\frac{\sum_{i=1}^{1} +v_{ei}}{22} \times 100$$

For example, a test note in which no survey respondent had recorded as having an effect on the test process received a rating of 0%. A note in which 11 participants (of the 22 possible responses) specified an effect received an impact rating of 50% (11/22), and so
on. These results are compared by the specimen categories as listed in Table 9.1. Each category was then provided with an impact rate range depicting the variation amongst the notes in the category, the median rating along with data about the number of notes in the category, their frequency and percentage of the total of respective wound or stool specimen requests.

The Kappa statistic was used to compare the amount of agreement between the professional groups (medical, scientist and technical) and between groups with different levels of experience (<5 years of experience and 5+ years experience). This statistic provides a measure of the agreement above and beyond that expected by chance (Lowe 1993; McGinn et al. 2004). SPSS version 15 was used to calculate the Kappa score (Norusis 1997; SPSS 2007). A Kappa value below zero can be interpreted as poor degree of agreement and a score of 1 represents perfect agreement (McGinn et al. 2004). The clinical notes were categorised as “Impact” or “No Impact”, according to the majority survey indication of each (professional and experience level) group. In situations where there was an even split of opinion, the clinical note was classified as “Impact”. The results were then compiled within a 2X2 table as in the example shown below:
Table 9.3: Example of a 2X2 table used to calculate the Kappa statistic

<table>
<thead>
<tr>
<th></th>
<th>Scientists</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Medical</td>
<td>Impact</td>
<td>No impact</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

A separate comparison was made of the clinical notes where participants recorded that the note had an effect on the interpretation of results and/or had consequences for patient treatment. These results are presented individually for both specimen types along with the category they fall under (e.g., abscess, ulcer etc.) and the frequency with which the note appeared in the Prgomet et al. study (Prgomet et al. 2008).

**Part iii) Expert microbiology panel**

The expert panel consisting of seven participants was invited to assess the findings and identify how electronic decision support in CPOE systems can improve pathology practice, rational ordering and patient outcomes. The panel comprised of one staff specialist, two microbiology registrars, a laboratory manager and three hospital scientists. Participants were provided with a summary of the results of the survey one week prior to the discussion along with a list of the following questions:

- Can you explain why some clinical notes (as listed in the findings) were considered important to the laboratory test process?
- What laboratory process is changed as a consequence of the clinical note?
• What would have happened differently if the clinical note had not been supplied?
• Does the clinical note affect laboratory efficiency (eg, urgency)?
• Does the clinical note have any impact on laboratory effectiveness (eg, interpretation of result?)
• Can you think of any consequences for the quality of care?
• How can the supply of important clinical information be optimised? Can electronic ordering systems help?

The discussion was taped and transcribed and resulted in 12 A4 pages containing 6106 words. Examples pointed to by the panel were then followed up for further information in a series of focused iterative discussions held with participants.

9.3 Findings

9.3.1 Survey results

The results of the survey analysis showed that 86% (43/50) of clinical notes for stool specimens and 97% (84/86) of wound specimens were identified by one or more participants as having some impact on the processing or interpretation of the test specimen. Table 9.4 lists the clinical notes for wounds and stools which recorded the highest impact ratings. The table also includes information about the frequency of the clinical note (ie, how often it appeared in the Prgomet et al. study) and its percentage of all requests in each of the respective (wound or stool) categories. The results for all stool and wound specimens are provided in Appendix 13 and 14 respectively. Table 9.5
provides a selection of notes that survey participants indicated would affect the interpretation of the test, possibly requiring comments back to the medical staff. Table 9.6 lists the clinical notes for wounds and stools in which all participants agreed had no impact on the test process.
<table>
<thead>
<tr>
<th>Wound Clinical note</th>
<th>Frequency (f)</th>
<th>% of all wound requests</th>
<th>No. of survey responses</th>
<th>Impact rating %</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abscess – site specified, Diabetic</td>
<td>1</td>
<td>0.2</td>
<td>19</td>
<td>86.4</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess – site specified, IV drug abuser</td>
<td>2</td>
<td>0.4</td>
<td>19</td>
<td>86.4</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess – site specified, NIDDM</td>
<td>1</td>
<td>0.2</td>
<td>19</td>
<td>86.4</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess – site specified, Pyrexial</td>
<td>1</td>
<td>0.2</td>
<td>19</td>
<td>86.4</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess</td>
<td>10</td>
<td>2</td>
<td>18</td>
<td>81.8</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess – pus</td>
<td>6</td>
<td>1.2</td>
<td>18</td>
<td>81.8</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess – site specified</td>
<td>51</td>
<td>10.2</td>
<td>18</td>
<td>81.8</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess – site specified, Infected AVF</td>
<td>1</td>
<td>0.2</td>
<td>18</td>
<td>81.8</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess, Cellulitis</td>
<td>2</td>
<td>0.4</td>
<td>18</td>
<td>81.8</td>
<td>Abscess</td>
</tr>
<tr>
<td>Gangrene – site specified</td>
<td>1</td>
<td>0.2</td>
<td>18</td>
<td>81.8</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess, Crohns Disease</td>
<td>1</td>
<td>0.2</td>
<td>17</td>
<td>77.3</td>
<td>Abscess</td>
</tr>
<tr>
<td>Abscess, Immunosuppressed</td>
<td>1</td>
<td>0.2</td>
<td>17</td>
<td>77.3</td>
<td>Abscess</td>
</tr>
<tr>
<td>?HSV</td>
<td>1</td>
<td>0.2</td>
<td>18</td>
<td>81.8</td>
<td>Other (org specified, clinical note)</td>
</tr>
<tr>
<td>Rupture of Membranes – premature</td>
<td>1</td>
<td>0.2</td>
<td>16</td>
<td>72.7</td>
<td>Other (org specified, clinical note)</td>
</tr>
<tr>
<td>Boil, History of MRSA</td>
<td>1</td>
<td>0.2</td>
<td>19</td>
<td>86.4</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – pressure, History of MRSA</td>
<td>1</td>
<td>0.2</td>
<td>19</td>
<td>86.4</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – site specified, ?MRSA</td>
<td>1</td>
<td>0.2</td>
<td>19</td>
<td>86.4</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – Diabetic, Previous MRSA</td>
<td>1</td>
<td>0.2</td>
<td>18</td>
<td>81.8</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – site specified, History of MRSA</td>
<td>1</td>
<td>0.2</td>
<td>18</td>
<td>81.8</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Pus</td>
<td>1</td>
<td>0.2</td>
<td>17</td>
<td>77.3</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Pus – site specified</td>
<td>10</td>
<td>2</td>
<td>17</td>
<td>77.3</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – ?MRSA</td>
<td>2</td>
<td>0.4</td>
<td>17</td>
<td>77.3</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>?MRSA</td>
<td>15</td>
<td>3</td>
<td>20</td>
<td>90.9</td>
<td>MRO (Multi Res Org [MRSA, URE etc])</td>
</tr>
<tr>
<td>?MRSA, Resistance to Penicillin</td>
<td>2</td>
<td>0.4</td>
<td>19</td>
<td>86.4</td>
<td>MRO (Multi Res Org [MRSA, URE etc])</td>
</tr>
<tr>
<td>Previous MRSA</td>
<td>2</td>
<td>0.4</td>
<td>17</td>
<td>77.3</td>
<td>MRO (Multi Res Org [MRSA, URE etc])</td>
</tr>
<tr>
<td>Abscess – Bartholin</td>
<td>5</td>
<td>1</td>
<td>19</td>
<td>86.4</td>
<td>Genital</td>
</tr>
<tr>
<td>Bleeding – vaginal</td>
<td>1</td>
<td>0.2</td>
<td>12</td>
<td>54.5</td>
<td>Genital</td>
</tr>
<tr>
<td>Stools Clinical note</td>
<td>Frequency (f)</td>
<td>% of all stool requests</td>
<td>No. of survey responses</td>
<td>Impact rating %</td>
<td>Category</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>--------------</td>
<td>-------------------------</td>
<td>-------------------------</td>
<td>----------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Diarrhoea – chronic, AIDS</td>
<td>1</td>
<td>0.3</td>
<td>22</td>
<td>100.0</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td>Diarrhoea, Leukaemia</td>
<td>1</td>
<td>0.3</td>
<td>14</td>
<td>63.6</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td>Diarrhoea – post chemo</td>
<td>1</td>
<td>0.3</td>
<td>13</td>
<td>59.1</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td>Diarrhoea, Pain – abdominal</td>
<td>1</td>
<td>0.3</td>
<td>13</td>
<td>59.1</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td>?Infection – CDT</td>
<td>2</td>
<td>0.5</td>
<td>21</td>
<td>95.5</td>
<td>Infection</td>
</tr>
<tr>
<td>Diarrhoea – travellers</td>
<td>1</td>
<td>0.3</td>
<td>21</td>
<td>95.5</td>
<td>Other (Traveller, Clinical note, Organisation)</td>
</tr>
<tr>
<td>Recent travel</td>
<td>1</td>
<td>0.3</td>
<td>21</td>
<td>95.5</td>
<td>Other (Traveller, Clinical note, Organisation)</td>
</tr>
<tr>
<td>?Giardiasis</td>
<td>3</td>
<td>0.8</td>
<td>22</td>
<td>100.0</td>
<td>Parasite</td>
</tr>
<tr>
<td>Infection – ascaris</td>
<td>2</td>
<td>0.5</td>
<td>22</td>
<td>100.0</td>
<td>Parasite</td>
</tr>
<tr>
<td>?Rotavirus</td>
<td>3</td>
<td>0.8</td>
<td>22</td>
<td>100.0</td>
<td>Rotavirus</td>
</tr>
<tr>
<td>?Rotavirus ?Giardiasis</td>
<td>1</td>
<td>0.3</td>
<td>22</td>
<td>100.0</td>
<td>Rotavirus</td>
</tr>
<tr>
<td>?Gastroenteritis, ?Rotavirus, ?Shigella</td>
<td>1</td>
<td>0.3</td>
<td>21</td>
<td>95.5</td>
<td>Rotavirus</td>
</tr>
<tr>
<td>?Rotavirus ?Adenovirus</td>
<td>2</td>
<td>0.5</td>
<td>21</td>
<td>95.5</td>
<td>Rotavirus</td>
</tr>
</tbody>
</table>

Table 9.4: Clinical notes which recorded the highest impact rating
<table>
<thead>
<tr>
<th>Stools clinical note</th>
<th>Frequency (f)</th>
<th>% of total wound or stool requests</th>
<th>No of survey responses</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhoea – chronic, AIDS</td>
<td>1</td>
<td>0.3</td>
<td>7</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td>?Rotavirus ?Giardiasis</td>
<td>1</td>
<td>0.3</td>
<td>6</td>
<td>Rotavirus</td>
</tr>
<tr>
<td>Diarrhoea – bloody, vomiting</td>
<td>1</td>
<td>0.3</td>
<td>5</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td>?Giardiasis</td>
<td>3</td>
<td>0.8</td>
<td>5</td>
<td>Parasite</td>
</tr>
<tr>
<td>Infection – ascaris</td>
<td>2</td>
<td>0.5</td>
<td>5</td>
<td>Parasite</td>
</tr>
<tr>
<td>?Gastroenteritis, ?Rotavirus, ?Shigella</td>
<td>1</td>
<td>0.3</td>
<td>5</td>
<td>Rotavirus</td>
</tr>
<tr>
<td>?Infection CDT</td>
<td>2</td>
<td>0.5</td>
<td>5</td>
<td>Rotavirus</td>
</tr>
<tr>
<td>Diarrhoea — bloody</td>
<td>3</td>
<td>0.8</td>
<td>3</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td><strong>Wound clinical note</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abscess – pus, Allergic to Penicillin &amp; Keflex</td>
<td>1</td>
<td>0.2</td>
<td>14</td>
<td>Abscess</td>
</tr>
<tr>
<td>?MRSA</td>
<td>15</td>
<td>3</td>
<td>11</td>
<td>MRO (Multi Res Org [MRSA, URE etc])</td>
</tr>
<tr>
<td>?MRSA, Resistance to Penicillin</td>
<td>2</td>
<td>0.4</td>
<td>11</td>
<td>MRO (Multi Res Org [MRSA, URE etc])</td>
</tr>
<tr>
<td>Wound – site specified</td>
<td>8</td>
<td>1.6</td>
<td>11</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Lymphoma – non-Hodgkin's</td>
<td>1</td>
<td>0.2</td>
<td>10</td>
<td>Other (org specified, clinical note)</td>
</tr>
<tr>
<td>Ulcer – Diabetic, On Antibiotics</td>
<td>1</td>
<td>0.2</td>
<td>10</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – site specified, History of pseudomonas</td>
<td>1</td>
<td>0.2</td>
<td>10</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – site specified, On Antibiotics, Diabetes</td>
<td>1</td>
<td>0.2</td>
<td>10</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Diabetic septic foot</td>
<td>3</td>
<td>0.6</td>
<td>10</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Abscess – site specified, Diabetic</td>
<td>1</td>
<td>0.2</td>
<td>9</td>
<td>Abscess</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>1</td>
<td>0.2</td>
<td>9</td>
<td>Other (org specified, clinical note)</td>
</tr>
<tr>
<td>Boil, History of MRSA</td>
<td>1</td>
<td>0.2</td>
<td>9</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – Diabetic, Previous MRSA</td>
<td>1</td>
<td>0.2</td>
<td>9</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Wound – infection, On Penicillin</td>
<td>2</td>
<td>0.4</td>
<td>9</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Ulcer – site specified, NIDDM, ?Osteomyelitis, ?Infection</td>
<td>1</td>
<td>0.2</td>
<td>8</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Abscess – site specified, Infected AVF</td>
<td>1</td>
<td>0.2</td>
<td>7</td>
<td>Abscess</td>
</tr>
<tr>
<td>Ulcer – pressure, History of MRSA</td>
<td>1</td>
<td>0.2</td>
<td>7</td>
<td>Ulcer/Boil</td>
</tr>
<tr>
<td>Wound – spider bite</td>
<td>1</td>
<td>0.2</td>
<td>6</td>
<td>Ulcer/Boil</td>
</tr>
</tbody>
</table>

Table 9.5: Clinical notes which survey participants indicated would affect the interpretation of test results
<table>
<thead>
<tr>
<th>Wounds</th>
<th>Stools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Febrile</td>
<td>Infection</td>
</tr>
<tr>
<td>Wound infection - falls</td>
<td>Sepsis</td>
</tr>
<tr>
<td></td>
<td>Diarrhoea</td>
</tr>
<tr>
<td></td>
<td>Diarrhoea Febrile</td>
</tr>
<tr>
<td></td>
<td>Diarrhoea Pregnant</td>
</tr>
<tr>
<td></td>
<td>Diarrhoea, vomiting</td>
</tr>
<tr>
<td></td>
<td>Stool – loose</td>
</tr>
</tbody>
</table>

Table 9.6: Clinical notes which survey respondents recorded as having no impact on the processing of tests

The results are summarised in an aggregate form in Table 9.7. This table compares the impact level range for each of the categories and provides the median level of impact. It also reports the number of types of clinical notes found in each category, their frequency and percentage of all wound or stool requests. For instance, the category Multi-Resistant Organism (MRO) contained three types of clinical notes and accounted for 19 (3.8%) of all wound specimen requests (n=501). This category recorded a median impact rating of 86.4% which ranged from 77.3% to 90.9%. In contrast, ulcer/boil notes which have the highest number of categories (50) and appeared most often (164 times, 32.8%) had a lower median level of impact of 31.8% and ranged from 0% to 86.4%. For stool specimens, the parasite category which has two types and accounted for five or 1.3% of all stool requests (n=379), recorded a 100% impact level. On the other hand, diarrhoea notes, which had 63 types and made up the greatest percentage of stool notes, had a 31.8% median and ranged from 0% to 100%.
<table>
<thead>
<tr>
<th>Wounds</th>
<th>Range of impact rating %</th>
<th>Median rating %</th>
<th>No. of Clinical notes (in category)</th>
<th>No. of times the category appeared</th>
<th>% (of total wound or stool requests)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abscess</td>
<td>22.7 – 86.4</td>
<td>81.8</td>
<td>18</td>
<td>114</td>
<td>22.8</td>
</tr>
<tr>
<td>Genital</td>
<td>54.5 – 86.4</td>
<td>70.5</td>
<td>2</td>
<td>6</td>
<td>1.2</td>
</tr>
<tr>
<td>MRO (Multi Resistant Organism) [eg, MRSA]</td>
<td>77.3 – 90.9</td>
<td>86.4</td>
<td>3</td>
<td>19</td>
<td>3.8</td>
</tr>
<tr>
<td>Other (organism specified, clinical note)</td>
<td>0 – 81.8</td>
<td>13.6</td>
<td>13</td>
<td>19</td>
<td>3.8</td>
</tr>
<tr>
<td>Ulcer/boil</td>
<td>0 – 86.4</td>
<td>31.8</td>
<td>50</td>
<td>164</td>
<td>32.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stools</th>
<th>Range of impact rating %</th>
<th>Median rating %</th>
<th>No. of Clinical notes (in category)</th>
<th>No. of times the category appeared</th>
<th>% (of total wound or stool requests)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotics</td>
<td>27.3 – 36.4</td>
<td>31.8</td>
<td>3</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>0 – 100.00</td>
<td>31.8</td>
<td>19</td>
<td>63</td>
<td>17</td>
</tr>
<tr>
<td>Gastro</td>
<td>9.1 – 9.1</td>
<td>9.1</td>
<td>2</td>
<td>10</td>
<td>2.6</td>
</tr>
<tr>
<td>Infection</td>
<td>0 – 95.5</td>
<td>47.7</td>
<td>2</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td>Other (Traveller, Clinical note, Organisation)</td>
<td>0 – 95.5</td>
<td>27.3</td>
<td>18</td>
<td>25</td>
<td>7.1</td>
</tr>
<tr>
<td>Parasite</td>
<td>100 – 100</td>
<td>100</td>
<td>2</td>
<td>5</td>
<td>1.3</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>95.5 – 100</td>
<td>97.7</td>
<td>4</td>
<td>7</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Table 9.7: Summary of survey findings for wound and stool notes

Kappa statistics for the two specimen categories are presented in Table 9.8. They indicate moderate levels of agreement between medical/technical (.465 stools and .462 wounds) and medical/scientific staff (.541 and .508) but substantial agreement between technical/scientific staff (.725 and .930) and level of experience (.699 and .835).
Table 9.8: Kappa statistics and significance for levels of agreement between professional groups and levels of experience

<table>
<thead>
<tr>
<th></th>
<th>Stools Kappa statistic and significance</th>
<th>Wounds Kappa statistic and significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical and Technical</td>
<td>.465 (p&lt;0.001)</td>
<td>.462 (p&lt;0.001)</td>
</tr>
<tr>
<td>Technical and Scientist</td>
<td>.725 (p&lt;0.001)</td>
<td>.930 (p&lt;0.001)</td>
</tr>
<tr>
<td>Medical and Scientist</td>
<td>.541 (p&lt;0.001)</td>
<td>.508 (p&lt;0.001)</td>
</tr>
<tr>
<td>&lt;5 years and 5+ years experience</td>
<td>.699 (p&lt;0.0001)</td>
<td>.835 (p&lt;0.001)</td>
</tr>
</tbody>
</table>

Table 9.9 (wounds) and 9.10 (stools) list the highest ranked clinical notes and provide indicative examples of comments provided by survey participants detailing the effect of the clinical note on the test process. For instance in Table 9.9 the response to the clinical note *MRSA* would mean the setting up of an MRSA plate with chromogenic media and the working up of a staph aureaus. However, if the clinical note read *Abscess – site specified, diabetic*, the laboratory procedure would involve the set up of an anaerobic agar [ANA], Anaerobic incubation [AnO₂] plate plus an Metronidazole disc to also test for TB [Tuberculosis]. For stool specimens, if the clinical note indicated *Recent travel*, the test process would involve a parasite, ova and cysts examination and other procedures including alkaline peptone water, vibrio cultures, thiosulphate cirate bile salts sucrose agar, subselenite broth and salmonella shigella agar.
<table>
<thead>
<tr>
<th>Clinical Note</th>
<th>Comment</th>
<th>Impact rating %</th>
</tr>
</thead>
<tbody>
<tr>
<td>?MRSA</td>
<td>Set up MRSA plate Chromogenic media Work up any staph aureaus</td>
<td>90.9</td>
</tr>
<tr>
<td>?MRSA, Resistance to Penicillin</td>
<td>Set up MRSA plate/agar/media/chromogenic</td>
<td>86.4</td>
</tr>
<tr>
<td>Abscess – Bartholin</td>
<td>Set up ANAs [Anaerobic agar] plates Set up CNAO₂ (aerobic special agar plate) AnO₂ [Anaerobic incubation], ?GC searching for neisseria gonorrhoe Add CHOC [Chocolatised horse blood agar] plate for Haemophilia</td>
<td>86.4</td>
</tr>
<tr>
<td>Abscess – site specified, Diabetic</td>
<td>Set up ANA AnO₂ plate + MTZ [Metronidazole] disc May also test for TB [Tuberculosis]</td>
<td>86.4</td>
</tr>
<tr>
<td>Abscess – site specified, IV drug abuser</td>
<td>Set up ANAs Anaerobic plates Set up AnO₂, CNAO₂</td>
<td>86.4</td>
</tr>
<tr>
<td>Abscess – site specified, NIDDM (Non-Insulin Dependent Diabetes Mellitis)</td>
<td>Set up ANAs AnO₂ plate + MTZ disc Set up AnAO₂ + CNAO₂</td>
<td>86.4</td>
</tr>
<tr>
<td>Abscess – site specified, Pyrexial</td>
<td>Set up ANAs Anaerobic plates/cultures Set up AnO₂, CNAO₂</td>
<td>86.4</td>
</tr>
<tr>
<td>Boil, History of MRSA</td>
<td>Set up MRSA plate/agar/media/chromogenic</td>
<td>86.4</td>
</tr>
<tr>
<td>Ulcer – site specified, ?MRSA</td>
<td>Set up MRSA Set CNA anaerobic Add CNANA HBA, MAC, CNAO₂</td>
<td>86.4</td>
</tr>
<tr>
<td>?HSV</td>
<td>Forward to virology Swabs in transport media unsuitable for HSV [Herpes Simplex Virus]</td>
<td>81.8</td>
</tr>
</tbody>
</table>

Table 9.9: Examples of additional comments accompanying high-impact rated wound clinical notes from survey respondents
<table>
<thead>
<tr>
<th>Clinical Note</th>
<th>Comment</th>
<th>Impact rating %</th>
</tr>
</thead>
<tbody>
<tr>
<td>?Giardiasis</td>
<td>Giardia/crypto Add COP [Cysts ova and parasites]</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Look for parasites</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Set up ELISA (Enzyme-linked immunosorbent assay) Do IH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Iron Haematoxylin] stain</td>
<td></td>
</tr>
<tr>
<td>?Rotavirus</td>
<td>Add rota antigen, send to virology</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>ROTAG [Rotavirus antigen]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adeno test</td>
<td></td>
</tr>
<tr>
<td>?Rotavirus, ?Giardiasis</td>
<td>Add rota/parasite examination</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Rotavirus/adenovirus test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Giardia/crypto ELISA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Workup IH stain</td>
<td></td>
</tr>
<tr>
<td>Diarrhoea – chronic, AIDS</td>
<td>Crypto, microsporidia, CMV [Cytomegalovirus]</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Mycobacteria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sent for TB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HUS (Haemolytic uroamic syndrome)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wubculture selenite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COP [Cysts ova and parasites]</td>
<td></td>
</tr>
<tr>
<td>Infection – ascaris</td>
<td>Parasite examination</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Add COP [Cysts ova and parasites]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Harada cultures</td>
<td></td>
</tr>
<tr>
<td>?Gastroenteritis, ?Rotavirus, ?Shigella</td>
<td>Rota/adeno antigen</td>
<td>95.5</td>
</tr>
<tr>
<td></td>
<td>Add virology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Subculture selenite broth onto SS [Salmonella shigella agar]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Add SM2 [special media for salmonella]</td>
<td></td>
</tr>
<tr>
<td>?Infection – CDT</td>
<td>Clostridium difficile toxin [CDT] test</td>
<td>95.5</td>
</tr>
<tr>
<td></td>
<td>Set up Clostridium</td>
<td></td>
</tr>
<tr>
<td>?Rotavirus, ?Adenovirus</td>
<td>Do rota, adeno antigen</td>
<td>95.5</td>
</tr>
<tr>
<td></td>
<td>send to virology</td>
<td></td>
</tr>
<tr>
<td>Diarrhoea – travellers</td>
<td>TCBS [Thiosulphate cirate bile salts sucrose agar], Alkaline</td>
<td>95.5</td>
</tr>
<tr>
<td></td>
<td>Peptone Water [APW]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sub selenite broth, parasite workup</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heamolytic uroamic syndrome [HUS]</td>
<td></td>
</tr>
<tr>
<td>Recent travel</td>
<td>Parasite examination, ova, cysts exam, set up COP, APW</td>
<td>95.5</td>
</tr>
<tr>
<td></td>
<td>[Alkaline peptone water], vibrio cultures, TCBS, ssub selenite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>broth subbed to SS [Salmonella shigella agar]</td>
<td></td>
</tr>
</tbody>
</table>

Table 9.10: Examples of additional comments accompanying high-impact rated stool clinical notes from survey respondents
9.3.2 Expert panel

*The impact of clinical notes*

The panel distinguished between two areas in which clinical notes may impact upon the processing of microbiology laboratory tests. The first way affects what tests are performed on the specimen, either in the setting up of culture plates, or the particular ways the specimen is dealt with. As one participant noted, often the most crucial piece of information required is confirmation of the nature of the specimen, the exact site from which it was taken and even the method of collection. Without clinical notes the laboratory is constrained to perform the minimum number of tests. It is unable to be comprehensive if it does not have anything specific to look for. A valuable example of this is in the situation where a patient may have entered hospital after a car accident with a head injury. If the clinical notes read “Wound swab: head. Exposed to river water in accident”, laboratory staff would then test for organisms found in the water in addition to the standard tests for a head injury. On the other hand, if the clinician only provided the note “Wound swab – head”, the lack of information about the river water may result in a dangerous infection going undetected possibly resulting in future complications for the patient. The context of the specimen is therefore important for identifying the correct treatment.

The second area in which a clinical note may impact is on the interpretation of the test result. Laboratory professionals are generally provided with little idea of why a specimen was sent to them, and what the physician may have had in mind. As one participant explained:
“We have these terrible examples sometimes where we continue to work away on things for possibly two weeks and it is rubbish because we don’t have the necessary information to make the judgment that … [it] wasn’t worth it”.

“Things that don’t come labelled and it’s a fluid and you’re guessing, (whatever it is) – the site from where these specimens are taken are not put down at all. This means time-consuming phone calls before we can do anything”.

Participants also described how clinical notes act as triggers for further action. For instance, food poisoning involving seafood would require an additional medium looking for specific organisms. Many of these triggers are formalised in the department manual which direct a certain set of processing procedures that follow receipt of a clinical note:

“One specific example I can think of … we were looking for normal pathogens in [a] particular patient and found nothing. Two weeks down the track someone did a HIV [Human immunodeficiency virus] test and they turned out to be HIV positive and we found a fungus … which requires a very specialised technique to diagnose it. It’s not until someone provides that information that we then go and look for it”.

Table 9.11 provides an example of the change of procedures for a skin swab that can be caused by different clinical notes. However, not all clinical notes trigger protocols. The primary role of some types of clinical notes may just be to help formulate questions aiding the process of working out what is and what isn’t important.
Table 9.11: Microbiology department guideline for processing skin swab in the light of accompanying notes

**Efficiency and effectiveness and the quality of care**

Participants described how the efficiency and effectiveness of the laboratory operation is closely connected to the provision of quality information, helping the laboratory to specify, search and identify the right organism. As one participant explained:

“MRSA [Methicillin-resistant Staphylococcus aureus] – it’s a good example in that if it’s a wound swab and we don’t know anything about the patient it might take us 24 hours, sometimes 48 hours … and we then do sensitivity testing so it’s another 24 hours, so it could be 72 hours before we know it’s an MRSA. If they suspect MRSA or they’ve been in another institution and transferred here for example, we
can put a medium as part of the primary culture plates … we’re 95% sure it’s an MRSA. So in 24 hours we’ve been able to provide that and they can isolate them, so it’s not just efficiency within the lab [laboratory] it’s hopefully being more efficient in the wards as well, so infection control can act a bit quicker. They can be 48 hours earlier than it would be otherwise”.

The panel noted that there are significant financial implications involved with clinical notes, particularly if the absence of an important piece of information may have led to wasted effort and time, along with the cost of expensive reagents and laboratory consumables. Participants emphasised the consequences of providing no clinical notes, which can include, over ordering or sending the wrong specimen for the patient’s condition, and even the danger of specimen contamination:

“What we find if there are blood cultures in casualty is that they’re growing skin organisms, which might not be significant, but sometimes they are, and you ring up and in fact the patient had no infection at all. So why send that specimen, get it contaminated and put a whole lot of people through the hoops? I could use that very good example because if we get a co-ag negative staph, which is possibly a blood culture contaminant, ring it up to casualty, the patient never admitted, went home, they have to bring the patient back and re-assess the patient”.

A clinical note of ?HSV (Herpes Simplex Virus) has an important impact on how the specimen is transported. Most swabs come in a transport media which allows the bacteria to be preserved. This means that the collection of the specimen is crucial to the testing
process. The moment anaerobes are exposed to air, they begin to die. If an HSV-suspect specimen was collected in a normal transport media, the virus may: 1) be overrun by bacteria that multiply much faster, or 2) may be exposed to air which would cause the anaerobes to start dying, making the specimen unsuitable for testing. When viral transport media are used, the bacteria are prevented from growing and the virus is allowed to survive. Therefore, the clinical note allows the laboratory to check that the method of collection was appropriate before going ahead with the test. If the HSV query was not present, not only would the virus not be tested for, but the virus may no longer be detectable using existing test parameters.

Clinical notes are important not only for how the specimens are tested, but also where the test is undertaken. Viruses, parasites, and bacteria all go to different departments. If a clinical note is not initially flagged, then an organism may go unnoticed. In the example of a child with diarrhoea, if the _Giardia_ or _Rotavirus_ queries are not included as a clinical note, the test may not be immediately directed to the suitable pathology areas (eg, parasitology and virology) for testing. As a consequence, an invasive organism could remain unidentified.

There are also important patient care implications involved with the provision of clinical notes. Panel participants described how this is often the case with the specification of an abscess as a clinical note. This triggers the laboratory to test for anaerobes. Anaerobes and aerobes require unique treatment that may not occur if the clinical note is missing. One example of this involves serious wounds where there has been deep penetration of the skin. On the top of the skin there will be aerobes growing affecting the skin and exhausting the
oxygen, leading to the creation of an anaerobic condition. Anaerobes like clostridium can cause an abscess to occur underneath the skin, sometimes allowing gangrene to become established. General antibiotics are unlikely to get rid of an abscess where anaerobes are present, so if the appropriate clinical note does not indicate the required tests to be done, it can mean the difference between keeping a limb and losing it, or in extreme cases, death.

**Design implications for electronic ordering**

The introduction of electronic ordering was seen in a positive light by the panel, particularly because of the impact it had made on the legibility of clinical notes and the improved access to vital patient information. One participant explained that:

> “The Cerner system was in operation when I came back after a three year absence. I find that we’re being like detectives, clicking on all sorts of areas of the Cerner system to get little pieces of information. We’ll click the encounter history, we’ll click on our previous results, or on anything that we can think of that might give us a tiny fragment of information”.

However, this process can be time consuming. And as the panel pointed out, clinical notes can come in many forms, and their quality is not uniform. Improving communication across the laboratory – ward interface should not mean the transmission of enormous volumes of irrelevant information, just because it is easy to do so. The panel was concerned that there is a danger of data overload, where a lot of data is supplied
irrespective of its value. The importance of this issue is expressed in the following panel exchange:

**Participant A**: “At the moment we’re talking about systems where clinical notes have to be entered in the request form but at some point I imagine patient records are going to go into an electronic format and then it might become an issue of who can access what, rather than specific bits of information being put onto the form. Is this all going to change?”

**Participant B**: “Do you see us … sitting reading plates and looking up the whole of the patients’ clinical notes? (laughter)”.

The panel was positive about the ability of electronic ordering systems to provide standardised formats for improving the supply and quality of clinical notes. However it also expressed concern that using the system to prompt clinicians for important information could lead to “tick box fatigue”. Instead, they saw a need to supplement clinical decision-making prompts with education processes:

“We know what clinical notes would be important to us. Travel, history, etc, etc, but in fact there are quite a wide range of clinical notes and I can quite see that if you had a tick-box system where you had 30 things you had to tick they’d go demented. I think the best hope is to educate clinicians as to what we think is important in terms of clinical notes. That is if it’s a stool specimen what is important, and then it’s a much smaller range of information that’s necessary”.

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9.4 Discussion

*The effect of clinical notes on test processing*

The findings of the survey highlighted a number of instances where laboratory professionals (technicians, scientists and medical) recorded high levels of impact for different types of clinical notes accompanying stool or wound specimens. There were only two clinical note examples for wounds and seven for stools which participants unanimously recorded as having no effect on the processing of tests. For wound specimen notes, the category of notes which achieved the highest median rating were those associated with multi-resistant organisms (86.4%), followed by abscesses (81.8%) and genital (70.5%). The category with the lowest median rating was the category called “other” which included notes specifying an organism, or containing other information. For stool specimens, the categories with the highest median rate were those which specified a parasite (100%), followed by the rotavirus category (97.7%). The lowest stool category was gastro notes (9.1%).

When participants were asked to specify the consequences of clinical notes which recorded high impact levels, they described the set of laboratory procedures triggered by the clinical notes. For instance if the clinical note *MRSA* is specified in a wound specimen by the clinician, laboratory staff are prompted to use a special methicillin plate. The methicillin isolates the organism faster. This means that a result can be provided in one day instead of three. This can mean the difference between getting a patient into isolation or an infection spreading throughout a ward until it is contained and treated. In cases of diarrhoea, age
may determine the conditions of contamination and therefore the possible viruses or parasites involved. For instance, if the patient is a child, the most common cause of diarrhoea for children is rotavirus, so the specimen may be sent to virology to detect that particular virus. If the patient is an older person involved in an outbreak situation in a nursing home then the virology section of the Microbiology department may then want to search for nora virus.

*The effect of clinical notes on the interpretation of test results*

The findings provided a large number of examples where participants specified that a clinical note would affect interpretation, treatment or the report sent to the clinician. Many of these notes eg, *?MRSA* and *Diarrhoea – chronic AIDS* were also considered to be important in the processing of the test. But there were some notes such as *Ulcer – site specified, History of pseudomonas* and *Wound – infection*, and *On Penicillin* which did not rate highly as affecting the test process but were considered to be important in the interpretation process.

In many cases the information about test processing is protocol-driven, usually as part of a laboratory guideline which specifies what tests are required with the presence of a certain clinical note. Not all clinical notes trigger protocols in the laboratory. In some cases a clinical note may help the process of formulating comments or questions that are provided to the responsible clinician as a diagnostic aid. Participants explained that sometimes the most important piece of information could be confirmation of the nature of the specimen and the exact site from which it was taken from. This is because laboratory personnel are
constrained in their attempts to be comprehensive if they are not provided with an indication of what it is they need to investigate.

The findings confirm that the transfer of requests between clinicians and the laboratory makes up an important communication link between the ward and the laboratory (Deeble & Lewis-Hughes 1991; White 2002). This information exchange can include a clinical reason for, or expectation from the test, and provides the laboratory with context from which they can add value to the test process (Marques & McDonald 2000; White 2002).

**Implications for electronic ordering**

Pathology laboratories can be considered to be the “court of last resort” – their role being to integrate data from a broader pathological and clinical context and translate it into clinically meaningful information (Hardwick 1998) (Hardwick 2002). If it is possible to identify clinical notes that are important for the processing and interpretation of tests, their absence must therefore have implications for the efficiency and effectiveness of laboratory functioning. In some cases, the lack of important information may lead to wasted time and effort with potentially significant financial consequences. Participants in this study provided a set of examples to verify this, pointing to: a) the effect a clinical note may have on the urgency of the test process eg, *MRSA* and, b) the appropriateness of the test order eg, specimens testing for skin organisms in patients without any noted infection. The supply of accurate and essential contextual clinical information can therefore be expected to facilitate appropriate and effective laboratory utilisation and maximise pathology service contribution to the diagnostic process (Plebani 1999).
These findings have major implications for the design and implementation of CPOE systems. Past research using hand-written forms has shown that the provision of educational information about test applicability is an important way of informing physicians about their test choices and changing their behaviour (Deeble & Lewis-Hughes 1991; Axt-Adam et al. 1993). The introduction of CPOE systems, which allow clinicians to order directly via a computer, can promote this change of behaviour.

Participants in this study were careful to explain that the quality of clinical notes provided by clinicians is not uniform, and there is the danger of either providing unnecessary data which is irrelevant to the laboratory, or of overburdening clinicians with demands for more and more data entry tasks. Problems of data overload also increases the likelihood of information going unseen because of the increased effort it takes to access it (Feied et al. 2000; Handler et al. 2004; van der Sijs et al. 2006). Peute and Jaspers addressed the issue in their usability study of a laboratory order entry system in an Academic Medical Centre in The Netherlands. The authors reported on physicians’ concern about the burden of providing unnecessary additional information with their laboratory orders. This led them to search for ways of avoiding the task, which in turn resulted in incomplete orders that the laboratories were unable to adequately perform (Peute & Jaspers 2007).

**Information, its meaning and context**

The findings from this study reinforce the important role that context plays in the laboratory test process and its impact on patient care. Whilst CPOE systems have the potential to
greatly enhance the gathering and presentation of information, their usability is intrinsically linked to the context or carrier of the information (Berg & Goorman 1999). Indeed, as White warns, the ability to automate pathology testing should not lead to mistaken perceptions of reliability leading to a possible decline in communication across the laboratory – ward interface:

“… communication with diagnostic laboratories remains important for safe patient care, and … test results still need to be interpreted in the context of other clinical information about a patient, and not accepted without question” (page 142) (Graham H White reply to Hutchinson) (Hutchinson 2003).

The challenge facing designers and users of CPOE systems is to provide precise frameworks (understood by all users) which can be used to convey exact meaning and minimise misunderstandings (O'Reilly & Pondy 1979).

9.5 Conclusion

This chapter identified a number of examples where clinical information can affect the choice of microbiology test, its processing, and even the urgency with which it is undertaken. They also highlighted areas where a clinical note can affect the interpretation or comments issued by the laboratory. In some situations the primary role of a clinical note may be to help formulate questions to aid the process of working out what tests are, and are not, important to undertake.
The findings also draw out an important element of the pathology test process, reinforcing the need for communication at the laboratory–ward interface (Plebani 1999). The role of pathology laboratories goes beyond just reporting the most accurate results, toward accounting for and integrating the clinical information that motivated the order of the test in the first place (Marques & McDonald 2000). The role of clinical notes is therefore best described as providing the laboratory with the context from which they are able to add value to the patient care process (White 2002). After all, the value of a laboratory test must be measured not only by its chemical and clinical performance but on its effect on improving patient outcomes (Plebani 1999).
These findings also highlight a number of important implications for the design and implementation of CPOE systems. Whilst it is clear that electronic systems have the technical capacity to provide information quickly and efficiently, the organisational communication challenges can be substantial. This study drew out a number of these issues. One such problem is that of data overload where information is elicited irrespective of its importance, context and value. Another problem is finding the correct mechanism to establish a meaningful channel of information exchange across the laboratory – ward interface, without overburdening clinicians with excessive and unnecessary data entry tasks.

The findings outlined in this chapter allow the refinement of the organisational and communication framework with the introduction of “information exchange – meaning and context” (see Figure 9.1). The chapter has highlighted the importance of information exchange in the test ordering and interpretation process, with important organisational and temporal implications for not only what laboratory work is undertaken, but also when and how it is performed. Information exchange is also a factor in the communication processes that underpin the pathology procedure. The chapter introduces an important caveat – information should not be perceived simply as an easily collected and transferable commodity divorced from the clinical context and meaning of its production (Berg & Goorman 1999). The next chapter will utilise the organisational communication framework to examine the impact of the introduction of CPOE system on the Blood Bank. This will provide a valuable means of testing and expanding the conceptual validity of the framework through the prism of a dissimilar case scenario.
Chapter 10  Blood Bank – the implications of CPOE on the provision of safe, efficient and quality laboratory services
10.1 Introduction

The previous chapter looked into the impact of hand-written clinical notes supplied by physicians on test request forms on microbiology test processes, its potential effect on patient care and the implications for the design of CPOE systems. It presented a combination of consensus, qualitative and quantitative techniques to identify examples where clinical notes can affect the choice of test and its processing, and their potential consequences for the laboratory contribution to patient care. The Microbiology department was used to highlight the importance of information exchange to the provision of context and meaning to the laboratory process and the laboratory–ward interface (Plebani 1999).

This chapter shifts the emphasis to the Blood Bank with the aim of examining the organisational and communications impact of CPOE on the department’s functioning. This part of the study revisits the themes identified from the initial investigation of the Blood Bank (reported in Chapter 5) to assess the changes and work practice shifts brought about by the CPOE system.

The research utilised quantitative and qualitative data. Quantitative data were used to measure changes in the number of incoming telephone calls compared before and after the introduction of the CPOE system. Qualitative data include the results of focus groups, observation sessions and interviews held after the introduction of the system. These findings are contrasted with earlier pre-implementation findings to uncover any changes and shifts in work process. The organisational communication framework is used to further
examine the impact of CPOE. In this way the framework provides a means of understanding the consequences of the findings while at the same time being subjected to the test and refinement after the addition of new evidence (Layder 1998). The chapter concludes with an appraisal of the potential consequences of CPOE systems for the Blood Bank, the specialised nature of its work and the effect on the Blood Bank’s provision of a safe, efficient and effective service.

10.2 Methods

10.2.1 Qualitative data collection

This chapter reports on qualitative data collected in the Blood Bank department in the post implementation period, from May 2006 to August 2008. The data were collected formatively, allowing for issues and questions to be examined at the time they occurred. The research was also iterative and interactive, allowing for feedback from pathology staff. In total there were two focus group discussions, eight unstructured interview sessions and twelve observation sessions that lasted from between 15 minutes to one hour, and amounted to eight hours in total. The qualitative data incorporated discussions with 14 participants including four hospital scientists, one senior laboratory scientist–in-charge, four technical officers and five medical officers. The interviews were supported by observation sessions involving demonstrations and visualisations of particular issues (Weir et al. 2007). Two focus groups held on 25 February 2008 were taped and transcribed resulting in 15 transcript pages (A4 single spaced) and 5180 words. The focus groups each consisted of three participants. They included three technical officers, two hospital scientists and one
Laboratory Manager. A set of semi-structured questions (see Table 10.1) designed to investigate the impact of the CPOE system were used. Two of the interviews were transcribed resulting in 9 pages (A4 single spaced) and 4701 words. Additional short discussion sessions, including phone and email communication were carried out to clarify issues and investigate the validity of emerging themes.

Table 10.1: Questions asked at Blood Bank focus groups

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>What were your expectations of the new electronic ordering system?</td>
</tr>
<tr>
<td>2.</td>
<td>Were there any unexpected consequences of the new system?</td>
</tr>
<tr>
<td>3.</td>
<td>In what ways has it changed the way that you operate?</td>
</tr>
<tr>
<td>4.</td>
<td>Has it altered the way that you communicate and relate with clinicians?</td>
</tr>
<tr>
<td>5.</td>
<td>What impact has the system had on healthcare delivery and patient care?</td>
</tr>
<tr>
<td>6.</td>
<td>In hindsight, what would you have done differently?</td>
</tr>
</tbody>
</table>

**10.2.2 Quantitative data collection**

In order to measure the impact of CPOE on telephone communications Blood Bank participants were provided with a phone log to complete for the period 19 – 25 May 2008 (see Appendix 15). The phone log used identical categories to the departmental log used to monitor phone calls during the period 5 – 11 May 2005 (see Chapter 5) before the implementation of the new system. Blood Bank participants were asked to log incoming phone calls for one centrally placed telephone extension, and list details about the time of the call, its originating ward along with the reason for the call as per the list outlined in Table 5.1 (see Chapter 5). The same month (May) was chosen for the monitoring exercise.
and the dates of collection (19 – 25 May 2008) were selected from a list of suitable days.

In 2005 the monitoring sheets recorded 199 calls for the period 5 – 11 May. An identical number of calls were recorded in the period 19 – 25 May 2008. Hospital communication records were used to obtain the total number of calls per month for each extension in the Blood Bank. This made it possible to estimate that the monitoring sheets provided a sample of 45 – 50% of all calls received by the telephone extension for both the pre- and post- implementation periods.

The results of the monitoring sheets were compared using frequency and proportion analyses across the two time periods to check for any changes in the categories of incoming telephone calls. Statistical significance of differences were tested using the Chi-square test for independence with the Yates’ Correction for Continuity for 2X2 tables (Pallant 2001) in SPSS version 15 (SPSS 2007).

Data relating to the total number of monthly calls received by the Blood Bank between May 2005 and October 2006 were obtained from hospital communication records. These data were compared with the total number of orders and product requests (red cells, platelets and fresh frozen plasma) for each corresponding month to identify the percentage of incoming calls relative to Blood Bank requests for each month.
10.3 Results

10.3.1 Qualitative results

The initial research phase (see Chapter 5) identified a number of distinctive characteristics of the Blood Bank. Not only does the Blood Bank issue test results, in the way that other pathology departments do, it also dispenses blood products. This helps to explain the range of processes and professions (eg, haematologists, laboratory scientists, physicians, nurses and technical officers) that are involved in the department’s work procedures. These relationships and interactions are in turn reliant on the timely exchange and confirmation of information between clinical staff and the Blood Bank, which were expected to be affected by the introduction of the new CPOE system.

Robust communication channels

The collaborative effort between staff in the Blood Bank and the wards relies heavily on an information infrastructure that allows hospital personnel to convey request information efficiently and accurately. Traditionally, the telephone has played a major role in this exchange. The telephone is a synchronous channel of communication in which the exchange of information occurs simultaneously. The changeover from a synchronous exchange to an asynchronous one (where a message is posted on the system) represents an important change in the ordering process. During the course of the implementation period the Blood Bank substituted fax requests for blood products as a replacement of the previous
practice which allowed for orders to be placed over the phone. This new procedure meant that a request is faxed to the Blood Bank and when it arrives in the department it triggers an alarm system to notify staff of its presence. Participants believed that this procedure had improved communication between the ward and the laboratory.

Despite it being over two years since the introduction of CPOE in the hospital, requests for blood products (platelets and fresh frozen plasma) are still not electronically ordered. Initially, almost one year after the introduction of CPOE, this was explained by laboratory managers as necessary because it provided time for the system to become accepted and “settled”. After two years it became clear that the asynchronous character of electronic ordering remained a major cause of trepidation about electronic ordering in the Blood Bank setting. As a senior laboratory scientist explained:

“There are concerns which I have to convince myself we are able to be overcome, and those concerns are … when that product is being ordered electronically. If it is ordered by phone or fax you know straight away, but if it is ordered electronically it will just sit in the ‘end list’ … All it needs is an alert … that an order has been received, but there’s no alert electronically”.

**Efficiency and effectiveness**

The Blood Bank, in collaboration with clinical staff, has a responsibility to ensure that patient details and specimens are correctly labelled, to avoid the possibility of patient identification error. This has implications for the integrity of the product and the efficiency
with which the product is dispatched. It also has major consequences for patient care, particularly if the dispatch of blood products is not carried out promptly and efficiently. Blood Bank staff noted that the accuracy of electronic ordering was considered superior to the previous hand-written process and the internal system checking processes were safer. This includes CPOE’s ability to immediately highlight important data entry errors, eg, incorrect blood group. The system was also felt to have improved accountability and enhanced the monitoring and traceability of Blood Bank processes, even though it was generally considered to be slower:

“For example, an issue of fresh frozen plasma; before we just logged it in, we had a book, now we have to say that we’re thawing it and we’ve got to order the test for fresh frozen, then we have to result … the fresh frozen that we’ve actually thawed it out. Then we have to print labels to say that this is a thawed product and it expires on this day. It is more time consuming because we have to jump through more hoops, but in saying that we’re more thorough in doing our work. Everything is traceable, Cerner knows where a product goes and where it’s gone and who processed it, who stored the sample” (Focus group participant).

The quality and safety of work practices

The issues of specimen validity and the temporal cycles that impact on their work were also addressed by participants. The Blood Bank regularly needs to know that blood products sent to wards have been received, as it is not possible to leave products at room temperature for extended periods. For instance, red cell products cannot be left out of the refrigerator
for more than half an hour. To guard against this occurrence the Blood Bank rings wards to ensure that the physician is notified and aware of the presence of the blood product. As noted by one participant:

“It is very time consuming for us to ring them, especially when you’re calling ED [Emergency Department]. You need to go through ten different phone calls … just to be able to get to the doctor that’s looking after the patient” (Blood Bank participant).

Participants also explained that if a patient has not been exposed to foreign blood cells from a transfusion the blood specimen is regarded as valid for ten days. However, if a patient has been transfused within the last three months, or is pregnant, they are regarded to have been exposed to foreign red cell agents and hence capable of producing anti-bodies against those red cells. A sample is therefore required every three to four days before the Blood Bank is able to say: “this is a patient’s current anti-body status, it is nil and it is safe to computer cross-match blood.”

The temporal issues that impact on specimen validity and blood product viability have important safety implications for the Blood Bank and the quality of patient care. One of the scenarios described by participants, involved situations where a blood product’s viability may have expired and the new system responds by immediately issuing a warning to the operator. However, because the system does not prevent the blood product from being issued, there is a possibility of inadvertently overriding the warning, particularly if the operator has not being sufficiently attentive. As one participant explained:
“People don’t always follow every alert that’s put to them and unless there’s something in place to prevent them from doing that they will just ignore a lot of alerts because they get so many. It’s like having a sign – you have one sign on the wall, people might pay attention to it, but if you have 100 signs on the wall you’re not going to notice it” (Blood Bank participant).

Blood Bank staff reported that the issue of overrides had been noticed during an initial evaluation of the new system and had been reported to system operators as part of a change-request process. The Blood Bank was waiting for modifications to occur. In the meantime however, there had been two critical incidents where the system had been mistakenly overridden which caused expired blood products to be sent out. The issue of negotiating system changes to suit their department work process requirements was described in the following manner:

“We have had changes implemented. Sometimes we asked for a change and we’re told, ‘no, one size fits all, it’s not possible’” (Focus group participant).
### 10.3.2 Quantitative results

The total number of calls received each month by the Blood Bank for the period May 2005 to October 2006 is shown in Table 10.2. The average number of calls per month during the period was 1913. The period with the highest number of incoming calls was November 2005 to January 2006, which represented the implementation changeover period for the new Cerner CPOE and results reporting system. These three months recorded 2181, 2095 and 2211 calls respectively. After January 2006 the number of incoming calls per month showed a gradual (but not consistent) decline to October 2006 where the number of calls was recorded as 1574, which is lower than the figure (n=1706) for the same month in 2005. The pattern is broadly similar when the total number of calls is represented as a percentage of the total number of orders and product requests for red cell, platelet and fresh frozen plasma transfusions for each month. This is shown in Table 10.2 and illustrated graphically in Figure 10.1. These figures show a rise from 69.6% in October 2005 (before the changeover) to 89.1% in November, 86.1% in December and 88.4% in January 2006. The figures remained high until June 2006 whereupon they began to decline.
<table>
<thead>
<tr>
<th>Month</th>
<th>Number of incoming calls</th>
<th>Total orders and product requests</th>
<th>Incoming calls as a percentage of total orders and product requests</th>
</tr>
</thead>
<tbody>
<tr>
<td>May-05</td>
<td>1841</td>
<td>2692</td>
<td>68.4</td>
</tr>
<tr>
<td>Jun-05</td>
<td>1746</td>
<td>2602</td>
<td>67.1</td>
</tr>
<tr>
<td>Jul-05</td>
<td>1704</td>
<td>2503</td>
<td>68.1</td>
</tr>
<tr>
<td>Aug-05</td>
<td>2154</td>
<td>2822</td>
<td>76.3</td>
</tr>
<tr>
<td>Sep-05</td>
<td>1887</td>
<td>2549</td>
<td>74.0</td>
</tr>
<tr>
<td>Oct-05</td>
<td>1706</td>
<td>2450</td>
<td>69.6</td>
</tr>
<tr>
<td>Nov-05</td>
<td>2181</td>
<td>2449</td>
<td>89.1</td>
</tr>
<tr>
<td>Dec-05</td>
<td>2095</td>
<td>2434</td>
<td>86.1</td>
</tr>
<tr>
<td>Jan-06</td>
<td>2211</td>
<td>2500</td>
<td>88.4</td>
</tr>
<tr>
<td>Feb-06</td>
<td>1784</td>
<td>2470</td>
<td>72.2</td>
</tr>
<tr>
<td>Mar-06</td>
<td>2103</td>
<td>3138</td>
<td>67.0</td>
</tr>
<tr>
<td>Apr-06</td>
<td>2062</td>
<td>2486</td>
<td>82.9</td>
</tr>
<tr>
<td>May-06</td>
<td>2019</td>
<td>2610</td>
<td>77.4</td>
</tr>
<tr>
<td>Jun-06</td>
<td>1997</td>
<td>2370</td>
<td>84.3</td>
</tr>
<tr>
<td>Jul-06</td>
<td>1840</td>
<td>2535</td>
<td>72.6</td>
</tr>
<tr>
<td>Aug-06</td>
<td>1682</td>
<td>2567</td>
<td>65.5</td>
</tr>
<tr>
<td>Sep-06</td>
<td>1856</td>
<td>2743</td>
<td>67.7</td>
</tr>
<tr>
<td>Oct-06</td>
<td>1574</td>
<td>2433</td>
<td>64.7</td>
</tr>
<tr>
<td>Mean</td>
<td>1913</td>
<td>2575</td>
<td>74.5</td>
</tr>
</tbody>
</table>

Table 10.2: Total number of incoming calls; total number of orders and product requests (red cells, platelets and fresh frozen plasma), and incoming calls as a percentage of orders and products requested for the period May 2005 to October 2006. Shaded rows represent the pre-implementation period beginning 22 November.
Figure 10.1: Incoming telephone calls received by the Blood Bank as a percentage of total orders and products (red cells, platelets and fresh frozen plasma) for the period May 2005 to October 2006.
Figure 10.2: Comparison of type of telephone calls received by the Blood Bank for the period 2005 (5-11 May) and 2008 (19-25 May)

<table>
<thead>
<tr>
<th>Reason for call</th>
<th>2005 N (%)</th>
<th>2008 N (%)</th>
<th>Yates Continuity correction to Chi-Square</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Send Blood/Platelets/FFP</td>
<td>42 (20%)</td>
<td>25 (13%)</td>
<td>4.59</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Send Batch product</td>
<td>20 (10%)</td>
<td>4 (2%)</td>
<td>9.98</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Confirm Lamson receipt</td>
<td>12 (6%)</td>
<td>6 (3%)</td>
<td>1.46</td>
<td>0.23</td>
</tr>
<tr>
<td>Product order</td>
<td>41 (21%)</td>
<td>39 (20%)</td>
<td>0.02</td>
<td>0.90</td>
</tr>
<tr>
<td>Enquiry availability</td>
<td>37 (19%)</td>
<td>49 (25%)</td>
<td>1.80</td>
<td>0.18</td>
</tr>
<tr>
<td>Enquiry other</td>
<td>36 (18%)</td>
<td>66 (33%)</td>
<td>11.09</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Personal</td>
<td>11 (6%)</td>
<td>10 (5%)</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Total</td>
<td>199</td>
<td>199</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 10.3: Comparison of reasons for telephone calls to the Blood Bank compared by year with Chi-square test and significance of results
A comparison of the reasons for telephone calls to the Blood Bank across the pre- and post-implementation periods is shown in Figure 10.2 and Table 10.3. The biggest changes in proportions over the two periods were for the categories “send blood/platelets/FFP” which fell from 20% to 13%, “send batch product” from 10% to 2% and “enquiry other” which rose from 18% to 33%. The change in each of these categories was tested using Yates Continuity correction to the Chi-Square test and found to be significant.

10.4 Discussion

The findings outlined above describe the organisational and communications impact of CPOE on the functioning of the Blood Bank. They reveal a number of areas where modifications and changes to existing work practices were made as a result of CPOE implementation. The organisational communication framework (as shown in Figure 10.3) is utilised as a means of examining issues that are important and relevant to the Blood Bank’s functioning specifically, and to pathology laboratory work more generally. These factors include the mode (synchronous/asynchronous) of communication transfer, its impact on the department’s communication environment and the temporal and organisational ramifications of these changes.
10.4.1 The organisational communication environment

Synchronous and asynchronous channels

Previous chapters established the importance of communications in helping organisations to comprehend and control their environment (Euske & Roberts 1987). For the Blood Bank this includes timely exchange of information about test and product orders with clinical staff. In the past, as noted in Chapter 5, this communication has been synchronous, and reliant on the telephone for every step of the blood product ordering process, including the confirmation of receipt. When the Blood Bank changed its previous synchronous procedure for ordering blood products and replaced it with an asynchronous procedure requiring clinicians to send a faxed order, they also installed an alarm system to notify
Blood Bank staff of the arrival of all faxes. The alarm was a means of compensating for the lack of synchronicity, thereby seeking to ensure that no blood product order remained unnoticed. The importance of the issue of synchronicity is underscored by the fact that over two years after the implementation of electronic ordering for laboratory tests across the hospital, it is not possible to electronic order blood products (platelets and fresh frozen plasma). This is because there is still concern about the adequacy of the warning and notification mechanisms needed to alert Blood Bank staff.

The results also highlight the highly collaborative nature of the Blood Bank’s work involving a range of processes and personnel across the hospital. The ward – laboratory interface is predicated on robust levels of communication (ensuring receipt of messages). Such communication is underpinned by two-way process of message reinforcement (Eisenberg & Goodall 2004). It is more than a passive “sender-receiver” exchange across the hospital, but is instead a process of transaction involving feedback and validation (Weir et al. 2007), which is vital to conveying accurate meaning or understanding (O’Reilly & Pondy 1979) and ensuring the delivery of safe patient care (Georgiou et al. 2007).

Organisational communication environment

In Chapter 6 it was detailed how changes in the way that an organisation undertakes its information processing and decision-making tasks can also be affected by CPOE. These changes can impact on the organisational communication environment of the department, particularly the quantity and variety of information communicated, its complexity and diversity, which can in turn introduce turbulence and instability (Huber & Daft 1987). One
of the key safety functions of the Blood Bank is to ensure accurate patient identification along with correct labelling of all patient and specimen details. The introduction of the new CPOE system introduced a number of changes to the department’s environment. The analysis of the total number of incoming calls across the period May 2005 to October 2006 revealed a spike in the number of telephone calls and in the proportion of calls relative to the total number of test orders and product requests for each month, across the period of system changeover – November 2005 to January 2006. This rise was not consistent across the whole post-implementation period.

Comparisons of the proportion of the different types of incoming telephone calls showed a significant drop in the calls that asked for bloods, platelets, fresh frozen plasma or batch products to be sent. This decrease was paralleled by a significant rise in the number of incoming general call enquiries. To a large degree these findings are a reflection of the changeover in 2007 which required clinicians to fax blood issue requests as described above. They also suggest that the improved monitoring capacity of the new system (as reported by Blood Bank participants), in particular its ability to provide wards with real time information about the status of blood and batch products, may have contributed to the reduction of some categories of calls from the ward. However, the increase in the number of general enquiries highlights the ongoing importance of telephone communication between the ward and the laboratory. It may also point to the existence of a greater and more diverse range of reasons for ward – laboratory communication that are not reflected in the monitoring log findings.
Blood Bank participants were keen to emphasise that the CPOE system had improved accuracy and safety, particularly through its ability to highlight data entry errors and the improved accountability and monitoring facets of the system. However, participants also expressed concern that the proliferation of alerts warning operators about possible errors and mistakes, had become excessive and inappropriate and had failed to stop the issuing of expired blood products. This reinforces concerns that badly organised warning and support notifications can lead to misinterpretation and have adverse effects on patient care (Koppel et al. 2005).

**Organisational changes**

The study highlighted a number of organisational functions such as planning, organising, staffing and controlling (Fayol 1967; O'Reilly & Pondy 1979) that were affected by the introduction of the CPOE system. For instance, while the new system was thought to have slowed down some aspects of the Blood Bank process, it had made the department more thorough and accountable, possibly helping it to organise and control their workload better. But, as with the experience of the Clinical Chemistry and Haematology departments outlined in Chapter 7, the Blood Bank is also involved in a negotiation process aimed at ensuring that procedures introduced by the CPOE system, such as product expiry alerts, suit the distinctive context and organisational communication environment of the Blood Bank (McLaughlin et al. 1999). In part, as Aydin and Rice point out, these negotiations for process change are often brought about by role ambiguities or changes in work arrangements, and because laboratory staff seek ways to fit new CPOE-introduced changes into their daily work (Aydin & Rice 1992).
Finally, it is important to consider the influence of temporal factors on the introduction of CPOE in the department. As with the temporal requirements of the Clinical Chemistry and Haematology departments outlined in Chapter 8, the Blood Bank is also required to organise and plan its activities around unique organisational and clinical time cycles. Not only is the department required to monitor the time scale of test samples to ensure that they remain valid, they are also required to remain alert to any products whose viability has expired. This temporal factor helps to explain the importance of the alerts and warnings about product expiries. It also draws attention to the involvement of time considerations in decisions about synchronous/asynchronous means of communication. This is because the Blood Bank’s concern about asynchronous exchange is linked to the possibility that a request may remain unnoticed over an excessive and unsafe period of time. Even the introduction of more time-consuming but safer processes required by the new system is underpinned by temporal considerations particularly in regards to how the Blood Bank allocates, synchronises and schedules its work (Bardram 2000). They therefore constitute important considerations for the implementation and effective functioning of CPOE systems in Blood Bank settings.

10.4.2 Limitations

The use of telephone monitoring logs and the hospital communication records has provided a useful tool to examine the effects of CPOE on communication patterns of the Blood Bank. Hospital communication records provide aggregate figures about telephone
communication volumes that are insensitive to the type of calls being made. Conversely, the telephone monitoring log relies on accurate recording and categorisation of telephone calls which is not always easy to achieve in busy settings like the Blood Bank.

10.5 Conclusion

This chapter has employed the organisational and communication framework to highlight a number of areas where the changeover and introduction of a CPOE system had affected the functioning of the Blood Bank. It noted the organisational planning and control implications of the new system, particularly through participants’ experience of safer and more accountable work practices. This experience was linked to efforts by the department to negotiate the introduction of appropriate work practices. The importance of temporal factors was highlighted by the issue of specimen viability, and the introduction of electronic alerts warning operators about the existence of expired products. This issue was also one requiring ongoing mediation. The issue of synchronicity also featured prominently in the findings. This is because the Blood Bank’s reliance on real time communication with the ward had not been adequately addressed by the design features of the new system.

The maintenance and enhancement of effective communication channels between the Blood Bank staff and ward-based clinical staff, along with rigorous monitoring procedures, are essential for the safe and effective implementation of electronic ordering systems. New electronic ordering systems need to: i) facilitate timely communication between the Blood Bank and ward staff; ii) cater for the information management tasks involved in the Blood Bank; and iii) optimise the safety and quality components of the Blood Bank process.
These factors are important to the design and functioning of these systems. They can also contribute to ensuring high levels of staff support and preparedness in the face of changes that may be disruptive and difficult.

This chapter has used the Blood Bank as a unique setting to test (and refine) the organisational communication framework. Quantitative and qualitative data were used as a means of triangulating findings and to test the validity and reliability of data. This allowed comparisons with a number of the specific and unique features of the Blood Bank, while also highlighting organisational and communication issues that are commonly shared across the laboratory setting. In the next chapter, the emphasis shifts to an Emergency Department setting where CPOE has been introduced. This setting provides a valuable case study which can be used to compare the experiences, findings and perceptions of the laboratories and contrast them with those from a clinical setting.
Chapter 11  Emergency Department – at the crossroads of hospital information flow
11.1. Introduction

The preceding chapter used the Blood Bank as a case setting with which to explore the organisational and communications impact of CPOE over the two-year period since implementation. The findings demonstrated the importance of synchronicity to the safe and efficient functioning of the Blood Bank. They revealed that while electronic ordering was permitted for blood sample tests, it was not allowed for blood products (fresh frozen plasma, red cells and platelets) because of the concern about proper alerts and accountability procedures. Temporal issues played a big part in the changeover to the new system, particularly those that related to the product viability of blood products and the accompanying decision-support features that help prevent staff from issuing expired products. Blood Bank participants expressed satisfaction with the new procedures introduced by the new CPOE system, noting that even though it may be slower and possibly more cumbersome; the process had become safer and more accountable. The findings also revealed that the utilisation of the CPOE system was still, even two years after implementation, subject to continuing negotiation between the Blood Bank and IT system planners and managers.

This chapter adds a new dimension to the study by highlighting the experiences of clinicians from an Emergency Department (ED) setting to contrast with the findings from the pathology laboratories. Its aim is to present a detailed case study within the ED to gain insights into the perceptions of nurses and physicians regarding the impact that CPOE (within the first year of system use) has on their work and communication practices, and the
potential consequences of these on care delivery. The ED offers an insight into the effects of CPOE from a clinical standpoint and provides a different perspective from which to examine the organisational communication impact of CPOE.

ED is uniquely positioned at the crossroads of information flow within the hospital (Feied et al. 2000). It is a potentially valuable area for evaluating the broader, hospital-wide consequences of information systems like CPOE. Existing research of CPOE has shown that nurses in a US ED reported generally positive perceptions of CPOE’s effect on the efficiency of common care processes such as getting medications to patients (Banet et al. 2006). Asaro et al. found that the percentage of clinical time spent on direct ED patient care following CPOE implementation did not change (Asaro & Banet 2004). Other studies have investigated the impact of CPOE decision-support features and reported significant decreases in the need for pharmacist clarifications of orders (Bizovi et al. 2002). Schriger et al. showed an increase from 83% to 96% in guideline compliance rates for the treatment of occupational body fluid exposure in a US ED following the incorporation of guidelines into a CPOE system (Schriger et al. 1997). However, when Asaro et al. compared acute coronary syndrome guideline compliance in an US ED setting, first as a paper-based guideline, and then as a CPOE-based order set, they found no demonstrable improvement. The authors suggested that the lack of improvement was related to issues about the ease of system use (Asaro et al. 2006).

This chapter begins with an outline of the design and setting of this part of the study. It describes the way that the qualitative data were collected and analysed. The results of the study are then presented as seven initial themes that emerged from the findings. These
themes are described and illustrated with verbatim quotes which provide a contextually rich
depiction of each of the chosen issues. These themes are then aligned to the organisational
communication framework with particular emphasis on how they related to the planning
and control of ED work processes, their association with temporal factors involving the
scheduling and synchronisation of work, and their impact on the communication
environment in the ED. The findings of the study are discussed with reference as to how
the organisational communication implications of the ED experience relates to those of the
pathology laboratories and what significance they may have for promoting safe and
efficient work processes and patient care.

11.2 Methods

11.2.1 Design and setting

This case study employed qualitative methods including focus groups and interviews to
provide rich, in-depth data (Kaplan 1997). The study was carried out in the ED of large
Sydney metropolitan tertiary referral hospital. The department has a 66-bed capacity with
an annual census of approximately 60,000 patients. At the time of the study there was a
total of 225 ED staff including 50 medical officers (16 Staff Specialists, 24 Registrars and
10 Interns/Resident Medical Officers), 130 nursing staff and over 45 clerical staff and ward
orderlies. This component of the study was carried out during the period May to August
2006, some four months after system implementation commenced. This provided the
opportunity to gather formative data about changes to work, communication and clinical
care processes related to the implementation of the new system, as well as allowing scope for some reflection on past events.

11.2.2 Data collection

The study included seven semi-structured interviews held with three senior ED physicians (including the ED Clinical Director) along with one focus group of six ED physicians and five focus groups involving a total of 20 registered nurses. Chain referral sampling was used to identify and extend the participant base. This involved using individuals as informants to direct the researcher to other potential participants (Quine 1998). Theoretical sampling techniques were used to extend the participant base to include a cross section of clinical participants. The extension of the participant base was ended after it became clear that no new material was emerging (Bowling 1997).

During interviews and focus groups, participants were asked to discuss their expectations of the new ordering system. This provided the means of investigating aspects of the ED contextual setting (eg, what had happened prior), which may have contributed to their current views (McAlearney et al. 2007). Participants were also asked to: i) identify any unexpected consequences or alterations in the way they relate to other clinicians and/or patients following system implementation; ii) describe the impact the system had on healthcare delivery; and iii) explain what they thought could have been done differently with the advantage of hindsight. The interviews were transcribed by a person experienced in the task, and resulted in 114 typed transcript A4 pages and 53,489 words.
11.2.3 Analysis

This study utilised concurrent analysis techniques (Gifford 1998). This involved regular reviews of all interview data, the organisation of emerging categories and the identification of possible relationships or patterns. The interviews and focus groups were supplemented by a series of iterative discussions with senior clinical staff. This provided the study with an important feedback mechanism with which to address the construct validity of emerging themes (Yin 2003). It also opened up the opportunity of pursuing ideas and exploring issues in more depth (Murphy et al. 1998). Occasionally this involved decisions to collect further data, including through the addition of new participants. Themes arising from the data were then classified according to organisational communication framework outlined previously.

11.3 Results

Analysis of the data revealed seven themes. They are presented below along with verbatim quotes chosen because they provide a rich and representative description of the issue.

Expectations

The majority of participants (both physicians and nurses) reported that they did not have great expectations of the new CPOE system noting that computer systems are not foolproof. Some senior physicians had higher expectations:
“I was hoping that the system would use its electronic capability to flag issues, or clusters of results for the clinician, or the consumer, as a quality intervention, more than just a straight up reporting system” (Senior Medical Officer).

**Shifts in tasks and responsibility**

Many of the physicians referred to the impact of changes in the way that tests were ordered, including data entry tasks previously performed by laboratory staff. Physicians also reported that the system required shifts in responsibility for certain tasks. For example, questions that would routinely be asked of patients by service departments now became the duty of the treating clinician. This change in responsibility had an impact on the time spent ordering which in turn affected existing relationships between departments. In the past the radiology department took responsibility for ensuring that patients sent for X-rays were checked for any conditions that may endanger their safety as in the case of pregnancy or contrast allergy.

“The onus has gone away from the people who are actually performing the test – the radiologists – from asking these questions, on to the clinician to answer those questions. So there’s a shift of workload and a shift of responsibility” (ED Staff Specialist).

The new system also enabled a protocol-driven procedure which provided nurses with the ability to order in certain situations. Nurses noted that it had made the process of patient care more efficient. In the past they needed to chase physicians for a signature before an
order could be submitted; now it was possible to immediately order a test and obtain the physician’s electronic authorisation at a later time.

*Cumbersomeness of the system*

Participants commented on the time-saving advantages of the new system. Clinicians can now enter orders conveniently from areas within and outside the hospital allowing physicians to have easy access to patient information at all times. However, as one physician noted, this advantage is beneficial in ward situations but less so in ED because:

“… we don’t have to walk to the wards; all our patients are in one spot” (ED Staff Specialist).

A number of participants commented on the unwieldiness of the new system pointing to the numerous screens prompting them for information which they felt was unnecessary or redundant. Figure 11.1 provides an example of a “redundant screen” which asks the ordering clinician for information about pregnancy regardless of the sex or age of the patient. Figure 11.2 shows the screen which appeared every time a urine culture test was ordered, which physicians regarded as superfluous information (ie, what a urine culture is) and unnecessarily informed them that a repeat test was not required.
Figure 11.1: Screenshot of information required about pregnancy which appears regardless of patient age or sex

A Urine Culture equals Urine MC&S (a microscopy on the specimen is included).

A separate Urine Microscopy order is not required.

Figure 11.2: Screenshot of information received after order of urine test


**Decision support**

Many of the physicians addressed issues relating to the provision of decision support. While recognising that the idea of providing decision support was “good in theory”, they felt that the sheer repetitiveness of support being offered was interfering with its potential effectiveness.

“You know – when you order this test you have to do this. It’s like yes of course I bloody know that, I’ve been ordering this test for 20 years. Like the X-ray box when you click X-ray, it will come up saying you have to order an X-ray for a particular part of the body. Really? Thanks very much, I know that. I mean they’re just useless bits of support. It just irritates people; it added nothing to the process” (ED consultant).

Senior clinicians asked for a number of screens offering decision support to be removed, arguing that in many circumstances the sheer repetitiveness of the screens counteracted their usefulness and were becoming a hindrance.

**Monitoring the test order process**

Physicians were concerned that the new system did not allow them to adequately monitor the progress of test orders in the same way that the hospital’s previous home-grown system had:
“Whereas, before in the old … system, if you sent down a blood test, as soon as it was logged in, as a test being done, it would say “to follow”, until you actually got a result. Whereas now, it says you’ve ordered it, but if you just go to look at the results, it just won’t give you any result until there is a result. It won’t say it is in the system; it’s not ready yet” (ED Staff Specialist).

This situation has important implications for patient safety as described by one registrar:

“The situation that I was involved in was with somebody who was vomiting blood. He admitted to drinking a little bit, and his bloods came back and [the results] had everything there except the two AST [Aspartate aminotransferase] and ALT [Alanine aminotransferase] part of the liver function test, but they had everything else, and it looked on a casual glance like a full set of liver function tests. Three hours later, the AST and ALT come back on the computer and they’re 10,000! By this stage, I’m on the phone, but there’s been nothing on the computer screen to say we’re doing these tests, they’re to follow. They just don’t show up” (ED Registrar).

Time and efficiency

Participants expressed concern about the additional demands on their time required by the new system. Many reported that despite some valuable efficiency savings associated with the new system, there remained a big discrepancy between the time taken to complete a hand-written request form (usually about 30 seconds) and the new system which they said could take anywhere between 2 to 7 minutes depending on the tests being ordered.
“It certainly takes up more of your time, so it reduces the amount of time you’ve got to do other things. That is one of the things that always frustrates me – is that largely, particularly in emergency, it is the medical staff who are doing the data entry, and largely it is senior medical staff, because we see the bulk of the patients” (ED Consultant).

**System requirements**

A common theme among all participants was the importance of designing systems that adequately address the specific context and needs of individual hospitals. Some participants expressed concern that many aspects of the new system utilised features based on a hospital site whose experience and needs were not always identical with their own.

“What people didn’t realise was that different environments require different programs, and different tweaks to different programs, and they have different needs and necessities” (ED Staff Specialist).

There was a strong desire for greater consultation and input into the design of the system. The commonly held perception was that a lot of rules had been introduced without appropriate consultation with clinicians about their value or effectiveness.
11.3.1 Organisational communication framework

The initial themes were placed into an organisational communication framework. This provided a means of examining the impact of the CPOE system on the communication environment within the ED and other hospital departments; its relationship to the organisation, planning and control of the department’s work process along with the temporal landscape of the department, particularly its connection with the synchronisation, scheduling and allocation of work.

The results of this analysis are presented in Table 11.1. They show that five of the seven themes (responsibility shifts, system cumbersomeness, decision support, monitoring the test order process and time and efficiency) related to two or more of the organisational communication categories. The responsibility shifts theme fitted into each category because it involved communication changes in the way information was exchanged between the ward and ancillary department (pathology or radiology), along with a resultant shift in the organisation and control of tasks, and the temporal synchronisation of tasks.

The other theme which encompassed all three categories was monitoring the test order process. The descriptions provided by participants showed that the monitoring of tests involved issues related to the prompt and efficient communication of information, which in turn affect the temporal synchronisation and organisation of clinical work and patient care (as in the incident involving the incorrect discharge of a patient). It is also noteworthy that all of the themes that appeared in the communication category also appeared in the temporal category. For instance, the theme system cumbersomeness was related to the provision of information (sometimes considered unnecessary and duplicative) and decision
support (sometimes considered redundant). System cumbersomeness also had repercussions for the transfer of information and knowledge and hence the communication environment of the ED, and had direct temporal consequences for efficiency and scheduling of tasks. The themes expectations and system requirements both only appeared within the organisation category. This is because they related more directly to what the ED expected to receive and the consequences for how the department managed and controlled its work. The theme system requirements involved the negotiation, planning and control of work environment in the face of changes brought about by the CPOE system.

<table>
<thead>
<tr>
<th>Theme</th>
<th>COMMUNICATION</th>
<th>ORGANISATION</th>
<th>TEMPORAL</th>
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<tbody>
<tr>
<td>Expectations</td>
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<td>Responsibility shifts</td>
<td>X</td>
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<td>System cumbersomeness</td>
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<td>Decision support</td>
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<td>Monitoring the test order process</td>
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<td>Time and efficiency</td>
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</tr>
<tr>
<td>System requirements</td>
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</tbody>
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Table 11.1: The relationship of emergent themes to the concepts of communication, organisation and temporality

11.4 Discussion

The findings drew upon the organisational communication framework developed previously as a means of providing a lens through which to interpret the interaction between the new system and clinicians involved in the ED, the organisation of their work and its potential impact on patient care. They highlighted important consequences of the introduction of CPOE to the ED setting involving: i) changes to the way that information is gathered and exchanged between different parts of the hospital, particularly those involving
the frequency, type and complexity of information; ii) the impact of the new system on how work was managed, (eg, changes in nurse responsibility), and control (eg, the negotiations around changes to the system); and iii) the effect of the new system on timescape factors involving the synchronisation of tasks (eg, the reporting of results), the scheduling of tasks (eg, patient discharge) and allocation of tasks (eg, nurse responsibility for some ordering).

The organisational communication framework also provides the scaffolding for identifying and outlining some key implications of CPOE implementation in ED and its relationship and effect on pathology laboratories. These include: i) the need for robust channels of communication; and ii) the need to optimise data presentation and information monitoring.

**Developing robust channels of communication within the hospital**

ED is made up of complex organisational structures that contain their own conventions, rules, cognitive artefacts (eg, status boards and schedules) and work practices that are likely to be affected by the introduction of a new CPOE system (Nemeth et al. 2004). Elements of these special characteristics of the ED were highlighted in this study by participants’ concerns about changes in their existing practices, their need to efficiently monitor information, and in statements that emphasised the need for CPOE to suit the requirements that are distinctive to the ED. It is instructive that ED clinicians expressed concern about the level of pre-implementation consultation with their department. It was only after the passing of time and the build up of problems, in combination with numerous representations to management, that ED clinicians felt that the issues they were confronting began to be addressed. The information technology implementation process is made up of
some inherent level of negotiation between different departments and occupational groups (Aydin & Rice 1992). Successful implementation is most likely to coincide with improved levels of collaboration across the hospital aimed at addressing any non-functioning aspects of the system (Stablein et al. 2003).

The advantages of CPOE can be dependent on a range of context-specific factors (Handler et al. 2004). What may appear as useful for one department may not be seen the same way by another. The findings of this study show that the introduction of decision-support mechanisms in the ED can be challenging, particularly if alerts, reminders and guideline information at the point of care are not seen to be achieving their intended goals, but rather causing frustration and slowing down the clinician (Handler et al. 2004). These concerns have prompted the call for the selective and gradual deployment of patient- and context-specific decision support carried out in consultation with clinical users with due consideration to the work flow and culture of the ED (Holroyd et al. 2007). This is an important process in helping to persuade clinicians of its value in improving the quality of care (Asaro et al. 2006).

This study highlighted areas where changes in clinical work processes and the introduction of new time consuming procedures may slow clinicians and pull them away from the patient’s bedside with detrimental effects on efficiency and patient flow. The issue is an important one, particularly as patient satisfaction is often directly connected to the quality of interpersonal interaction between patients and healthcare providers (Boudreaux & O’Hea 2004). Davidson et al. have previously reported concerns that the high stress component of ED work (where speed and reliability is essential) can force clinicians to push the limits of
their multi-tasking abilities leading to possible lapses in awareness and vigilance (Davidson et al. 2004).

**Optimising data presentation and information monitoring**

The inability to know instantly what tests have been ordered and at what stage in the laboratory process they are at can lead to confusion. Whilst this is not an order entry issue per se, it does highlight how the incorporation of CPOE systems with downstream reporting systems can have important consequences for the patient care process (Handler et al. 2004). It is also a point that will resonate with clinicians in other hospital settings because the absence of good monitoring systems leaves open questions in clinicians’ minds about whether or not tests have been ordered, leading to the possibility of repeat orders. The inability to easily track tests can also increase the potential for adverse events exemplified in the incident involving a critical test result. Hospital system planners should aim to maximise the ability of the clinician to see the right type of data when needed. Many leading commentaries in this area have also noted that badly designed interfaces (eg, fragmented displays that prevent a coherent overview) (Koppel et al. 2005) can lead to cognitive errors (Bates et al. 2001; Horsky et al. 2003) such as the misinterpretation of information, resulting in substandard medical care.

The likelihood of information going unseen is linked to the effort required to obtain it. This has led Feied et al., to recommend the implementation of “flat” systems where most functions are available in one place, doing away with “deep” nested levels of navigation (Feied et al. 2004), a feature also raised by study participants concerned about the number
of screens they were required to traverse in order to find the appropriate test. The
development of flat systems may require a possible trade off involving a reduction in the
amount of guidance and support offered by the system, and information requested from
clinicians. These are issues that can compromise patient safety (van der Sijs et al. 2006).
The resolution of such matters will need to accommodate the diverse ways that clinicians
work within computerised environments. It will also need to secure strong clinical and
institutional support for the development of electronic support features (Kaplan & Maxwell
1994; Bobb et al. 2007).

**Limitations of this study**

This case study was carried out in one Australian hospital ED setting during the first year of
implementation. This design was chosen in order to gain insights into the issues that
clinicians face in day-to-day situations where the problems are “hiding in plain sight”
(Koppel et al. 2005). The disadvantage of such study designs is that they often lack the
advantage of hindsight and overview offered by summative study designs. It is important
to recognise that the passage of time is a big factor in the implementation process; initial
problems can often give way to reasonable and robust solutions. But there is emerging
evidence that without aggressive attention to the details of problems as they appear there is
the likelihood that they will be disguised by workarounds (Ash et al. 2003) and other
inadequate “solutions” (Georgiou et al. 2007). There are limits to the generalisability of a
study in a single hospital, particularly one whose large workload is likely to exacerbate
potential problems. However, the experiences described in this study can help to identify
and illustrate problems likely to be directly confronted by other EDs and more generally by other departments across the hospital.

11.5 Conclusion

This chapter provided insights into the perceptions of nurses and physicians about the introduction of a CPOE system and its impact on work and communication with the ED. The organisational communication framework provided the basis for identifying and assessing the effect of CPOE within the ED and its relationship with other departments like pathology services, and the implications of the system on clinical work and the provision of patient care. The chapter highlights how the ED needs access to large amounts of information in a timely fashion, with the benefit of appropriate decision-support mechanisms. But at the same time, the complexity of the ED makes it highly vulnerable to disruption caused by inadequate system design and ineffective channels of communication across the hospital. The challenge of CPOE implementation in ED is to understand clearly what is expected to be achieved and what the risks and drawbacks are. This must involve consideration of what work practices and processes are likely to be affected and changed by the new system.

The next chapter will proceed to summarise and assess the findings of the thesis in the light of its aim and the questions it set out to answer in Chapter 2. The chapter will draw together the study’s findings across the different pathology departments and the ED setting and identify the organisational communication implications of CPOE for pathology laboratories, their work processes and relationships both with each other and across the
hospital. The chapter will also summarise the role the organisational communication framework played in: a) guiding the selection of relevant data; b) undertaking the interpretation of the findings; and c) offering an explanation of the underlying causes or influences that affect CPOE implementation (Reeves et al. 2008).
Chapter 12  Discussion
12.1 Introduction

The previous chapter reported on the findings of the impact of CPOE within an Emergency Department (ED) setting. It outlined the effects that the system had on work and communication practices and discussed the potential consequence of these on the delivery of patient care. The ED was chosen because it provides a valuable clinical perspective from which to contrast and test the findings from the pathology departments through the lens of the organisational communication framework.

This chapter will respond to the stated aim of the thesis and the questions it set out to answer. It brings together the study’s findings from across the different pathology departments and the ED, and considers the organisational and communication implications of CPOE for pathology laboratories, their work processes and relationships. It also identifies the underlying mechanisms associated with the success or otherwise of CPOE in the pathology service in the light of the multi-method and theory-driven approach adopted by this research.

The chapter begins by restating the aim of the research as it emerged from gaps identified from the existing literature in this field. Each of the research questions are then outlined and addressed. An assessment of the impact of CPOE on key indicators of pathology performance is made followed by an overview of the effects of CPOE on the functioning and organisational dynamics of the different departments and the implications for relationships across the hospital for clinicians, wards and the laboratories. This is followed
by a discussion of the implications of CPOE on the delivery of patient care. The final
section draws on the results of all the empirical findings, from the performance indicators
to the observational and consensus techniques, to highlight the organisational
communication framework, which was crucial to the synthesis and integration of the
findings.

12.2 Aim of the research

This thesis set out to investigate the organisational and communication implications of
CPOE systems for pathology laboratories. The research focused on work processes and
relationships with other hospital departments, using comparative examinations to identify
the tasks they are involved in and the particular needs the laboratories expect to be filled by
the new system. The review of the literature revealed that although there is evidence of the
potential of CPOE to impact on the efficiency and effectiveness of pathology processes eg,
turnaround times (Georgiou & Westbrook 2006; Georgiou et al. 2007; Collin et al. 2008;
Westbrook et al. 2008), it is primarily constituted of results from a handful of hospital sites,
often using home-grown systems (Georgiou et al. 2007). This raises issues about the
generalisability of the findings and their applicability to hospitals of different size, make up
or history (Kaplan 2001). The review also noted that the literature paid little attention to
the impact of CPOE on the pathology department. The metrics used to evaluate CPOE are
dominated by those concerned with the health professional’s decision to order (eg, test
volumes and guideline compliance) and the impact of the test result (patient management),
with less attention given to the laboratory test processing stage.
The literature review highlighted a growing awareness of the impact of CPOE on order management, work organisation and departmental relationships (Sittig & Stead 1994; Aarts & Peel 1999; Georgiou et al. 2005). But despite this developing field of research, pathology services have not been given prominent attention, with the noticeable exception of some early groundbreaking studies in this area by Aydin, Davidson and Chismar and Kaplan (Kaplan 1987; Aydin 1994; Davidson & Chismar 1999). More recent studies which include the author of this thesis (Georgiou et al. 2005; Georgiou et al. 2007; Georgiou & Westbrook 2007; Georgiou et al. 2007; Iedema et al. 2007; Peute & Jaspers 2007; Westbrook et al. 2008) have contributed to this field of investigation. However, CPOE and pathology services remains a research area in need of greater attention (Georgiou et al. 2007).

The literature review also focused attention on two key components of CPOE and pathology services which have underpinned this research. The first related to the information-intense character of pathology services. Pathology tests and data play a vital part in the patient care process. This explains why pathology data represent the great bulk of information that make up electronic repositories in healthcare settings (Becich 2000). Cowan characterised the pathology process “as a complex information system designed to produce useful information for individual or groups of patients” (page 3) (Cowan 2001). The second component related to the complex organisational structures that constitute the pathology department, each with their own formalised rules and conventions that have evolved over time (Davidson & Chismar 1999). The existing literature in this area has tended to treat pathology laboratories as a singular entity with limited attention to the range
of activities and processes within its constituent parts, or with regard to their social, organisational and communication structure.

12.3 Research findings

This research has addressed this gap in the existing literature and has made substantial contributions to the body of knowledge in this field. The next section brings together the findings of the multiple case studies (as summarised in Table 12.1) to supply answers to the five key research questions that emerged from the literature review.
<table>
<thead>
<tr>
<th>Research question</th>
<th>Key findings</th>
<th>Case study (Research chapter)</th>
</tr>
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</table>
| What is the impact of CPOE on key indicators of pathology laboratory performance (eg, test volumes, turnaround times)? | • Increase in the volume of incoming and outgoing calls in Central Specimen Reception (CSR) immediately following CPOE implementation  
• Decrease in the number of unfulfilled test requests after CPOE implementation  
• Proportion of add-on tests remained stable over the year following CPOE implementation  
• Significant reduction in total turnaround times (77 minutes to 68 minutes) post-implementation  
• Increase in the median number of tests per patient episode (22 to 24) post-implementation  
• Changes in category of phone calls received by the Blood Bank post-implementation | CSR (Chapter 6)                                                                                                                                   |
| What is the effect of CPOE on the functioning and organisational dynamics of different departments of the pathology laboratory service? | • Each pathology department has distinctive organisational and scientific functions which can simultaneously affect and be affected by the introduction of CPOE  
• In CSR, CPOE minimised data entry and enhanced efficiency whilst impacting on the quantity, complexity and stability of existing communication channels  
• Tracking, add-ons and middleware functions are critical components of Clinical Chemistry and Haematology requiring negotiation and change after CPOE introduction  
• While CPOE improved temporal efficiency of Clinical Chemistry and Haematology test processing, it also affected the synchronisation, scheduling and allocation of work | Pathology department – Phase I of research (Chapter 5)  
CSR (Chapter 6)  
Clinical Chemistry and Haematology (Chapter 7 and 8) |
| What are the implications of CPOE on clinician/ward/laboratory relationships?     | • CSR reported improvement in department accountability providing clinicians with the means of identifying unfulfilled requests thereby potentially reducing duplication  
• Information exchange across the laboratory – ward interface is a critically important feature of departmental relationships but continues to lack explication and synoptic standardisation  
• The asynchronous character of CPOE communication is a potential hurdle for diffusion into Blood Bank settings  
• CPOE screen design, test result reporting and test monitoring functions are major factors that affected the Emergency Department | Central Specimen Reception (Chapter 6)  
Microbiology (Chapter 9)  
Blood Bank (Chapter 10)  
Emergency Department (Chapter 11) |
| What are the implications of CPOE for the delivery of patient care?               | • Efficiency – improved turnaround times can lead to quicker time to patient diagnosis and/or treatment  
• Effectiveness – less unfulfilled test requests and duplication mean improved care effectiveness  
• Safety – enhanced laboratory/ward communication, accountability and safety. Inadequate system design features can adversely affect patient care | Clinical Chemistry and Haematology (Chapter 7)  
CSR (Chapter 6)  
Emergency Department (Chapter 11) |
| What are the underlying mechanisms identified with the successful (or unsuccessful) functioning of CPOE systems within pathology services? | • Communication environment (information load, complexity and turbulence)  
• Synchronous and asynchronous communication exchange  
• Organisational functions (planning, organising, staffing, controlling) and their relationship to communication processes  
• Timescape of the organisation and the synchronisation, scheduling and allocation of tasks  
• Information exchange – meaning and context | Synthesis of all case study findings (Chapter 12) |

Table 12.1: Research questions, key findings and their associated case study and chapter
12.3.1 Indicators of pathology performance

*Central Specimen Reception*

The Central Specimen Reception department of the pathology service recorded a significant increase in the volume of telephone and fax communication after the implementation of CPOE. The outgoing calls rose from 2037 in June – August 2005 to 5850 in the same period one year later. The numbers were even more dramatic for incoming calls; rising from 1268 to 10,678 in the corresponding periods (see Chapter 6, Table 6.1). When considered as a proportion of the total number of requests received, the figures rose from 0.02 to 0.05 for outgoing calls, and 0.01 to 0.09 for incoming calls. These findings reflect the increase in department communication activity related to the implementation of the new system.

Unfulfilled requests, defined as test requests which did not involve a blood collection, were monitored from September 2005 to March 2006. This time frame included a period immediately before the system changeover alongside the early days following implementation. The figures revealed a significant rise in the proportion of unfulfilled requests in December 2005 followed by a series of significant falls across each following month (see Chapter 6, Table 6.2). By March 2006 the proportion of unfulfilled requests was 0.003 compared to September 2005 when it was 0.008. Pre- and post-CPOE comparisons of the reasons and actions taken for unfulfilled requests also showed major changes. There was a significant drop in the number of duplicate requests from 69% to
35% and cancelled requests from 96% to 76%. Conversely, the proportion of rescheduled requests increased significantly from 4% to 24%.

Both these performance indicators are important monitors of communication activity on the one hand and information exchange on the other. They also represent contrasting modes of communication transfer, from the predominantly synchronous mode using telephone calls where information is exchanged in real time, to asynchronous modes where information about unfulfilled test requests is exchanged using messages or notes (Georgiou et al. 2007). Together they provide valuable indicators of the effect of CPOE systems on how laboratory work is performed, its effectiveness and efficiency.

**Blood Bank**

Telephone calls to the Blood Bank are an intrinsic part of the department’s ordering process. On average 75% of all Blood Bank orders are associated with a phone call. During the months immediately following the introduction of the new Cerner PathNet result reporting system in November 2005 and PowerChart in January 2006, the figures rose from 69.6% in October 2005 (before the changeover) to 89.1% in November, 86.1% in December, and 88.4% in January 2006. The figures remained high for the next six months and did not decrease until July 2006. A comparison of the reasons for calls received in 2005 with those received in 2008 showed some significant changes. Fewer calls were made to notify the Blood Bank to send batch products or bloods, platelets and fresh frozen plasma, while general enquiries to the department increased. These results reflected changes in the make up and diversity of the ward/department interface.
**Clinical Chemistry and Haematology**

Within the Clinical Chemistry and Haematology departments measurements were taken of the volume and rate of add-on tests (defined as an additional assay performed on a previously analysed specimen) (Melanson et al. 2006; Georgiou et al. 2007), along with measurements of the volumes and turnaround times for pathology laboratory tests. For both departments these are relevant performance measures. In the case of add-ons they provide an important measure of the scope of the issue, and its relationship to increased departmental workload (Melanson et al. 2004) and potentially inappropriate ordering behaviour.

An analysis of all add-ons for the period of 2006 across the hospital showed that Clinical Chemistry received 52.2% and Haematology 17.1% of all hospital add-on tests. When add-ons are measured as a percentage of all specimen requests, Emergency Departments were the originating source of the greatest proportion of add-ons. This represented 5.6% of all ED Clinical Chemistry requests and 6.7% of all ED Haematology requests. The average add-on/specimen percentage for each month across the hospital was 3.5%. There was no indication of any major change in this percentage over 2006. When the add-on rate was compared as a percentage of the total number of tests, the figure was 1.3% across the whole hospital and 1.5% and 0.6% for Clinical Chemistry and Haematology respectively. These rates are broadly comparable with the 1.5% and 0.7% rates reported by Melanson et al. from a comparison of add-on testing for one week in Clinical Chemistry laboratories in two large academic medical centres in the US (Melanson et al. 2006).
Add-ons were also compared by the time taken for an add-on test from the time of original specimen collection. The importance of this metric is that some individual tests, especially in the Haematology department, have time limit thresholds that determine whether it is possible to proceed. The findings showed that there was a higher percentage of add-ons requested within four hours for Haematology (72.1%) than for Clinical Chemistry (58.6%).

*Turnaround times and test volumes*

Turnaround time performance is viewed as a critical part of both departments’ work and their contribution to effective patient care (Westbrook et al. 2008). The before and after CPOE comparison of median turnaround times showed significant decreases – from 77 to 68 minutes – for total turnaround time, measured from the time a specimen is collected to the time a result is issued. This represented time savings of 11.7%. For laboratory turnaround times, measured from the time a specimen is received in the laboratory to the time a result is issued, the median time fell by 14.3% from 42 to 36 minutes. These efficiency gains were made despite the significant rise in the median number of tests per patient episode from 22 to 24.
Global perspective

The findings of this section of research contrast the impact of CPOE on different sections of the pathology service. On a global level they reveal the diverse needs of the departments, particularly as they relate to their organisational and scientific functions and the different roles they play in the pathology test process, as depicted in Figure 12.1. Unfulfilled test requests for instance, represent an important measure of functioning that is unique to the test ordering phase and the Central Specimen Reception department. Add-on measures were strongly related to the functions of the Clinical Chemistry and Haematology departments and were viewed as important indices of department workload. The add-on findings quantified the scope of the issue, identified differences across the pathology service and hospital, and assessed temporal add-on trends following the introduction of
CPOE. Test turnaround times are critical measures of efficiency for the laboratory and clinicians, with important connotations for patient care quality. The significant levels of improvement, despite the increase in test volumes, are clear signs of CPOE’s ability to support improved pathology efficiency. But, as the measures of telephone and fax communication show, these gains may be accompanied by dramatic changes in the volume and type of communications across the hospital.

Indicators, such as the ones discussed above, provide important soundings about the impact of CPOE on pathology services. They promote explicitness and precision about what is being attempted and what is achieved (NHS Institute for Innovation and Improvement 2007). In and of themselves, they do not represent the complete picture, but partial glimpses of the subject at hand (Pawson 1999). Part of the problem is that it is only ever possible to represent indicators as separate entities each with their own distinctive rationale and value, which can easily become frozen in time (Lyell et al. 2008). In reality, pathology laboratories are a dynamic part of a complex system involving interactions and feedback (Sterman 2006). The data from the indicators should therefore inform, and also be informed by the findings from the other research questions.

12.3.2 Functioning and organisational dynamics

Organisational and scientific functions

The second research question asked about the effect of CPOE on the functioning and organisational dynamics of different departments of the pathology laboratory service. The
initial phase of the research (reported in Chapter 5) described the context of each of the pathology departments before the introduction of CPOE. The chapter highlighted the distinctive organisational tasks of the laboratories alongside their scientific functions. These contrasting roles reflect the contextual differences between the laboratories (Review of NHS Pathology Services in England 2006) which are likely to be affected by CPOE (Snyder et al. 2006). Appreciation of the contextual setting of the laboratories is an important means of identifying the mechanisms (albeit latent) that can help to explain the impact of CPOE. These mechanisms were then synthesised into an organisational and communication framework which highlighted the importance of: a) communication processes (eg, telephone calls); b) organisational processes (eg, monitoring and tracking); and c) temporal laboratory processes. The impact of these factors on the different parts of the pathology test process is depicted in Figure 12.2, showing that communication factors specifically affect the ward – laboratory interface, temporal factors impact on the whole laboratory test order process, and organisational factors are relevant to the processing phase of the test order.
CSR was described as the pathology service’s gatekeeper, whose task is akin to a de facto “guardian” of the accuracy, efficiency and integrity of the test ordering process. CSR reported that CPOE had minimised their data entry tasks and enhanced the efficiency of the department’s work processes. This had led to improved levels of accuracy and fewer incidents of request duplication. These changes in CSR functioning were accompanied by changes in the department’s communication environment, i.e., the information load, stability and complexity of communication channels (Huber & Daft 1987). This was evidenced by: a) the increased volume of incoming and outgoing calls to CSR; b) the adoption of new data gathering requirements (i.e., the monitoring of unfulfilled requests); and c) the introduction of initial turbulence and dysfunction, particularly in the changeover period,
which was also revealed in the results of the CSR performance indicators discussed earlier. The research findings thus showed that the communication environment of a setting can provide a valuable perspective not only about how organisations undertake their work but also about the impact of any changes, such as the introduction of CPOE.

The organisation of work

In contrast to the “gatekeeper” role of CSR, the Clinical Chemistry and Haematology departments can be described as pathology’s “frontline”, responsible for a significant proportion of pathology’s workload, including life-threatening urgent tests. They are also the departments most often considered the physician’s point of first reference. It follows therefore that important department functions such as the tracking, storage and retrieval of specimens are a critical part of both departments’ workload. These workload functions, along with the procedures undertaken to process add-ons, represent key indices of department functionality related to the test processing stage (see Figure 12.2). The findings highlight the importance of middleware (defined as the bridging software between the Laboratory Information System [also referred to as Hoslab] and the laboratory analyser) and the impact that the new system had on the middleware requirements of both departments. In the Haematology department, middleware failed to function with the new system and was no longer used to validate test results. In Clinical Chemistry, middleware provided tracking and storage information about the status of specimens along with a list of the test processes required. Both departments were forced to adopt new organisational procedures to compensate for changes brought about by the new system. While the Haematology department reverted to manual methods of validation, Clinical Chemistry
negotiated the introduction of Specimen Orderable Status software with the software vendor as a means of replicating the previous system’s tracking functionality. These changes had important ramifications for the way that both departments planned, organised and controlled their respective organisational environment. The results draw attention to the ability of new technology to realign responsibilities and tasks (Aydin 1989). As Barley has pointed out, workplaces are often combinations of old and new technologies operated concurrently but representing different features of the organisation’s culture, history or social idiosyncrasies (Barley 1995).

**Temporal landscape**

The significant decreases in turnaround times have already been described. These results reflect improved efficiency of the pathology service and have potentially positive implications for the delivery of patient care. Although of significant importance, turnaround times only represent one aspect of the temporal landscape of the pathology laboratories. As per Zerubavel, turnaround times can be described as part of a linear-vectorial perspective on time because of the concentration on a series of events which are measured in seconds, minutes, hours, days etc (Zerubavel 1979). But there are also qualitative dimensions of time which seek to account for the tempo (pace and intensity) of activities, along with their patterns (periodicity of events), sequence and synchronisation, which according to Adam come together to make up an organisational timescape (Adam 2004). Each of these dimensions is identifiable in the work of the Clinical Chemistry and Haematology laboratories, from the way their work is coordinated across the hospital, processed to coincide with specimen viability spans, and even synchronised to suit the
availability of their respective test reagents. The tracking and monitoring functionality of 
the new system had important temporal consequences for the laboratories, affecting the 
pace, periodicity, sequence and synchronisation of the test process. This is a key factor in 
dealing with add-on requests. When an add-on request arrives in the laboratory not only 
does the specimen it relates to need to be found within the sequential and synchronised 
laboratory process, its viability also needs to be confirmed. Some tests (eg, Erythrocyte 
Sedimentation Rate [ESR]) cannot be carried out on unfrozen blood specimens after four 
hours have elapsed from collection. The importance of this was underscored in the results 
of add-on time measures reported earlier. CPOE can play an important mediating role in 
the temporal coordination of the laboratory, which is integrally connected with the 
organisation and planning of the laboratory work processes.

12.3.3 Implications on clinician/ward/laboratory relationships

The pathology test process, as it moves from an order to analysis and result, is best 
conceptualised as part of a collaborative laboratory – ward effort involving many different 
groups (Gorman et al. 2003). This collaborative effort is in turn reliant on a myriad of 
processes which underpin communication and information exchange (O'Reilly & Pondy 
1979). CPOE systems have the capacity to increase the speed, integration and exchange of 
information while also reducing costs (Fulk & DeSanctis 1995), thereby affecting the 
laboratory – ward relationship. The findings from this study highlighted areas where the 
introduction of CPOE had led either to improvements in communication and monitoring 
processes (eg, CSR and Blood Bank), or were stalled by the lack of existing information 
exchange standards and structures (eg, Microbiology).
Accountability

In the preceding section detailing the effect of CPOE on CSR, the reduced data entry tasks and efficiency gains were highlighted. Changes in the communication environment were related to the adoption of new data-gathering requirements connected to the monitoring of unfulfilled requests. These added tasks however were also linked to a strongly perceived improvement in department accountability, which provided clinicians with a means of monitoring the status of test requests. In the past, unfulfilled test requests caused by patient unavailability or discharge were often the cause of clinical enquiries to the department. This was also seen as a contributing factor to the fall in the proportion of duplicate tests and the rise in the rescheduled tests that occurred as a consequence of CPOE, as shown in the performance measures reported above. The findings thus revealed that CPOE had contributed positively to the way that CSR processes and manages test requests and to the way the department communicates information to clinicians on the wards. The issue of accountability and improved monitoring capacity were not limited to CSR but also featured strongly in the Blood Bank. Here it was the step-by-step formalisation of Blood Bank tasks introduced by the new system, which despite making the process more time consuming, had contributed to increased traceability. This improvement allowed the laboratory and ward to monitor where a product is currently, where it has gone, who processed it and who stored it.
Meaning and context of information exchange

Clinical notes supplied by physicians to accompany laboratory test orders provide the laboratory with the patient care context in which it can contribute value. The iterative consensus methods described in Chapter 9 showed that a representative sample of Microbiology staff ascribed high levels of impact to a large proportion of clinical notes supplied by physicians, particularly those that provided information about Multi-Resistant Organisms and abscesses for wound cultures, and parasites and rotaviruses for stool cultures. These notes can trigger different courses of action ranging from the way a test is processed right through to the way it may be interpreted. In this way the role of pathology laboratories can be described as integrating data from a broader pathological and clinical context and translating it into clinically meaningful information (Hardwick 1998; Hardwick 2002). These findings have important implications for the design of CPOE systems which aim to maximise the exchange of information. Yet, despite the recognised and often-stated importance of supplying patient-centred clinical notes (Nakhleh et al. 1999; Plebani 1999; Marques & McDonald 2000; Hutchinson 2003; Panteghini 2004) there is little evidence about what type of information may be important to supply and when and in what circumstances the information can help to enhance the communication across the laboratory–ward interface.

The synchronicity of communication

As reported in Chapter 10, a key feature of the Blood Bank organisational and communication environment is the need to maintain timely exchange of information with
wards. This exchange relates to the order, availability and time-critical delivery of test and product orders. In the past this communication was reliant on regular telephone communication that incorporated everything from the product order, news of its progress and readiness, right through to the actual physical receipt of the product. However, the change of synchronous telephone communication to asynchronous CPOE communication is problematic (Beuscart-Zephir et al. 2005). Two years after the implementation of CPOE, whilst it is possible to electronically order blood tests, clinicians are still required to fax handwritten requests for blood products (platelets and fresh frozen plasma) to the Blood Bank. This is because of the continuing concern about the adequacy of warning and notification mechanisms needed to ensure that no blood product request goes unnoticed. The communication of information across the laboratory – ward interface is clearly not “passive” or “one-way” but more accurately a transaction process involving feedback and validation (Weir et al. 2007).

**CPOE and the Emergency Department**

In Chapter 11 the research investigated the impact of CPOE on the Emergency Department (ED). This facet of the research provided an insight into the effect of CPOE from a clinical setting located at the crossroads of hospital information flow. The results revealed changes in the way that information is gathered and exchanged between the pathology department and ED. It also detailed shifts in the organisation and control of tasks, some of which involved basic data entry tasks, while others required major responsibility shifts such as added patient data collection requirements. The results showed that ED clinicians need access to large amounts of data in a timely fashion, but the data must be relevant with due
consideration to context. This can be enhanced through the use of appropriate system
design features which include decision support. Inadequate system features, in this case the
inability to readily and efficiently access information about the status of prior tests, can lead
to ineffective channels of communication with serious consequences for patient care. This
finding contrasts with those from CSR and the Blood Bank which showed improvements in
the monitoring of tests. It suggests that the realisation of the benefits of new monitoring
and accountability functions is an important design issue for system planners, which must
take into account the particular needs of different hospital clinical settings.

12.3.4 The implications for patient care

The implications of CPOE for patient care can be considered under the following
categories: a) efficiency (the value and efficacy of services in terms of cost, time and
standards of practice) (Potter 2000); b) effectiveness (the success of the intervention)
(Scriven 1991); and c) the quality of care (ensuring that the right thing is performed well
and according to relevant standards) (Brook & Kosecoff 1988; Donabedian 1988; Davidson
2005).

Efficiency

The most dramatic efficiency gains occurred in the area of turnaround times. The impact
was shown across both turnaround time measurements (total and in-laboratory)
representing time savings of a median of 9 minutes (11.7%) for total turnaround time and 6
minutes (14.3%) for in-laboratory turnaround time. Turnaround times are frequently used
as measures of laboratory performance (Manor 1999) and usually correlate with clinician satisfaction with laboratory performance because of their influence on the time to patient diagnosis and/or treatment (Howanitz & Howanitz 2001; Steindel & Howanitz 2001). The evidence from this section of the research demonstrates the potential of CPOE to contribute positively to the quality of patient care, while also highlighting the need for further research (Westbrook et al. 2008).

**Effectiveness**

The proportion of unfulfilled test requests received by CSR rose dramatically immediately following the system changeover but then fell to proportions that were lower than the pre-CPOE period. The number of duplicate unfulfilled requests also fell significantly. These results were complemented by reported improvements in the levels of CSR accountability provided by CPOE. These improvements provided clinicians with access to information about their laboratory requests (particularly valuable in situations when the rescheduling of a specimen collection is required) with the prospect of more effective patient care procedures related to specimen collection.

**Quality of care**

The impact of CPOE should also be considered within the context of the broader hospital environment where pathology laboratories play the role of generators of information that is critical for the admission, treatment and discharge of patients (Forsman 1996). The contribution that laboratories make to the patient care process is therefore reliant on the
efficient management and timely communication of relevant information to enhance patient care delivery (Review of NHS Pathology Services in England 2006). Viewed in this way, the impact that CPOE has on improving accountability (Central Specimen Reception), safety (Blood Bank) and information exchange (Microbiology) all have major and positive implications for patient care delivery. However, the findings also point to the areas where inadequate or poor design can lead to dysfunction with adverse consequences for patient care. In the situation of the ED, where the notification of pending results was not directly apparent to physicians, it has the potential to lead to episodes where pending critical laboratory tests are missed, leading to possible adverse patient safety events.

12.3.5 Underlying mechanisms

The last research question relates to the underlying mechanisms that affect the success or otherwise of CPOE. This question provides the opportunity for the research to bring together the theoretical framework outlined in the initial phase of the research, iteratively refined in the course of the research that followed, and then finalised and tested in the final stages of the thesis. This framework represents the realisation of the theory-driven and multi-method approach which aimed to identify the factors that contribute to making CPOE work in the pathology laboratory setting, or not work as the case may be (Tilley & Clarke 2006). A systems perspective of health was presented whereby healthcare is viewed as a product of the interaction of people, technology, departments and processes of care and where changes in one of these features can affect others, sometimes in unexpected ways (Aarts & Gorman 2007). The value of this contribution is described by Steinfield and Fulk in the following way:
“Why is the development of theoretical structures so critical to the study of new information technologies in organizations? First, theory provides a framework for synthesis and integration of empirical findings. Theory can help make sense of the jumble of research findings that have accumulated in the last two decades. Theory can (1) provide road maps as to what patterns to look for in data, (2) point us toward explanations for the patterns, (3) help to resolve inconsistencies across studies, and (4) help to account for anomalous findings” (page 13) (Steinfield & Fulk 1990).

The organisational and communication framework (see Figure 12.3) was developed from the juxtaposition of information processing, communication, temporal, organisational decision-making and control components that underpin the process of transforming pathology specimens and orders from clinicians into meaningful diagnostic information. This framework is dealt with in the following section under five separate (but also interconnected) parts: a) the communication environment; b) synchronous and asynchronous communication exchange; c) organisational functions (planning, organising, staffing and controlling); d) the timescape of the organisation and the synchronisation, scheduling and allocation of tasks; and e) the meaning and context of information exchange.

The communication environment

Communication processes are at the heart of the pathology ordering process both in terms of the relationships across the different laboratories and with the clinical wards.
Communications can be described as the “social glue” that holds organisations together (Euske & Roberts 1987). The communication exchange can occur across different channels (telephone, paper requests, electronic orders or verbally) and it can come in synchronous or asynchronous forms. Any change in the form or channel of communication can have major consequences for work relations and organisation, particularly when a new CPOE system intrudes on the way information processing, decision-making and organisational control are carried out. This can be assessed as part of the organisation’s communication environment (Huber & Daft 1987) with consideration of the communication and information load (quantity, ambiguity and variety of information required to be communicated); the complexity (diversity and interdependence of the component parts) of the information; and the turbulence and degrees of instability experienced.

Figure 12.3: An organisational communication framework of the impact of CPOE on pathology laboratories
**Synchronous and asynchronous communication exchange**

New technologies like CPOE greatly increase the efficiency and volume of data transfer by allowing expanded connectivity channels alongside access to more information sources across multiple points (Fulk & DeSanctis 1995). But in doing so, they are capable of altering the type of interactions between different parts of the hospital and transforming previously synchronous transactions to asynchronous ones. This is an important consideration for the implementation of CPOE because of its potential impact on how departments inform, communicate and collaborate with each other (Aydin 1994).

**Planning, organising, staffing and controlling**

The management of every organisation can be said to revolve around the classic management functions of planning, organising, staffing and controlling (Fayol 1967; O'Reilly & Pondy 1979). Each of these tasks is connected to a communication dimension. In order to *plan* it is important to access information with which to forecast and predict the course of the future. The *organisation* of work requires people and resources to be set out within established communication channels. *Staffing* includes communication required for the management of resources and *controlling* involves the coordination of resources using the exchange of information (O'Reilly & Pondy 1979). Changes in communication patterns can result in new ways of interacting that can alter the organisational culture and ways of doing things (Van Maanen & Barley 1985). It follows therefore that the success or otherwise of CPOE is heavily dependent on its design, its deployment and the way that it is employed within each unique work environment (Barley & Kunda 2001).
**Timescape of an organisation**

The temporal landscape of an organisation is a crucial (but often neglected) part of its make-up and functioning (Fisher 1978). Organisations are constantly searching for ways to organise their time because of the implications for how their work is prioritised, allocated and coordinated (Bardram 2000). They do so in the context of time frames which can have vastly different assumptions and meanings. For instance, clock time is a crucial component of the laboratory test ordering process and has an important effect on the patient care process. Clock time is homogenous, divisible in structure and linear and absolute (Zerubavel 1979; Lee & Liebenau 1999; Adam 2004), usually measured in seconds, minutes, hours, days etc. But time can also be portrayed through a series of events which may be qualitative. Such events are not absolute but are usually discontinuous and flow unevenly (Lee & Liebenau 1999). Time can be conceived as part of a timescape affecting the way that organisations undertake, plan and manage the tempo (pace of activity), patterns (periods of events), sequence and synchronisation of work (Adam 2004).

There are also different ways of considering the role of time. The impact of CPOE on time views the concept as a dependent variable addressing how it may have changed decision-making processes and organisational ways of operating. But time needs to also be considered as an independent variable whereby technology is required to be reorganised and shaped to enable the organisation to function properly (Lee & Liebenau 1999).
Information exchange – meaning and context

The rapid development of ICT has increased the ability of institutions to build huge databases whereby information is amassed, exchanged and stored. This has led to the commodification of data as information (Barley & Orr 1997). The formalisation of data in ICT systems like CPOE may also create ambiguity and uncertainty (Davidson & Chismar 1999) because it dramatically changes the information environment in which people work (Weir et al. 2007). Information exchange should not neglect the social context which provides its meaning and importance (Brown & Duguid 2000). Data are always produced with a particular purpose. And their specificity and flexibility is likewise customised to suit that purpose (Berg & Goorman 1999).

The generally accepted model of information exchange views the process as a metaphoric pipeline whereby information flows from one person to another (Eisenberg & Goodall 2004). The problem with such models is that the transfer of information is viewed as a one-way process made up of an active sender and a passive receiver. In reality, as in the pathology test ordering process, people play both roles and are simultaneously engaged in sending (encoding) and receiving (decoding) messages (Wenberg & Wilmot 1973). Information exchange is more a transaction in which feedback is a crucial component (Eisenberg & Goodall 2004). O’Reilly and Pondy suggest the formula “meaning = information + context” to convey the importance of the process:

“Communication, then, is much more complicated than just having the right information at the right time. Merely receiving a message does not ensure that a
receiver will interpret it correctly. In addition to being received, the information has to be believed, weighted correctly, combined with other information, and an appropriate decision made. While the exchange of information between a sender and a receiver is a necessary element in the communication process, it is only one part. In order for two people to attach the same meaning to a given message, both must understand not only the information which forms the message but also the context in which the message was sent and received” (page 137-38) (O'Reilly & Pondy 1979).

12.4 Conclusion

This chapter has discussed the empirical findings of the research in the light of the aim to investigate the organisational and communication implications of CPOE systems for pathology laboratories, their work processes and relationships with other hospital departments. In doing so it has brought together the comparative examinations of different laboratories, their tasks and the needs they expect to be filled. It has achieved this using a multiple case design, investigating the research topic within its real-life context using a number of related cases to develop a theoretical framework to orient, test and extend the investigation. The research used a realist and multi-method approach to obtain data related to its different research questions as a means of identifying the contextual (eg, local, historical or institutional) factors that may operate within different settings, in order to appreciate the latent mechanisms (eg, social and technical) that can affect outcomes (eg, performance, organisational or clinical). Accordingly, as described by Walshe, the purpose of this approach was to:
“… establish when, how and why the intervention works, to unpick the complex relationship between context, content, application and outcomes, and to develop a necessarily contingent and situational understanding of effectiveness” (page 58) (Walshe 2007).

The last chapter of the research will conclude with an outline of the implications of the findings of the thesis. They will be presented in the context of the challenges associated with CPOE for healthcare planners, hospital management, clinicians, pathology departments and software vendors.
Chapter 13 Conclusion
13.1 Introduction

In the previous chapter the key findings of the research were presented in the context of the overall aim of investigating the organisation and communication implications of CPOE systems for pathology laboratories, their work processes and relationships with other hospital departments. The findings were based on comparative examinations of the pathology departments to identify the tasks the laboratories are involved in and the particular needs they expect to be filled by the new system. The chapter drew attention to the effects of CPOE on key indicators of pathology performance such as telephone communications, unfulfilled test requests and turnaround times. It then proceeded to discuss the effects of CPOE on the functioning and organisational dynamics of different pathology departments, highlighting areas such as CSR which witnessed important changes affecting the efficiency of their work, and Clinical Chemistry and Haematology where the new system impacted on the temporal efficiency of their test processing functions. The implications for relationships across the hospital and for patient care were also assessed in terms of the communication channels between the departments and the wards, and the impact that improved communication can have on the quality of patient care. The chapter concluded with a description of the organisational communication framework which synthesised the findings and explained the relationship between the context, content, application and outcomes of the implementation. This chapter will draw out the central implications of the research findings and the challenges they pose for healthcare planners, hospital management, clinicians, pathology departments and software vendors.
The chapter begins by drawing on the findings of the multiple case studies to highlight the contrasting perspectives from different departments within the one pathology service. It then proceeds to explain that CPOE implementation is not a one-sided technical question but involves complex social and organisational considerations. The best way to consider the impact of technology is not only to recognise its capacity to affect the organisational environment it is introduced into, but also how it is affected by that environment.

13.2 Implications of research findings

One size does not uniformly fit all

The process of CPOE implementation success is most often measured in terms of performance indicators which determine improvements over time. Turnaround times, for instance, are a critical measure of pathology performance and are therefore given high priority in evaluations of CPOE and pathology (Georgiou et al. 2007; Hawkins 2007; Georgiou et al. 2008). But implementation success can have many different components including effectiveness, efficiency, commitment, clinician satisfaction and laboratory satisfaction (Berg 2001). It is vitally important therefore to ascertain what type of success is being aimed for, and for whom is it being sought?

The multiple case studies described in this research highlighted different perspectives about what was counted as CPOE implementation success. Some of them were measurable using performance indicators (eg, turnaround times), while others were explained in terms of the ability to alter CPOE software to suit department needs in a better way. Each department,
despite numerous areas of overlap, had their own distinctive scientific, organisational and
temporal requirements and expectations of CPOE. Pre-existing assumptions about
development and implementation that may exist in one context may not easily translate to
another (Kaplan & Shaw 2004). For system planners, hospital managers, pathology
departments and software vendors the implications are: one size does not uniformly fit all.

This study has shown that CPOE can severely affect many organisational and
communication features of the hospital and its departments (Davidson 2000). Successful
CPOE implementation should therefore be premised on a solid understanding of the
organisational, communication, information and temporal circumstances in which the
system is meant to operate (Berg & Goorman 1999).

The evidence from this study also highlights the value of adopting a broad system
perspective to the evaluation of CPOE by taking into consideration the interconnectedness
of all parts of the hospital environment. One of the recognised values of information
systems is their ability to integrate departments and organisations (Stockdale & Standing
2006). The functioning of new CPOE systems is therefore contingent on a number of
factors that may not always be evident through the prism of a single part of the pathology
service or hospital.
Recognition that one size does not fit all also implies that the answer about whether a CPOE implementation has been successful or not needs to be socially negotiated (Berg 2001). Each case study in this thesis highlighted areas of negotiation about how work was undertaken, achieved and changed. Sometimes it was about altering work patterns, other times it was about changing features of the electronic system. Negotiation is a key part of how the implementation of CPOE and its impact is defined and undertaken. In their classic work on the social organisation of medical work, Strauss et al. point out that the way that an organisation negotiates can vary widely from explicit compromises, informal agreements, to even coercion and threats. Whatever the form of negotiation it is “a necessary cement for organizational action” (page 267) (Strauss et al. 1985).

The manner in which the hospital department, health professional, manager or administrator view the impact of CPOE will depend not only on the goals they establish but also on how they address and interpret these goals during and after implementation. The concept of success is a dynamic process, and by no means static. Many things can change over the period of time including what managers and healthcare professionals think is success (Berg 2001). It would seem logical therefore to take measures to ensure that the negotiation processes are enhanced through transparency and collaboration. The challenge therefore should be to make implementations synonymous with the forging of new relationships between hospital departments along with timely problem-solving processes (Stablein et al. 2003; Georgiou & Westbrook 2006). The provision of solid research and
evaluation evidence about organisational and communication processes should be a key component of building such relationships.

The results of this research further show that CPOE systems may not be uniformly successful despite the best of intentions. CPOE systems are put together with the aim of providing people with the means to make them work. It is never out of the question that people may choose not to make them work. CPOE systems are therefore contingent on the conditions and circumstances in which they are placed to make them work. These conditions and circumstances are part of what gets negotiated in the messy world of health IT implementation. Realist evaluation approaches, with their emphasis on contextual factors, latent mechanisms and outcomes, can thus play a valuable role in identifying the issues that explain why a CPOE system may or may not work.

*Technology can affect and be affected by context, circumstances and environment*

Finally, it is important to stress a factor that emerged repeatedly in the empirical findings of this study. It is too simplistic to view the diffusion of CPOE as merely a matter of matching the technology to organisational need (McLaughlin et al. 1999). This perspective tends to perceive singular technical solutions to problems without recourse to the organisational and work practice issues and their consequences for patient care (Wears & Berg 2005; Harrison et al. 2007). Accordingly, the process of implementation is seen predominantly as a “roll-out” or “diffusion” of the new system (Berg 2001) whereby technological innovation is the independent variable driving change. The evidence from this thesis shows that it is neither possible, nor desirable, to avoid the complex social and
organisational processes involved in the installation of CPOE systems (McLaughlin et al. 1999). To think otherwise is to ignore what Berg describes as, “the mutual transformation of the organization by the technology, and of the system by the organization” (page 147) (Berg 2001). The process of implementing CPOE is complicated and drawn out (McLaughlin et al. 1999). It is also a risky and costly investment (Birkmeyer et al. 2002) with many potential drawbacks. There are enormous benefits and significant potential for CPOE to contribute to enhanced patient care. This has been shown by prior evidence along with the findings presented in this research. But for that potential to be realised it is imperative that the challenge of CPOE implementation is met with continuing focus and research attention on the real-life question of what works, for whom and in what circumstances (Pawson & Tilley 1997).

The consequences of these implications apply to all the stakeholders (albeit with different emphases) involved in the challenge of CPOE implementation, whether they be healthcare planners, hospital management, clinicians, pathology departments or software vendors. All need to be sensitive to the implication that one size does not necessarily fit all. In some cases, as for software vendors, it will require adjustments, changes or even the redesign of software features to cater for different contingencies. Alternatively, those involved in the implementation process will need to be aware that the roll-out of CPOE is not a one-way process. New technology will affect the organisation of the healthcare facility, but the new technology’s fit and usability will in turn be shaped by how users manage its uptake. Finally, the process of implementation of CPOE is itself a negotiated process. The value of CPOE has to be negotiated and built by its users – the very people who are required to establish and make it work within their own setting (McLaughlin et al. 1999; Sittig et al.
2005; Georgiou et al. 2009). It is possible, nay, imperative to establish robust avenues for negotiation, mediation and communication that transcend department boundaries (Georgiou et al. 2009), and by doing so, realise the transformative potential of CPOE to enhance the delivery of quality patient care.
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Appendix 1

Sydney South West Area Health Service Human Research Ethics Committee (Western Zone) ethics approval Project No 2005/058 (4 August 2005)

Sydney South West Area Health Service Human Research Ethics Committee (Western Zone) ethics approval Project No 2007/077 (25 July 2007)
Human Research Ethics Committee (Western Zone)
Locked Bag 7017, Liverpool BC, NSW 1871
Phone: 02 9828 5727
Facsimile: 02 9828 5962

August 4, 2005

Associate Professor Johanna Westbrook
Centre for Health Informatics
University of NSW
NSW 2052

Dear Associate Professor Westbrook,

Project No 2005/058 - Evaluating the Impact of Information and Communication Technologies (ICT) on organisational processes and Outcomes: a multidisciplinary, multi-method approach

The Sydney South West Area Health Service Human Research Ethics Committee wishes to acknowledge receipt of your correspondence dated 1st July, 2005 enclosing the requested documentation for the above study.

Approval has now been granted for you to commence the study within the South Western Area Pathology Service on the same terms and conditions as granted by Central Sydney Area Health Service Human Research Ethics Committee.

Ethics clearance is granted for periods of up to twelve months. This project will be due for renewal on 31st December, 2005 and you must provide a Progress Report (attached) or final report by this date. If no report is supplied, ethics clearance for this project may be cancelled.

Please note that the Committee must be notified IMMEDIATELY of any untoward or unexpected complications or side affects arising during the project or of any ethical or medico-legal problems that may arise. Also, any changes to the original protocol must be submitted to the Committee for approval.

Would you please quote the above project number in all future correspondence relating to this project.

Yours sincerely,

PROFESSOR HUGH DICKSON
Chairperson
SSWAHS Human Research Ethics Committee

For: Dr Diana Horvath, AO
Chief Executive, SSWAHS
Dear Professor Westbrook,


The SSWAHS Human Research Ethics Committee wishes to acknowledge receipt of your correspondence with regards to the above project.

As all of the issues raised by the Committee have now been satisfactorily addressed, formal approval is hereby granted for this study to proceed as a Category A Project. The committee has approved the following documentation:

- Subject Information Statement - Appendix A1 Interviews and focus groups Version 1.1.doc
- Subject Information Statement – Appendix B1 Observation (including video) Version 1.1 (2 July 07).doc
- Consent Form – Appendix B2_Sent_Version 1.1_(2 July 07).doc

Ethics clearance is granted for periods of up to twelve months. This project will be due for renewal on 31st May, 2008 and you must provide a Progress Report (attached) or final report by this date. If no report is supplied, ethics clearance for this project may be cancelled.

Your attention is drawn to the attached document Guidelines for Investigators which sets out not only the principles under which research should be conducted, but also the conditions under which Ethics approval is granted by the Committee. Also enclosed for your information, is a copy of the document Guidelines for Responsible Practice in Research and Dealing with Problems of Research Misconduct.
Please note that the Committee must be notified **IMMEDIATELY** of any untoward or unexpected complications or side effects arising during the project or of any ethical or medico-legal problems that may arise. Also, any changes to the original protocol must be submitted to the Committee for approval.

Would you please quote the above project number in all future correspondence relating to this project.

Yours sincerely,

PROFESSOR MICHAEL FROMMER
Chairperson
SSWAHS Human Research Ethics Committee

For:  Mr Mike Wallace
       Chief Executive, SSWAHS

**Category A:** Projects with limited risk potential, including quality assurance surveys.
**Category B:** Projects with significant patient risks.
**Category C:** Drug trials (international/national) sponsored by drug companies and already covered for risk evaluation and monitoring of adverse reactions.
Appendix 2

Subject Information Statement Sydney South West Area Health Service Project 2005/08
SUBJECT INFORMATION STATEMENT

EVALUATION OF POINT OF CARE CLINICAL INFORMATION TECHNOLOGY

Subject selection and purpose of study
You are invited to participate in a study of the decision support features of the electronic ordering system within your hospital/department. We are interested in understanding factors that can enhance the efficiency of pathology services leading to more effective and rational pathology ordering and improved patient care. You are invited to take part as a possible participant in this study because you are a member of staff who can use these systems.

Description of study and risks
If you decide to participate, you will participate in an interview, and or focus group facilitated by a researcher. The focus of the discussion will be your experiences of the order entry system and how you use it. Interviews and focus groups will last approximately 45 minutes.

We cannot and do not guarantee or promise that you will receive any benefits from this study.

Confidentiality and disclosure of information
Interviews and focus groups will be tape recorded to ensure accuracy. Provided that you have signed the accompanying consent form, any information that is obtained in connection with this study that can be identified with you will remain confidential and will be disclosed only with your permission or except as required by law. We plan to discuss the results with the NSW Department of Health and this hospital. The study will also be reported at conferences and in journals. In any publication, information will be provided in such a way that you cannot be identified. We will provide you with any new information that could influence your decision to remain in the study.

Financial Costs
It is not anticipated that you will incur any additional costs if you participate in this study. You will not receive any payment for participation in this study. If you take part in a focus group, light refreshments will be provided.

Your consent
Your decision whether or not to participate will not prejudice your present or future treatment or your relationship with South Western Sydney Area Health Service or any other institution cooperating in this study or any person treating you. If you decide to participate, you are free to withdraw your consent and to discontinue your participation at any time without prejudice.

If you have any questions, please feel free to ask us. If you have any additional questions later, Professor Westbrook, chief investigator (02 9351 9677) will be happy to answer them.

You are making a decision whether or not to participate. Your signature on the consent form indicates that, having read the information provided above, you have decided to participate.
IDENTIFYING HOW ELECTRONIC DECISION SUPPORT IN COMPUTERISED PATHOLOGY ORDER ENTRY SYSTEMS CAN IMPROVE PATHOLOGY PRACTICE, RATIONAL ORDERING AND PATIENT OUTCOMES

Contact details for principal researchers in this project are:

Professor Johanna Westbrook, Health Informatics Research & Evaluation Unit, Faculty of Health Sciences, Cumberland Campus, The University of Sydney, Lidcombe 1825. Tel: 02 9351 9677
Professor David J Davies, South Western Area Pathology Services, Locked Mail Bag 7090, Liverpool 1871. Tel: 02 9828 5002
Mr Andrew Georgiou, Health Informatics Research & Evaluation Unit, Faculty of Health Sciences, Cumberland Campus, The University of Sydney, Lidcombe 1825. Tel: 02 9036 7331
Dr Joanne Callen, Health Information Management, Faculty of Health Sciences, Cumberland Campus, The University of Sydney, Lidcombe 1825. Tel: 02 9351 9558

Complaints may be directed to the Ethics Secretariat, South Western Sydney Area Health Service, Locked Bag 7017, LIVERPOOL BC, NSW, 1871 (phone 9828 6552, fax 9828 6551, email jennie.grech@swsahs.nsw.gov.au).

You will be given a copy of this form to keep.
Appendix 3

Consent form Sydney South West Area Health Service Project 2005/058
CONSENT FORM

EVALUATION OF POINT OF CARE CLINICAL INFORMATION TECHNOLOGY

(Interviews and Focus Groups)

1. I, .................................................................................. of .........................................

.................................................................................., aged..................................years,

agree to participate as a subject in an interview or as a focus group participant in the study
described in the subject information statement set out above (or: attached to this form).

2. I acknowledge that I have read the Subject Information Statement, which explains why I have
been selected, the aims of the study and the nature and the possible risks of the investigation, and
the statement has been explained to me to my satisfaction.

3. Before signing this Consent Form, I have been given the opportunity to ask any questions relating
to any possible physical and mental harm I might suffer as a result of my participation. I have
received satisfactory answers to any questions that I have asked.

4. My decision whether or not to participate will not prejudice my present or future treatment or my
employment with Sydney South West Area Health Service or any other institution cooperating in
this study or any person treating me. If I decide to participate, I am free to withdraw my consent
and to discontinue my participation at any time without prejudice.

5. I agree that research data gathered from the results of the study may be published, provided that
I cannot be identified.

6. I understand that if I have any questions relating to my participation in this research, I may
contact the chief investigator, Professor Johanna Westbrook on telephone 02 9351 9667 who will
be happy to answer them.

7. I acknowledge receipt of a copy of this Consent Form and the Subject Information Statement.

Complaints may be directed to the Ethics Secretariat (Western Zone), SSWAHS Area Health Service,
Locked Bag 7017, LIVERPOOL BC, NSW, 1871 (phone 9828 6552, fax 9828 6551, email
jennie.grech@swsahehs.nsw.gov.au).

Signature of subject __________________________ Signature of witness __________________________

Please PRINT name __________________________ Please PRINT name __________________________

Date __________________________ Date __________________________

Signature(s) of investigator(s) __________________________

Please PRINT Name __________________________

Date: ____________________________________________
Appendix 4

Evaluation of CPOE impact on pathology services (Interviewer’s guide)
EVALUATION OF CPOE IMPACT ON PATHOLOGY SERVICES
INTERVIEWER’S GUIDE

AIM:

The aim of the focus group is to discuss your expectations of the new electronic pathology ordering system.

QUESTIONS:

1. What do you know of the new electronic pathology ordering system?
2. Thinking about how pathology ordering is managed in the hospital now, what do you think some of the problems are?
3. Next, I’d like you to think about the advantages and disadvantages of the current system. What are some of the potential benefits of the new system?
4. What are some of the potential barriers or difficulties that could be encountered with the system?
   a. Is the organisation ready for change?
   b. How have implementations at your site worked in the past?
5. When the system has been installed in the hospital, what factors do you think will affect whether the system is used effectively?
6. Do you think it will change the way that work is done?
7. Do you think it will change the way staff interacts with each other?
8. How will you know if the system is successful or not?

INTERVIEWER’S GUIDE:

Introduction:

1. Welcome
2. Introduce yourself
3. What is the aim of the interview
4. Why did we choose the interviewee
5. What is the end goal of the interviews
Welcome.

My name is ________________ and I am from ________________. This discussion aims to obtain your views and expectations of the impact of the new electronic ordering system.

I am not associated with the new system in any way, so please feel free to talk about whatever your want.

We invited you to participate in the meeting because of the perspective and different experiences you could offer to the discussion. Your comments and thoughts will help us to better understand the impact and effect of the new electronic ordering system.

6. Explain the ground rules of the discussion.
7. There are not right or wrong answers

Above all, we want your opinion. There are no right or wrong answers, especially about the things we are going to talk about. So please be free to say what exactly what you feel.

8. Explain the taping procedure.

The discussion will be taped. This is so that I don’t have to feverishly scribble down everything you say.

As a participant in this research:
- You may stop at any time
- You may ask questions at any time
- You may leave at any time
- There is no deception involved
- Your answers are kept confidential

Are there any questions at this point?

9. Introduction by the interviewee.

I would like us to start (for the purposes of the tape) asking you to briefly explain your position and role.
I have one final question, which I would like to get all your opinions on. Take a few moments if you need to.

How will you know if this system is successful or not?
Appendix 5

Central Specimen Reception Forms Manual – Problem Specimen Report
Appendix 6

Central Specimen Reception Forms Manual – Unable to Collect Patient
SPECIMEN RECEPTION FORMS MANUAL

UNABLE TO COLLECT PATIENT*  WARD COLLECTION

Name: ______________________  MRN: ______________________

Ward: ________  Date: ________  Collector's name: ________

Comment: (Please circle appropriate) 1. Difficult collection
5. Pt. Not Fasting  6. Other: ______________________

Notified: * ______________________

Rescheduled:  7. Run: ______________________
Cancel:  Reason: ______________________

* RECORD THE DOCTOR'S NURSES NAME

Attach tube label
Appendix 7

Calculation of median number of tests per specimen using 2005 – 2007 laboratory test data
GET
   FILE='E:\_HIREU Collaboration\CPOE\SWAHS\SWAHS HosLab\_HosLab\HosLab05to07_1_TestbySpecbyPat_Agg_1_LIV.sav'.
   DATASET NAME DataSet1 WINDOW=FRONT.
GET
   FILE='E:\_HIREU Collaboration\CPOE\SWAHS\SWAHS HosLab\_HosLab\HosLab05to07_1_TestbySpecbyPat_Agg_1_LIV.sav'.
   DATASET NAME DataSet2 WINDOW=FRONT.
   DATASET ACTIVATE DataSet1.
EXAMINE
   VARIABLES=TestbySpec BY YearCol
   /PLOT NONE
   /STATISTICS DESCRIPTIVES
   /CINTERVAL 95
   /MISSING LISTWISE
   /NOTOTAL.

Explore

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Appendix 8

List of data variables used for comparison of pathology test volumes and turnaround times for 2005 and 2006
Fields:

MRN
Hospital
Lab No
Ward
DOB
Urgency
Collection Date
Order Set
Test
Result
Abnormal Flag
In Lab Date
Completed Date
TAT - Collection to completed (Minutes)
TAT - In Lab to completed (Minutes)
Office Hours - 'Y' or 'N' - between 08:00 and 17:00
Clinical Notes
Encounter Number
Admission Date
Discharge Date
Length of Stay (No of full days)
DRG
MDC
Age (No of full years between date of birth and collection date - 0 means less than 1 year old. Blank means no DOB given)
Appendix 9

List of test assays used for analysis of test turnaround times and volumes for 2005 and 2006
<table>
<thead>
<tr>
<th>Test name</th>
<th>Common Request Entry name</th>
<th>Department</th>
<th>2005</th>
<th>2006</th>
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<td>APTT</td>
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<td>Clinical Chemistry</td>
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<td>Clinical Chemistry</td>
<td>ALP</td>
<td>ALP</td>
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<td>AMS</td>
<td>Clinical Chemistry</td>
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<td>Amylase</td>
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<td>Clinical Chemistry</td>
<td>pCO2 pO2  pH</td>
<td>PCO2 PH PO2</td>
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<td>Aspartate Aminotransaminase</td>
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<td>Clinical Chemistry</td>
<td>GEN GENP GENT</td>
<td>Gentamicin Random Gentamicin Peak Gentamicin Trough</td>
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</table>
Appendix 10

Microbiology clinical notes survey instrument (wounds)
Thank you for taking the time to assist with this study. The aim of this project is to identify the significance of clinical notes. The list of notes that appears below was identified from an audit of hand written laboratory test requests carried out during 2006.

Name_________________________________________________ Position______________________________________________

Qualification___________________________________________ Years of experience_____________________________________

**WOUNDS**

<table>
<thead>
<tr>
<th></th>
<th>Does this clinical note make a difference to the way you process the specimen? If Yes, please explain the difference.</th>
<th>Does this clinical note make a difference to the way you interpret the results? If Yes, please explain how.</th>
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<tbody>
<tr>
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<tr>
<td>?MRSA</td>
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<td>Does this clinical note make a difference to the way you interpret the results? If Yes, please explain how.</td>
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<tr>
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</tr>
<tr>
<td>MRSA, Resistance to Penicillin</td>
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<tr>
<td>?Pseudomonas</td>
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<tr>
<td>Abscess - Bartholin</td>
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<tr>
<td>Abscess - pus</td>
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<td>Abscess - pus, Allergic to Penicillin &amp; Keflex</td>
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<td>Abscess, Crohns Disease</td>
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<td>Abscess, Immunosuppressed</td>
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<td>Bleeding - vaginal</td>
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<td>Boil - ?infected</td>
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<td>Boil, History of MRSA</td>
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<td>Burn</td>
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<tr>
<td>Fracture - site specified</td>
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<td>Laceration - site specified</td>
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<td>Lesion - infected</td>
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<td>Lymphoma - non-Hodgkin's</td>
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<td>-------------------------------</td>
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<tr>
<td>On Penicillin</td>
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<tr>
<td>Pemphigoid bullous</td>
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<tr>
<td>Previous MRSA</td>
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<td>Previous pseudomonas colonisation</td>
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<td>Pus</td>
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<td>Skin tag - site specified, infected</td>
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<td>Does this clinical note make a difference to the way you interpret the results? If Yes, please explain how.</td>
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<tr>
<td>Ulcer - pressure</td>
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<td>Ulcer - pressure, ?infected</td>
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<tr>
<td>Ulcer - pressure, History of MRSA</td>
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<td></td>
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<tr>
<td>Ulcer - site specified</td>
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<tr>
<td>Ulcer - site specified, ?MRSA</td>
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<td></td>
</tr>
<tr>
<td>Ulcer - site specified, Bone infection</td>
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<td></td>
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<tr>
<td>Ulcer - site specified, Depression, PVD</td>
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<tr>
<td>Ulcer - site specified, History of MRSA</td>
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<td>Condition</td>
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</tr>
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<td>Ulcer - site specified, History of pseudomonas</td>
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<td>Ulcer - site specified, On Antibiotics, Diabetes</td>
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<td>Ulcer - site specified, PVD</td>
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<tr>
<td>-------------------------</td>
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<td>Wound - infection, On Penicillin</td>
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<td>Wound - necrotic, On Penicillin</td>
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<td>Wound - postoperative</td>
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<td>Wound - postoperative, ?infected</td>
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<td>Wound - postoperative, Febrile</td>
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<tr>
<td>Wound - postoperative, infected</td>
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<td>Does this clinical note make a difference to the way you interpret the results? If Yes, please explain how.</td>
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<tr>
<td>-----------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Wound - postoperative, Seroma</td>
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<td>Wound - site specified</td>
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<tr>
<td>Wound - spider bite</td>
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Appendix 11

Microbiology clinical notes survey instrument (stools)
Thank you for taking the time to assist with this study. The aim of this project is to identify the significance of clinical notes. The list of notes that appears below was identified from an audit of hand written laboratory test requests carried out during 2006.

Name_________________________________________________ Position______________________________________________

Qualification___________________________________________ Years of experience_____________________________________

**STOOLS**

<table>
<thead>
<tr>
<th>Does this clinical note make a difference to the way you process the specimen? If Yes, please explain the difference.</th>
<th>Does this clinical note make a difference to the way you interpret the results? If Yes, please explain how.</th>
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<td>?Gastroenteritis</td>
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<td>?Gastroenteritis, ?Rotavirus, ?Shigella</td>
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</tr>
<tr>
<td>?Giardiasis</td>
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<tr>
<td>?IBD, SLE</td>
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<tr>
<td>?Infection - CDT</td>
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<tr>
<td>?Infection</td>
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</tr>
<tr>
<td>?Rotavirus</td>
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<td>?Rotavirus, ?Adenovirus</td>
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<td>?Rotavirus, ?Giardiasis</td>
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<tr>
<td>?Sepsis</td>
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</tr>
<tr>
<td>?Shigella</td>
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<td>Anaemia, Pancreatitis</td>
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<td>Bleeding - rectal</td>
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<td>Colitis - ulcerative</td>
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<td>Diarrhoea - bloody</td>
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<tr>
<td>Diarrhoea - bloody, Vomiting</td>
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<tr>
<td>Diarrhoea - chronic</td>
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<tr>
<td>Diarrhoea - chronic, AIDS</td>
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<td>Diarrhoea - Not improving on Steroids</td>
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<tr>
<td>Condition</td>
<td>Does this clinical note make a difference to the way you process the specimen? If Yes, please explain the difference.</td>
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<tr>
<td>Diarrhoea - On Antibiotics</td>
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<tr>
<td>Diarrhoea - on Antibiotics, Vomiting</td>
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<tr>
<td>Diarrhoea - post chemo</td>
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<tr>
<td>Diarrhoea - postop</td>
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<tr>
<td>Diarrhoea - travellers</td>
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<td>Diarrhoea</td>
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<tr>
<td>Diarrhoea, ?Coeliac</td>
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<tr>
<td>Diarrhoea, Carcinoma - colon</td>
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<td>Diarrhoea, Febrile</td>
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<td>Does this clinical note make a difference to the way you process the specimen? If Yes, please explain the difference.</td>
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<td>Diarrhoea, Pain - abdominal</td>
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<td>Diarrhoea, Pregnant</td>
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<td>Diarrhoea, SLE</td>
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<tr>
<td>Diarrhoea, Vomiting</td>
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<tr>
<td>Febrile</td>
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<td>Gastroenteritis</td>
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<td>Hepatitis</td>
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<td>Does this clinical note make a difference to the way you process the specimen? If Yes, please explain the difference.</td>
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<td>Infection - ascaris</td>
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<td>Maternal drug abuse</td>
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<td>Melaena</td>
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<td>On Antibiotics</td>
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<td>Pain - epigastric</td>
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<td>Pain - iliac fossa, On Antibiotics</td>
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<tr>
<td>PUO</td>
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<td>Recent chemo</td>
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<tr>
<td>Recent travel</td>
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<td>Does this clinical note make a difference to the way you process the specimen? If Yes, please explain the difference.</td>
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<tr>
<td>Renal Failure</td>
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<td>Stool - bloody</td>
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<td>Stool - loose</td>
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</table>
Appendix 12

Microbiology laboratory business manager’s letter introducing the Microbiology Clinical Notes Study, 14 February 2007
Microbiology Clinical Notes Study

This study has been underway in SWAPS (and in particular Microbiology) since the beginning of last year. The general idea of the study has been to assess the number of requests with clinical notes (pre Cerner) and then to assess the significance of the clinical notes received. One of the researchers documented all the clinical notes written on to our request forms for the month of March 2006. These clinical notes were then categorised in to specimen types

This part of the survey is to assess the significance/importance of the clinical notes received. Please sit down by yourself (do not discuss with anyone else) and fill in the forms for two specimen types (stools and wounds). This survey will also help us identify areas of training required in the lab.

There are two columns, one for processing and the other for interpretation of cultures as a result of the clinical notes. Please use the following abbreviations and where relevant, please elaborate on your reasons (don’t write an essay).

For processing use:  P (plates changed or added),
T (tests added such as microscopy, stain etc),
C (comment e.g. specimen unsuitable),
O (other differences)

For interpretation:  I (interpretation changed as a result of clinical notes)
C (comment about the culture)
T (suggest treatment due to clinical notes)
O (other interpretations)

This is not intended to catch you out, it is a survey and a learning exercise for all of us. Different levels of training/experience will obviously impact on the results so it is important to include the information at the beginning of the surveys however, you do not have to include your name.

Please complete these forms as soon as possible. You may take them home but please make sure to return them to me.

Thanks for your help.

George Toouli
14th February 2007
Appendix 13

Survey results for stool clinical notes
### SURVEY RESULTS FOR STOOL CLINICAL NOTES

<table>
<thead>
<tr>
<th>Clinical Note</th>
<th>f</th>
<th>% (of all stool requests)</th>
<th>No. of Responses from lab survey</th>
<th>Impact %</th>
<th>Categorisation</th>
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<td>2.4</td>
<td>8</td>
<td>36.4</td>
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<td>0.3</td>
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<td>31.8</td>
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Other (Traveller, Clinical note, Organisation)
Appendix 14

Survey results for wound clinical notes
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<th>% (of all wound requests)</th>
<th>No. of Responses from lab survey</th>
<th>Impact (%)</th>
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</tr>
<tr>
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<td>5</td>
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<tr>
<td>Boil - ?Infected</td>
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<td>4</td>
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<tr>
<td>Cellulitis - discharge</td>
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<tr>
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<td>Count</td>
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<tr>
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<td>Osteomyelitis</td>
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<tr>
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<tr>
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Appendix 15

Telephone call monitoring sheets for Blood Bank
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<th>Initials</th>
<th>Ward</th>
<th>Send Blood/Plats/FFP</th>
<th>Send Batch product</th>
<th>Confirm Lamson receipt</th>
<th>Product order Blood/Plats/FFP</th>
<th>Enquiry only Availability</th>
<th>Enquiry Other</th>
<th>Personal call</th>
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</table>
Appendix 16

Publications arising out of the research to date


Essential Public Health: Theory and Practice

Reviewed by Karen Willis
Mother and Child Health Research, Latrobe University, Victoria

Public health policy and practice draws on a wide range of disciplines. The challenge in teaching public health is in drawing on the best of these disciplines to instil in students a critical and evidence-based approach. This text written in the UK aims to equip students with sufficient knowledge of the sciences underpinning public health (Part One – The public health toolkit) and then develop this knowledge through the application of public health knowledge to a range of issues (Part Two – The challenges of public health in practice). The text is accompanied by a CD of additional information and quizzes related to the content of each chapter.

In Part One, the authors have provided clear and, generally, accessible explanations of the language of public health knowledge, and explained the underpinnings of epidemiological, demographic and evidence knowledge bases. The book and its accompanying CD is therefore a valuable resource for public health students and practitioners. The text begins with a chapter on demography and this provides a valuable context for the following chapters on epidemiology, evidence-based health care and improving population health, before closer examination of skills required for needs assessment, evaluation, decision making and health protection. There is good use of tables and diagrams to illustrate the points being made.

In Part Two, population health issues (children, adults, the aged) are examined, along with problems of health inequalities, health policy, quality improvement and international development. Again, graphic depictions are used to illustrate the problems of various population groups. The first three chapters in this section describe these problems in depth, and invariably conclude that strategies such as lobbying and working with key stakeholders should be used to resolve the problems. There is however, very little information provided on how best to do this, and how the seemingly obvious problems presented may, in fact, be contested. In the chapter on adult health, a broad social view of health describes as one of the most important social changes of recent times. He is well-qualified for the task having written extensively on the subject of health and technology, and in his position of Director of the Science and Technology Studies Unit and Head of the Department of Sociology at the University of York in England. His resume even includes a stint as a Visiting Fellow at the Australian National University in 2006, which may explain many of the book’s frequent references to Australian experience in this area.

Generally, when we consider health technology, we think of health technology assessment (HTA), a science developed to deal with the tide of new technologies in society. But Webster’s sociological critique posits a wider framework beyond the traditional tendency to evaluate technologies as discrete innovations rather than as ‘part of a wider system.’ Webster advocates the utilisation of different types of evidence – experimental from clinical trials, evidential from existing clinical practice and experiential from patient experiences.

The book makes a distinction between three broad technology...
Book Reviews

developments: 1) genetics-related (genetic diagnosis, testing and screening, gene therapy, pharmacogenetics and pharmacogenomics and neutrigenomics); 2) informatics-based systems used for monitoring the individual, e.g. telecare, telemedicine and information systems used to manage clinical data about patients; and 3) tissue-related e.g. tissue engineering and stem cell research and therapy. Taken together, these developments are linked to some important transformations within health care. Webster highlights the shift in focus from “treatment and cure” to “management and care” – a consequence of major demographic shifts and the presence of a greater number of older people in the population.  

In the field of genetic medicine, he points to the drug industry’s move toward the genetic origin of disease rather than the current symptom-oriented approach.  

Webster devotes special attention to what he calls the “informaticisation of health”, a consequence of the dramatic growth of global information networks and computing capacity. For some, this has heralded the arrival of the “informational” society, and spawned the adoption of major health information technology initiatives, such as the multi-billion pound NHS Connecting for Health programme, with the expectation of greater accessibility, effectiveness and quality of health care provision.

True to the spirit of sociological critique, Webster also presents a classification of different perspectives about health technology. He contrasts “deterministic” perspectives, which presume that technologies have effects as a result of their inherent properties, with “social essentialist” approaches, which view technology as a blank slate awaiting interpretation and meaning. Webster himself favours a third option which he terms “technology-in-practice” which advocates a more complex approach to the role of technology and its users (medics, patients etc), and probably lies somewhere in between the other two.

It is a tall task to address the issue of health, technology and society in a relatively small (213 page) book of which 33 pages are taken up with an extensive bibliography and author and subject index. But the book’s combination of interesting case studies and thought-provoking (though not always extensive) critique make it a valuable, informative and interesting read. Its main achievement is to alert the reader to the inherent connection between health care, technology, society and the future.

References


Erratum

Due to an error in production, the author affiliations on the article ‘The validity of a depression screening tool modified for use with Aboriginal and Torres Strait Islander people’ (ANZJPH 32(4) p317-21, doi: 10.1111/j.1753-6405.2008.00247.x) were incorrect. The authors and their affiliations are:

Danielle Esler: Danila Diba Health Service, Northern Territory and Flinders University, South Australia and Monash University, Victoria and Northern Territory General Practice Education Training

Fay Johnston: Menzies School of Health Research, Northern Territory and Flinders University, South Australia and Menzies Research Institute, Tasmania

David Thomas: Menzies School of Health Research, Northern Territory and Institute of Advanced Studies, Charles Darwin University, Northern Territory

Bruce Davis: Danila Diba Health Service, Northern Territory

One reference in the same article was also incorrect:


Books Received

FAT: It’s Not What You Think

Discusses the critical role that fatty tissue plays in maintaining health. Leas shares the latest scientific research and explains the biology involved.

Responding to the challenge of cancer in Europe

Slovenia decided to focus on cancer as the key public health priority during its Presidency of the Council of the European Union in the first half of 2008. This book provides an overview of the epidemiology of cancer, including a discussion of the major risk factors. Contributors examine the current status and plausible future developments for cancer screening in the EU; drug discovery, evaluation and deployment; the role of psychosocial oncology; and the provision of palliative care. Current patterns of cancer survival and the challenges facing cancer researchers in Europe today are examined.

Monitoring the Impact of CPOE on Healthcare Delivery – A Benefits Realisation Approach

Andrew Georgiou¹, Mary Lam², Johanna Westbrook¹

¹Health Informatics Research and Evaluation Unit, Faculty of Health Sciences, The University of Sydney
²Discipline of Health Informatics, Faculty of Health Sciences, The University of Sydney

Abstract

Objective:
This paper aims to outline a suite of key indicators of Computerised Pathology Order Entry (CPOE) performance, assess their value as measurements of care delivery and their relevance to health professionals and patients.

Background:
CPOE systems have the potential to deliver substantial efficiency gains along with improvements in the effectiveness and quality of patient care. However, these potential gains may be offset by poor implementation strategies and inadequate attention to problems. The implementation of CPOE should be associated with careful monitoring of their impact, particularly in areas related to the quality and safety of patient care.

Methods:
We draw upon results from our own research over five years to focus on four key indicators of CPOE impact: laboratory turnaround times, test volumes, redundant test rate and length of stay. Each indicator is defined and the rationale for its measurement and potential uses identified. Possible confounders to the interpretation of the indicators are assessed and a guide to the quality and reliability of data sources is provided.

Results:
Turnaround time (TAT) can be used to monitor different parts of the test ordering process eg, total TAT - from the time of specimen collection to test result notification. Test volumes can be measured according to different parameters, eg, the number of tests per patient or per Diagnostic Resource Group to monitor adherence to electronic guidelines and test appropriateness. Redundant tests are those tests that are reordered within an inappropriate time frame and provide no additional clinical information. Length of stay can be used as an indicator of the ability of CPOE to improve efficiency, particularly in acute, time-critical hospital departments.

Conclusion:
These indicators can provide valuable information by which to monitor the implementation of CPOE and drive benefits realisation.

Keywords:
Computerised Provider Order Entry, Evaluation, Laboratories, Pathology
**Objective:**

This paper aims to outline a suite of key indicators of Computerised Pathology Order Entry (CPOE) performance, assess their value as measurements of care delivery and their relevance to health professionals and patients.

**Background:**

Health care systems in Australia and internationally are involved in the complex task of implementing Computerised Pathology Order Entry (CPOE) systems. These systems allow clinicians to directly enter orders into computers (Doolan and Bates 2002) which allow for efficient data management and can contribute to improved effectiveness and efficiency of patient care (Murff and Kannry 2001). The incorporation of decision support using defined order sets and the provision of evidence-based guidelines can also lead to improvements in the quality of care (The Leapfrog Group for Patient Safety 2003). Despite the enormous support for CPOE systems, their diffusion has been beset by implementation problems (Ash et al. 2004; Campbell et al. 2006). It would seem imperative therefore that CPOE implementation is associated with careful monitoring of its impact, particularly in areas related to the efficiency and effectiveness of patient care delivery, through the utilisation of robust performance indicators (quality measures). Evaluation of CPOE has an important role to play in achieving efficiency and effectiveness benefits. Yet there have been few papers documenting specific indicators that could be valuable to this process.

**Methods:**

This paper draws upon results from our own research, as well as that of others, to outline four key indicators of CPOE impact on pathology laboratory services: turnaround time, test volume, redundant test rate and length of stay. A performance indicator is defined as a statistic, or other unit of information which reflects, directly or indirectly, the performance of a system (Boyce 2002) and which can help to understand and improve the workings of a system (NHS Institute for Innovation and Improvement 2007). A template is provided for each indicator beginning with a definition and rationale for its measurement, its potential uses and evidence of its utilisation. Possible confounders to interpreting and understanding the indicator are assessed and a guide is provided to the quality and reliability of data sources.

**Results:**

Table 1 outlines key features of the four indicators and assesses their potential as measures of CPOE performance.

<table>
<thead>
<tr>
<th>Turnaround time (TAT):</th>
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<tbody>
<tr>
<td><strong>Definition</strong> The time in which a laboratory can process a specimen and provide a result. TAT can be measured for different aspects of the laboratory process eg time ordered to the time a result is issued, or the time a specimen reaches the laboratory to time a result issued (Georgiou et al. 2007). TAT can also be classified by test (eg, potassium), priority (eg, urgent) or population served (eg, ward setting) (Hawkins 2007).</td>
</tr>
<tr>
<td><strong>Aim</strong> To promote timely access to laboratory results.</td>
</tr>
</tbody>
</table>
Rationale: Clinical satisfaction with pathology services is related to the timeliness of test results because of its effect on time to patient diagnosis and/or treatment (Howanitz and Howanitz 2001).

Potential uses: Measure the impact of CPOE on laboratory performance and hospital efficiency.

Confounders: TAT can be affected by a number of institutional factors such as bed size, staffing levels, location and case mix; and by process factors like method of specimen transport (Hawkins 2007).

Data sources: Most laboratory services are required to collect and report TAT figures. The completeness and robustness of these data sources may be variable and depend on the data definitions employed (Australian Council on Healthcare Standards 2007).

Evidence: Several studies of CPOE performance using TAT report significant decreases (Mekhjian et al. 2002; Thompson et al. 2004) including a broad ranging Australian study with control which reported a significant average decrease in TAT of 15.5 minutes/test assay following CPOE implementation (Westbrook et al. 2006).

Comments: TAT measures are comprised of multiple sequential steps which each have their own minimum or fastest time (eg, centrifuge spinning time) which means that normal distributions are not expected (Hawkins et al. 1999). The Australian Council on Healthcare Standards monitors TAT using a numerator of total number of test results within a specified time period (eg, less than 60 minutes) and a denominator of the total number of requests for the relevant test received by the laboratory (Australian Council on Healthcare Standards 2007).

Test volumes:

- **Definition**: The total number of test assays requested or blood specimens taken for a given period measured through a variety of methods eg, per patient per day, per patient per Diagnostic Related Group (DRG). Test volumes can also be measured by specific test assay eg, Troponin T.

- **Aim**: To optimise efficient and effective test ordering.

- **Rationale**: Test ordering volumes for pathology services continue to rise and account for a large proportion of health spending (Conyers 1999). The impact of excessive ordering is not just financial; it may lead to an increase in false positives resulting in unnecessary, expensive diagnostic examinations (Axt-Adam et al. 1993).

- **Potential uses**: Measure test ordering efficiency.

- **Confounders**: Research in this field shows that the volume of test ordering may be affected by the type of hospital (ie, teaching or non-teaching), seniority and position of clinical staff and even by the number of doctors who see a patient (Valenstein 1996).

- **Data sources**: Laboratory information systems provide the raw data for monitoring test volumes. However, for comparing test volumes by DRG, patient or by doctor, data linkage to hospital or specific department information sources may be required.

- **Evidence**: Many studies of the impact of CPOE on test volumes have either reported significant decreases (Hwang et al. 2002; Wang et al. 2002) or no significant change (Ostbye et al. 1997; Westbrook et al. 2006).

- **Comments**: A major weakness of past studies has been the absence of explicit criteria to identify what is meant by inappropriate test ordering (van Walraven and Naylor 1998). Statistical Process Control methods can be a valuable means of monitoring variation in ordering patterns (Thor et al. 2007).

Redundant tests:

- **Definition**: A redundant test occurs when a test is reordered within an inappropriate time frame and provides no additional information (Bates et al. 1999; van Walraven and Raymond 2003). The measurement of redundant test rates requires the specification of tests and a time frame based on published literature or service guidelines. The redundant test rate can be calculated using the number of redundant tests for a specific test as the numerator and the total number of that test as the denominator.

- **Aim**: To improve the appropriateness of test request selection.
Conclusion:

The utilisation of performance indicators is crucial for monitoring the impact of CPOE systems and for ensuring the realisation of benefits from their implementation in complex hospital settings. But as the above template reveals, an indicator can never capture all the complexity of the system it purports to measure. In some cases indicators may provide succinct answers to questions. In most cases however, the best they may achieve is a picture of the variation in the system for which statistical process control methods (assessing common and special causes) can be of value (Thor et al. 2007).

Acknowledgements:

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References:


**Contact details:**
a.georgiou@usyd.edu.au Tel: + 61 2 9036 7331
Encyclopedia of Healthcare Information Systems

Nilmini Wickramasinghe
Illinois Institute of Technology, USA

Eliezer Geisler
Illinois Institute of Technology, USA

Volume II
E–Mo
Electronic Test Management Systems and Hospital Pathology Laboratory Services

Andrew Georgiou  
*The University of Sydney, Australia*

Johanna Westbrook  
*The University of Sydney, Australia*

Joanne Callen  
*The University of Sydney, Australia*

Jeffrey Braithwaite  
*University of New South Wales, Australia*

INTRODUCTION

Pathology can be described as the branch of medicine that deals with the nature, causes, and process of disease (McGrath, 2003). Pathology laboratories consider clinical and pathologic data and integrate them within an ever-changing context and then transmit a meaningful answer back to doctors and patients. In doing so, pathology laboratories play a key role in translating data into meaningful information (Hardwick, 1998). Pathology services are information intense organisational bodies that rely heavily on the proficient administration of information for patient care purposes (Travers, 1997). It is estimated that 70% of all important decisions affecting a patient’s life involve a laboratory or pathology test, and pathology data represent an average of 70% of documents residing in electronic repositories (Becich, 2000).

Yet, pathology services are still widely seen as a backroom function with many people unaware of their importance. Pathology has been dubbed the “hidden science that saves lives” by the Royal College of Pathologists in England (The Royal College of Pathologists, 2000). Pathology departments are facing challenges from new information and communication technology (ICT) advances and the advent of managed care approaches to health care planning and delivery. The Review of NHS Pathology Services in England in 2006 emphasised the key role of pathology services in patient pathways that begins with the choice of the most suitable test or investigation, and proceeds to the interpretation and supply of clinical advice across clinical specialties (Review of NHS Pathology Services in England, 2006). ICT developments are behind many of the moves aimed at extending the role of pathology services beyond the basic request and reporting cycle (Friedman, 1996).

BACKGROUND

In the last 10 years, there has been much emphasis on the potential for computerised provider order entry (CPOE) systems to improve the provision and quality of health care (Doolan & Bates, 2002; Sittig & Stead, 1994). CPOE systems provide clinicians with the ability to place orders directly into computers linked to databases containing specific clinical information and decision-support software (Birkmeyer, Lee, Bates, & Birkmeyer, 2002). Many health care systems internationally are involved in the implementation of CPOE systems (Humber, 2004; NSW Government Action Plan for Health, 2002; The Leapfrog Group for Patient Safety, 2003). These systems are cornerstones for the establishment of electronic medical records (Hwang, Park, & Bakken, 2002).

Even though there has been substantial support for the implementation of CPOE systems (The Leapfrog Group for Patient Safety, 2003) along with a growing evidence base of their impact on the delivery of health care (Birkmeyer et al., 2002; Doolan & Bates, 2002) and its efficiency (Mekhjian et al., 2002), uptake has been neither rapid nor even (Ash, Gorman, Seshadri, & Hersh, 2004). Some of the initial enthusiasm for
CPOE systems has been tempered by high profile cases of physician resistance (Berger, 2004), and implementation difficulties (Dykstra, 2002) along with concern about the huge investment and costs involved (Ash & Bates, 2005). Moreover, evidence about the unintended consequences of CPOE systems (Ash, Berg, & Coiera, 2004; Campbell, Sittig, Ash, Guappone, & Dykstra, 2006) and their potential to facilitate new types of errors (Koppel et al., 2005) have led to a renewed focus on the importance of evaluation (Ammenwerth & de Keizer, 2005; Friedman & Wyatt, 1997; Gell, 2001) as a means to improve their design and implementation.

So far the attention of the research and evaluation literature has tended to focus on high profile issues like medication errors, with less attention to areas like pathology laboratories and medical imaging, which together make up a major proportion of hospital orders (Abelson, Connelly, Klee, Maag, & Smith, 2001; Georgiou, Williamson, Westbrook, & Ray, 2007).

CPOE is by definition a system-wide phenomenon with implications for the way the whole hospital and related entities work and function. These issues and challenges cannot be addressed by silo-based approaches where departments are considered independently of each other (Georgiou & Westbrook, 2006; Stablein et al., 2003). Pathology services are themselves made up of a number of organisational subparts each with their own ways of operating and functioning. These issues and challenges cannot be addressed by silo-based approaches where departments are considered independently of each other (Georgiou & Westbrook, 2006; Stablein et al., 2003). Pathology services are themselves made up of a number of organisational subparts each with their own ways of operating and functioning (Davidson & Chismar, 1999b), that will be affected by (and in turn affect) CPOE implementation (Wears & Berg, 2005). In the following sections, we draw on existing research evidence and literature reviews (Georgiou & Westbrook, 2006; Georgiou et al., 2007) alongside our own research experience to formalise an evaluation framework that can be used to assess the impact of CPOE on pathology services.

EVALUATING THE IMPACT OF CPOE ON PATHOLOGY PROCESSES

A systematic review by Georgiou et al. (2007) conceptualised three stages in the pathology test management process beginning with: (a) the decision of the doctor or responsible clinician (doctor or other delegated health professional) to order a pathology test; followed by (b) the processing of the test order in the pathology laboratory and ending with (c) a result that is communicated to the clinician and health care team responsible for the care of the patient, which will then be used as part of the clinical decision-making process (Georgiou et al., 2007). Each of these stages involves a dimension of time (Howanitz & Howanitz, 2001) which can be measured by turnaround time (TAT) indicators involving a number of measures including: (1) Laboratory TAT – the time taken for the test order to be processed in the laboratory before a result is issued, and (2) Total TAT—the total time it takes for an order to be placed, processed and a result issued (Georgiou et al., 2007).

Test Order Stage

Each of the stages in the pathology test order process can be assessed with a range of indicators that have been used to monitor the impact of CPOE systems on pathology services and patient care (Georgiou et al., 2007). The ability of CPOE systems to provide decision support will most likely have an effect on the first stage of the pathology test order process involving the clinician’s decision about which test to order. Some researchers have paid particular attention to the ability of decision support systems to affect clinical compliance with practice guidelines (Overhage, Tierney, Zhou, & McDonald, 1997; Solomon et al., 1999). Decision support may also affect the appropriateness and volume of tests ordered. This is particularly the case for “redundant” tests, that is, tests that are repeated within an inappropriate time frame and provide no additional information (Bates et al., 1998; van Walraven & Naylor, 1998). The volume of tests can in turn be measured in different ways, for example, the number of tests per day (Hwang et al., 2002), or for a specified period, or per patient/admission (Tierney, Miller, & McDonald, 1990; Westbrook, Georgiou, Dimos, & Germanos, 2006). The volume of tests is likely to have a significant effect on test costs which can also be measured in various ways such as: total laboratory costs (Nightingale, Peters, Mutimer, & Neuberger, 1994) or per admission (Tierney et al., 1990). Some research has concentrated on the effect that CPOE systems have on work practices of clinicians and pathology services staff. One of the most important issues in this area involves quantifying the time spent ordering tests and its impact on other tasks (Shu et al., 2001). Another key concern in the area of work practices is ensuring that the new technology does not foster practices which affect the quality and safety of the ordering process (Koppel et al., 2005).
Test Processing Stage

Few studies have looked at the impact of CPOE on the pathology test processing stage (Georgiou et al., 2007). In part, this may be because existing laboratory quality control processes are used to ensure the accuracy and reproducibility of results (Tetrault, 2001), and CPOE is not expected to greatly impact this area. The greatest number of errors that occur during this stage are a result of incorrect transcriptions and specimen errors (Bonini, Plebani, Ceriotti, & Rubboli, 2002; Plebani & Carraro, 1997). CPOE is expected to affect this area because it provides a template for accurate and legible ordering by clinicians and eliminates the need for laboratories to record orders (Georgiou et al., 2007). One method that has been used to monitor the impact of CPOE systems in this area is to record the level of telephone activity between wards and the laboratory as a means of ascertaining whether computerised test management systems reduce the need to chase up missing or unclear documentation details (Ostbye, Moen, Erikssen, & Hurlen, 1997).

Test Result Application

The final stage of the process involves the application of test results as part of delivery of patient care. This is the stage where the test process impacts directly on the outcomes and quality of patient care (Nevalainen et al., 2000). Evaluation of the role of CPOE in this stage of the test management process can include comparison of the time it takes to reach a diagnosis (Smith & McNeely, 1999) or to initiate treatment (Kuperman et al., 1999) when using a CPOE system. It is also possible to monitor the length of stay of patients (Neilson et al., 2004) and aspects of patient safety such as adverse events and mortality (Kuperman et al., 1999). CPOE systems have been shown to be successful at improving the speed with which test results are made available to clinicians. However, little research attention has been given to how individual clinicians are able to manage high volume and rapid transfer of clinical information (Kilpatrick & Holding, 2001; Murff et al., 2003; Poon et al., 2004).

FUTURE TRENDS: EVALUATION FRAMEWORK

The various measures of CPOE performance and impact provide a framework (see Figure 1) with which to assess (a) efficiency (value and efficacy of services in terms of cost, time and standards of practice) (Potter, 2000; Scriven, 1991); (b) effectiveness (the best possible outcome) (Potter, 2000) or success of the intervention (Scriven, 1991); and (c) quality (ensuring that the right thing is performed well (Brook & Kosecoff, 1988; Donabedian, 1988) and that the system meets identified needs and other relevant standards (Davidson, 2005)). But as the interconnected components of Figure 1 illustrate, the domains of efficiency, effectiveness and quality are not mutually exclusive and involve measures that clearly straddle domains (e.g., length of stay). One of the limitations of existing literature in this field is that evaluations are often based on indicators measured in isolation and disconnected from each other. It is important to maintain a holistic overview of indicator measurements, understanding that the net effect of any particular information system will consist of a balance of positives and negatives, and possibly successes and failures (Pawson, 2004).

The framework outlined in Figure 1 concentrates on quantitative measures of evaluation. In recent years there has been a growing number of researchers (Ammenwerth et al., 2004; Ash, Sittig, Seshadri, Dykstra, Carpenter, & Starvi, 2004; Greatbatch, Murphy, & Dingwall, 2001; Kaplan, 2001; Stoop & Berg, 2003) who have employed qualitative research methods to evaluate health information systems, including CPOE systems in pathology (Callen, Westbrook, & Braithwaite, 2006; Davidson & Chismar, 1999a; Georgiou, Westbrook, Braithwaite, & Iedema, 2005; Georgiou, Westbrook, Braithwaite et al., 2007). These approaches have contributed to a better understanding of the context (e.g., effect on the hospital and clinical environment) (Callen, Braithwaite, & Westbrook, 2006) and processes of ICT implementation including their impact on communication channels between departments and disciplines (Aydin, 1989; Dykstra, 2002). Together with quantitative research, they can add a valuable multimethod dimension to evaluation studies (Georgiou, Westbrook, Braithwaite, Iedema, Dimos, & Germanos, 2005; Westbrook, Braithwaite, Iedema, & Coiera, 2004).
CONCLUSION

The implementation of CPOE systems is increasing internationally and there is a strong evidence base about their ability to contribute to the efficiency and effectiveness of health care delivery. However, this evidence has tended to be concentrated in a small number of United States’ hospitals (Chaudhry et al., 2006; Shekelle, Morton, & Keeler, 2006). This means that the generalisability of this evidence is limited because these hospitals often have home grown systems that are not commercially available and which evolved over many years, mostly in academic teaching hospitals (Classen, Avery, & Bates, 2007). This has underscored the drive to extend and systematise the evaluation of CPOE systems across a range of diverse settings (Classen et al., 2007) including pathology services. Evaluation frameworks built upon existing evidence and utilising the experience of skilled practitioners and researchers can help to orient the evaluation process and provide comparative and generalisable data with which to optimise the effect of CPOE systems on patient care delivery.

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van Walraven, C., & Naylor, C. D. (1998). Do we know what inappropriate laboratory utilization is? A system-


**KEY TERMS**

**Electronic Decision Support Systems:** Access to knowledge stored electronically to aid patients, carers, and service providers in making health care decisions (National Electronic Decision Support Taskforce, 2003).

**Computerised Provider Order Entry:** Electronic systems that allow physicians (or other authorised staff) to enter hospital orders directly into a computer.

**Evaluation:** To determine the merit, worth, or value of something, or the product of that process (Scriven, 1991).

**Impact:** Change or (sometimes) lack of change caused by an evaluand (that which is being evaluated). Similar in meaning to outcome and effect (Davidson, 2005).

**Indicator:** A factor, variable, or observation that is empirically connected with the criterion variable (Scriven, 1991).

**Pathology:** Clinically-led diagnostic, laboratory, and post mortem services that cover a range of tests on blood and other human materials necessary for diagnosis and monitoring of a wide range of clinical conditions so that appropriate treatment can be given (Department of Health, 2004).

**Quality:** Merit or the extent to which an evaluand meets identified needs and relevant standards (Davidson, 2005).

**Redundant tests:** A reordered or repeated laboratory test that is ordered within an inappropriate time frame and provides no additional information (Bates et al., 1998; van Walraven & Naylor, 1998).

**Turnaround Times (TAT):** A frequently used measure by pathology services. Total TAT can be defined as the time of physician order request to when the physician reviews the result. Laboratory TAT measures the time a specimen arrives at the laboratory to the time of results dispatch.
The use of performance metrics to monitor the impact of CPOE on pathology laboratory services

Andrew GEORGIOUa,1, Wendy MORSEb, Wyndham TIMMINSb, Sangeeta RAYc, Johanna I. WESTBROOKa

a Health Informatics Research & Evaluation Unit, Faculty of Health Sciences, The University of Sydney, 1825, Australia
b Sydney South West Area Health Service Pathology Liverpool, 1871, Australia
c Discipline of International Business, The University of Sydney, 2006 Australia

Abstract. Organisational communication perspectives provide a framework for examining the impact of new Computerised Physician Order Entry (CPOE) systems on health care organisations. The aim of this study was to utilise performance metrics (volume of telephone/fax calls and the management of unfulfilled test requests) as a way of monitoring the impact of a new CPOE system on the communication (synchronous and asynchronous) interface in the Central Specimen Reception (CSR) area of a pathology laboratory service. The total number of outgoing and incoming calls rose considerably after the implementation of the new system. The number of unfulfilled test requests initially increased in the implementation period and thereafter fell to below pre-implementation levels. There were significant differences in the relative proportion of duplicate (69% - 35%) and rescheduled requests (4% - 24%) between the pre- and post-periods. Performance metrics, can be relevant for measuring and monitoring changes in communication processes. This is important with CPOE systems whose introduction can have unexpected consequences requiring early detection and action.

Keywords. Computer order entry, Evaluation studies, Hospital information systems, Laboratories, Pathology

1. Introduction

CPOE systems automate the clinical ordering process [1], and through the incorporation of clinical decision support and database linkage have the potential to contribute to improving the efficiency and quality of health care delivery [2]. However their introduction into hospitals can also result in major changes to work practices particularly in the way that hospital departments communicate and work with each other [3]. To date there has been little research into the impact of these systems on laboratory functioning. The existing research in this area has tended to focus on the pre-analytical (doctor’s decision to order) and post-analytical (delivery and application of
test results) stages of the pathology ordering process, with little attention to ward-
laboratory communication patterns and work patterns [4].

Information processing and communications are critical features of most activities
within an organisation. Careful and systematic monitoring of how CPOE systems are
used and their contribution to these processes can help to maximise system
effectiveness [5]. The aim of this study was to utilise two performance metrics (volume
of telephone; and fax calls and the management of unfulfilled test requests) as a means
of monitoring the impact of a new CPOE system on the communication (synchronous
and asynchronous) interface in the Central Specimen Reception (CSR) area of a
pathology laboratory service after the changeover to a new results reporting system
followed by electronic ordering two months later.

2. Material and Methods

2.1. Research Setting

The study was undertaken in the CSR department (consisting of around 20 staff) of a
pathology laboratory service located in a large (640-bed) hospital in Sydney, Australia.
On 22 November 2005, the Cerner Millennium Pathnet system replaced the previous
laboratory information system. This was the precursor to the introduction in January
2006 of the Power Chart (version 2004.01) electronic ordering system which included
some basic decision support features including prompts for essential patient
information and notification of duplicate test requests.

2.2. Procedures

2.2.1 Telephone communications

Hospital communication data logs listing the number of incoming and outgoing calls
for each of the existing CSR phones and fax machines were accessed. These summaries
were grouped into five quarters beginning in June – August 2005 and ending June –
August 2006 to compare the number of calls over the period.

2.2.2 Unfulfilled test requests

In the pre-CPOE period, CSR blood collectors visited wards to access the hand written
requests. They matched the hand written request with the patient, and then proceeded
with the specimen collection. On occasions where a collection was unable to be taken,
and after consultation with the responsible clinician, the request was either put aside for
collection on a future round or a notation was made on the request form and then
returned to CSR as an unfulfilled request. An unfulfilled request is therefore one where
a blood specimen was not taken and the request cancelled. Unfulfilled requests can
occur for a number of reasons; it could be a duplicate test request inadvertently made
for the same patient by different clinicians; it may have been cancelled by the clinician;
or it may have been reissued as a new request. Unfulfilled request forms were stored
for an indefinite period before being discarded.

This procedure changed with the implementation of the new system on 22
November 2005. The department introduced a form to record the details of the episode
including patient identification, ward, and date, and the reason for not collecting a specimen. The form provided the following choices: 1) Difficult collection; 2) Patient refused; 3) Patient unavailable; 4) Patient aggressive; 5) Patient not fasting; 6) Other. The forms also required the collectors to record whether the collection was rescheduled or cancelled. The information from these forms was then used to either cancel or reschedule the test request in the electronic system. These forms, along with all unfulfilled requests forms prior to 22 November 2005, were made available to the research team to audit for the period September 2005 to March 2006. Data were collated and cross validated by two researchers. Data about the total number of test requests per month were obtained from the pathology information service.

2.3 Analysis

The total and average number of incoming and outgoing calls per telephone/fax line were analysed by three-month (quarterly) periods. The proportion of unfulfilled requests to the total number of tests over each month, and of telephone calls for each quarter were also calculated. To aid the longitudinal overview of these data, the month of November (unfulfilled requests) and the Sep-Nov quarter (phone calls) were included as part of the pre-implementation period. However the Chi-square tests comparing types of unfulfilled requests during the pre- and post- periods used 22 November 2005 as the delineator date.

3. Results

3.1 Telephone communication

Table 1 shows the number of outgoing and incoming calls per quarter alongside their proportion to the total number of test requests for each period. It also provides the average number of calls per telephone/fax line. The number of calls (incoming and outgoing) for each quarter doubled in the Mar-May 06 periods and remained high in the Jun-Aug 06 period. The average number of incoming calls over the study period changed considerably but with high standard deviation (SD) values. In contrast the averages for outgoing calls did not vary as much and the SD values were lower.

<table>
<thead>
<tr>
<th>No. total requests</th>
<th>No. outgoing calls (Proportion to total requests)</th>
<th>Mean (SD)</th>
<th>No. incoming calls (Proportion to total requests)</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun-Aug 05</td>
<td>121290</td>
<td>2037 (0.02)</td>
<td>169.8 (95.7)</td>
<td>1268 (0.01)</td>
</tr>
<tr>
<td>Sep-Nov 05</td>
<td>121372</td>
<td>2872 (0.02)</td>
<td>119.7 (68.2)</td>
<td>4054 (0.02)</td>
</tr>
<tr>
<td>Dec-Feb 06</td>
<td>111703</td>
<td>3061 (0.03)</td>
<td>145.8 (81.5)</td>
<td>4871 (0.04)</td>
</tr>
<tr>
<td>Mar-May 06</td>
<td>118290</td>
<td>6078 (0.05)</td>
<td>155.9 (96.1)</td>
<td>10683 (0.09)</td>
</tr>
<tr>
<td>Jun-Aug 06</td>
<td>125334</td>
<td>5850 (0.05)</td>
<td>121.9 (87.5)</td>
<td>10678 (0.09)</td>
</tr>
</tbody>
</table>

3.2 Unfulfilled test requests
There were 4794 unfulfilled test requests for the period September 2005 to March 2006. Table 2 shows that the number of unfulfilled test requests rose sharply from 356 in the pre-implementation month of September 2005, to a peak of 1543 in December 2005, and then fell to 143 in March 2006. There was a similar trend in the proportion of unfulfilled test requests to total test requests, rising from 0.008 in September 2005 to 0.04 in December 2005 and then decreasing to 0.003 in March 2006.

### Table 2

No. unfulfilled requests as a proportion of total requests (pre-implementation months shaded)

<table>
<thead>
<tr>
<th>Month</th>
<th>No. unfulfilled requests</th>
<th>No. total requests</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-05</td>
<td>356</td>
<td>42066</td>
<td>0.008</td>
</tr>
<tr>
<td>Oct-05</td>
<td>323</td>
<td>39551</td>
<td>0.008</td>
</tr>
<tr>
<td>Nov-05</td>
<td>395</td>
<td>39755</td>
<td>0.010</td>
</tr>
<tr>
<td>Dec-05</td>
<td>1543</td>
<td>38129</td>
<td>0.040</td>
</tr>
<tr>
<td>Jan-06</td>
<td>1234</td>
<td>36559</td>
<td>0.034</td>
</tr>
<tr>
<td>Feb-06</td>
<td>800</td>
<td>37015</td>
<td>0.022</td>
</tr>
<tr>
<td>Mar-06</td>
<td>143</td>
<td>42513</td>
<td>0.003</td>
</tr>
</tbody>
</table>

The number of cancelled and rescheduled requests was also compared over the pre- and post-implementation periods. In the pre-implementation period rescheduled requests amounted to 4% (n=26) of all unfulfilled requests. This proportion rose to 24% (n=969) post-implementation. Cancelled requests fell from 96% (n=672) of the total pre-implementation number to 76% (n=3127) in the post-implementation period ($\chi^2 = 144.1; df 1; p<0.0001$). There was also a significant decrease in the proportion of duplicate requests from 69% (n=484) to 35% (n=1448) ($\chi^2 = 286.4; df 1; p<0.0001$).

### 4. Discussion

The results show dramatic fluctuations in the number of telephone calls and unfulfilled test requests from the period prior to the system changeover and extending some months later. These fluctuations can impact on the synchronous and asynchronous channels of communication with consequences for work processes in the department.

#### 4.1. Synchronous communication

The results of the comparison of telephone calls revealed a major increase in the number of incoming and outgoing phone calls associated with the introduction of the new reporting system in November 2005 followed by the new ordering system in January 2006. This implies a rise in the level of activity within the department. The high standard deviation values for the means of incoming calls suggests that the increased number of calls has not occurred in a sustained way across the department, and are possibly concentrated in those sections which deal with enquiries from the wards. Conversely, the smaller standard deviation values for outgoing calls indicate that the increased number of calls was more consistent across the department. These
findings correspond with research suggesting that changes in modes of communication brought about by the introduction of asynchronous CPOE order channels can contribute to levels of disruption and dysfunction [6].

4.2. Asynchronous communication

In the pre-implementation period the recording of a reason for an unfulfilled test request was generally ad hoc and inconsistent. This procedure was standardised after the introduction of the new results reporting system on 22 November 2005. The introduction of structured information allows clinicians to electronically monitor the status of requests. It also indicates a higher level of CSR/ward accountability. However, the rise in the volume of telephone calls beginning with the introduction of the new results reporting system (November 2005) followed by the new order entry system (January 2006) suggests that the phone was used heavily by clinicians as a means of monitoring the status of test requests. This may have been a transitory phenomenon associated with unfamiliarity of the new system [7]. Regular monitoring of the situation using the metrics outlined in this study can answer this question.

While the proportion of unfulfilled requests increased dramatically following the system changeover on 22 November 2005, it fell away after a few months to levels below those found previously. This rise is possibly due to the instability associated with implementation. On the other hand, the significant decrease in the relative proportion of duplicate requests points to the existence of a more fundamental change associated with the new system. This supports existing evidence that CPOE can help to reduce the level of unnecessary and duplicate requests [8].

The fall in the number of cancelled requests as a proportion of all unfulfilled requests is more complicated. There are instances where it is obviously necessary to cancel a test request. Such an occasion occurs when a patient is discharged or a test request has been duplicated by mistake, or even when a doctor may decide to cancel a request. However, not all unfulfilled requests need to be cancelled. For instance, a patient may be temporarily unavailable or may not have fasted, or there may have been a situation where a collection was not possible. A patient may not be available for a blood collection for no other reason than they were undergoing treatment in another part of the hospital at the time. The decrease in the relative proportion of cancelled requests is therefore likely to be a consequence of the replacement of previous ad hoc monitoring systems with improved reporting structures associated with CPOE.

4.3. Laboratory impact

CSR occupies a specific organisational role in the laboratory test process sitting between the clinician’s decision to make a test request and the actual processing of the specimen [3]. Its responsibilities include the maintenance of maximum levels of coordination (of information and specimens), as the preservation of the integrity of the test request. This in turn involves attention to accuracy and requires high levels of accountability and efficiency. The results of this study show that CPOE can impact on these areas of responsibility. This can occur through the introduction of structured ways of entering data which can lead to improved levels of coordination and accountability. It can also lead to changes in the efficiency of work processes, especially through its ability to reduce duplication. However, these changes are not necessarily consistent.
The increased levels of telephone/fax communication in the department associated with the system changeover suggest that it may also severely affect work load levels.

4.4. Limitations:

The choice of research method, in this case the monitoring of telephone/fax communications and unfulfilled orders can be affected by issues of data comprehensiveness and reliability. This study has endeavoured to offset these potential limitations through rigorous attention to the accuracy and completeness of the data.

5. Conclusion

Communication within the hospital setting is all pervasive but is often overlooked or taken for granted. Performance metrics, chosen wisely and used carefully, can be relevant to the task of monitoring changes in communication processes. They can also serve as a valuable tool for identifying trends or potential problems as part of statistical process control methods aimed at the early detection and prevention of problems [9]. This is particularly important with CPOE systems where implementation can have unexpected (possibly dysfunctional) consequences requiring early detection and action.

6. Acknowledgements

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7. References

Multi-method studies in health services research

Andrew Georgiou, Johanna I. Westbrook

Health Informatics Research and Evaluation Unit,
University of Sydney, New South Wales

Joanne Callen
Faculty of Health Sciences, University of Sydney,
New South Wales

The editorial comments in ‘Dilemmas in publishing qualitative public health research’, along with the suggestion of increasing the word limit for qualitative research, are welcome. As researchers in the health informatics discipline we are regularly required to grapple with research questions using both quantitative and qualitative methods. We thought it would be valuable to share with you some of the thinking that has shaped our understanding of the issue.

There is now an extensive source of literature about the application of qualitative methods in health care. This literature has contributed to improving the rigour and widening the appeal of qualitative research. Along with the encouragement of prominent journals, it has also helped to overcome the academic ‘tribalism’ that often prevailed in the past. Hopefully, it is now possible to concentrate not only on the contributions both methods can separately make, but also on what each can contribute to the other.

This is particularly relevant in health informatics, where the major health care benefits promised by information and communication technologies (ICT) systems can be offset by complex social issues involving politics, culture, organisation, etc. One of the starkest examples of this occurred with the 2003 multi-million dollar failure of an electronic ordering system at Cedars-Sinai Hospital in Los Angeles because of resistance from doctors, who felt it endangered patient safety and caused too much work. Cases such as this have prompted considerable interest in multi-method research and evaluation approaches.

Multi-method approaches imply recognition of the complexity and multi-dimensionality of the health service, whereby the choice of research method is related to the relevant question being asked. A recent evaluation of a telemedicine application demonstrates this point. Clinical and health care process indicators were measured to determine whether the implementation of a telemedicine system linking a remote emergency department (ED) with a tertiary ED resulted in expected changes, such as more appropriate patient transfers. The results revealed significant changes in transfer rates between the hospitals, as expected. However, interviews with clinicians exposed some unexpected consequences. These included specialists at the tertiary hospital reporting increased feelings of responsibility for remote patients (that they could now see via the video link), which sometimes led to increased anxiety and a preference to have patients transferred, an effect counter to the original intention of the intervention. The combination of the study methods provided a clearer understanding of why the clinical indicators changed or did not, and also insights into how such interventions may have an impact upon the work of health professionals in unexpected ways. We believe the argument for a multi-method approach in public health and health services research is compelling.

References


Correspondence to:
Mr Andrew Georgiou, Health Informatics Research and Evaluation Unit, Cumberland Campus East Street, PO Box 170 Lidcombe, New South Wales 1825. Fax: (02) 9351 9676; e-mail: a.georgiou@usyd.edu.au
Pathology’s front line – a comparison of the experiences of electronic ordering in the Clinical Chemistry and Haematology departments

Andrew GEORGIOU\textsuperscript{a,1}, Stephen LANG\textsuperscript{b}, Frank ALVARO\textsuperscript{b}, Geoff WHITTAKER\textsuperscript{b}, Johanna I. WESTBROOK\textsuperscript{a}, Joanne CALLEN\textsuperscript{c}

\textsuperscript{a} Health Informatics Research & Evaluation Unit, Faculty of Health Sciences, The University of Sydney, 1825, Australia
\textsuperscript{b} Sydney South West Area Health Service Pathology Liverpool, 1871, Sydney, Australia
\textsuperscript{c} Faculty of Health Sciences, The University of Sydney, 1825, Australia

Abstract. Socio-technical approaches to health information systems evaluation are particularly relevant to the study of Computerised Provider Order Entry (CPOE) systems. Pathology services are made up of a number of departments each with unique and complex tasks and requirements. These different components of pathology have received very little research attention. This study used qualitative methods to identify key organisational and work process along with repercussions of the implementation of CPOE through a comparison of the Haematology and Clinical Chemistry departments of a hospital pathology service. The results focus attention on areas where the departments face similar challenges along with those areas where work practices diverged. This underlined the key importance of understanding the context and setting of pathology laboratories. The study also draws attention to the importance of cross departmental and multi-disciplinary negotiation in the implementation process and highlights the potential for technology to affect and be affected by the organisational context in which it is placed.

Keywords. Biochemistry, Evaluation studies, Haematology, Laboratories, Hospital information systems, Pathology, Qualitative research

1. Introduction

Over the last five years there has been a significant rise in the interest shown in socio-technical approaches to health informatics research and evaluation. This development has meant a shift away from one-sided technology-centred approaches to health informatics [1] and helped to establish social aspects (culture, values and politics) and technical aspects (equipment, procedures and technology) as interdependent and interrelated [2]. A number of landmark studies have questioned some of the underlying assumptions involved in the implementation of Information and Communication Technology (ICT) systems [3, 4] and focused attention on the nature of hospital work

\textsuperscript{1} Andrew Georgiou, Health Informatics Research & Evaluation Unit, Faculty of Health Sciences, The University of Sydney, Cumberland Campus, East Street PO Box 170 Lidcombe NSW 1825 Australia. E-mail: a.georgiou@usyd.edu.au URL address: www.fhs.usyd.edu.au/hireu
processes and environment [5, 6], as well as the relationship between departments and professions [7].

The adoption of socio-technical approaches has been particularly salient to the implementation and design of Computerised Provider Order Entry (CPOE) systems. These systems are currently a high priority for health systems across many parts of the world [8-11]. CPOE systems enable clinicians to enter orders electronically. In doing so they provide the potential to improve the quality of health care, particularly through the use of decision support mechanisms [12] and the interlinkage of information sources [13]. However, CPOE systems can have a variable (even detrimental) impact on hospital settings, with major impacts on performance, hospital culture and departmental relationships [14-16]. These experiences have led many to assert the point (often associated with socio-technical approaches to research and evaluation) that the technology artefact has the potential to affect and be affected by the organisation in which it becomes embedded [1, 17-19].

The introduction of CPOE systems into hospitals have a very major affect on ancillary departments such as pathology and medical imaging laboratories. Although a significant number of hospital orders involve one or other of those departments, there has been relatively little attention given to them within the research literature [20]. Existing laboratory studies have tended to concentrate on measuring the effect of CPOE on indicators of pathology and clinical performance such as test volumes [21], turnaround times from order to result [22, 23] and test costs [24]. And although there are some important pioneering studies [25, 26], there remains a paucity of research aimed at addressing questions of how users experience the new system, and of the organisational and social context in which it operates. Moreover, the attention to pathology services often fails to compare and account for the different sections and departments of the pathology service, their unique functions and requirements. Failure to adequately address the complex web of interactions that make up a pathology service can produce findings that lack granularity [27] and are not able to be easily transferred to other settings and locations. This study used qualitative methods with the aim of identifying key organisational and work process implications of the introduction of CPOE based upon a comparative analysis of the Haematology and Clinical Chemistry Departments of a pathology service.

2. Material and Methods

2.1. Research Setting

This study was carried out in the Haematology and Clinical Chemistry departments of a pathology service based at a major Sydney metropolitan tertiary referral and teaching hospital. Both departments employ approximately 35 staff (including scientific, technical and ancillary staff). Clinical Chemistry would normally process between 1200 – 1400 specimens per day. Haematology processes approximately 1200 specimens per day. The departments are part of a pathology service made up of over 300 staff serving an area health service comprising a number of hospitals. The Cerner Millenium Pathnet was introduced in November 2005, followed by Power Chart (version 2004.01) across the hospital in January 2006. This integrated system allowed doctors and other authorised clinicians to electronically place orders for a range of items including pathology and radiology tests. The system replaced the existing
Laboratory Information Service (Hoslab) that had been moulded to suit the needs of its users.

2.2. Design

The study adopted a formative design [28] with the objective of investigating the introduction of the new system in the course of its preparation and implementation between August 2005 and July 2006. This allowed the research team to examine issues and their impact during the course of implementation. The study used qualitative methods based on focus groups, interviews and participant observation as a means of understanding the influence of social and organisational factors and how users perceive and experience the system [29].

2.3. Participants

2.3.1 Focus group and interviews

The study included one focus group consisting of five Haematology hospital scientists and a series of individual interviews involving nine senior laboratory scientists and managers from the Haematology (6) and Clinical Chemistry departments (3). There was a total of 25 interview sessions all carried out by the lead researcher (AG). The initial focus group and interview sessions began before the introduction of CPOE and used a set of semi-structured questions about the nature of laboratory work processes. Participants were asked to describe characteristics of their current work (including problems) and discuss the likely effect of the new system. The themes that emerged from these initial sessions were developed in the course of the formative implementation experience. Interviews were carried out systematically over the course of the study and were often repeated for clarification purposes. This process also provided the research team with the ability to investigate the relevance and validity of emerging themes. The study employed chain referral sampling techniques using the recommendations of informants to extend the sample base [30]. Six of the interview sessions were taped and transcribed by a person experienced in the task. This resulted in 117 single spaced A4 pages. Research notes of all interviews and the focus group were recorded in a log with memos reflecting on the data and the research process. This log represented an audit trail of the progress and development of the research study [31].

2.3.2 Observations

There were four formal observation sessions lasting between 30 minutes to an hour and totalling nearly two hours, carried out across the two departments. These were supplemented by observations that were embedded into the interview process [32]. This usually involved demonstrations and visualisations of issues discussed. Notes from all the observation sessions were recorded in the researcher’s log.

The research was approved by the University of New South Wales Human Research Ethics Committee and the relevant Area Health Service Research Ethics Committee. Participants were provided with a letter outlining the study, its voluntary nature and the confidentiality of all findings and participants.
2.4. Data analysis

A grounded theory approach [33] was adopted to provide procedural guidance to the task of analysis. Emergent themes were identified using participants’ own words. These themes then formed part of the enquiry strategy, taken up for discussion with senior laboratory scientists and across both pathology departments. This process provided the study with an important means of feedback and respondent validation [34]. NVivo 2.0 [35] software was used to assist in the analysis of the data. Data source triangulation occurred with data collected from hospital scientists from both departments, and from managers to gain varied perspectives of laboratory work processes and their implications for CPOE implementation.

3. Results

Our analysis of the results of this study identified three recurring themes that we have described under the subheadings below. We have included quotations from interviews to represent these themes.

3.1 The contextual setting - Clinical Chemistry and Haematology

Participants described Haematology as the study of blood along with its cellular elements, and the diseases of the blood and blood forming tissues. Clinical chemistry was described as the analysis of blood and other body fluids for chemical components. These two departments could be said to be the general-type laboratories most often associated with pathology departments. They could also be described as the “front line” of pathology:

I suppose a lot of haematology tests and a lot of chemistry tests become more frontline tests, so when the patient first presents they’ll do those tests as a baseline. UECs, [Urea, Electrolytes, Creatinine] your full blood counts and maybe some coags [coagulation testing]. When they think – what’s going on, some ask for some more specialised tests – drug levels, serology, some microbiology if they think the infection is a concern. I suppose it’s the bread and butter of pathology tests, but also maybe kind of more front line tests as a lot of generalised information can be gathered by the clinician on the patient’s status. Then they start specialising and get into the esoteric things if required. (Clinical Chemistry participant)

Both departments have a large proportion of urgent (STAT) testing that they are required to perform. A huge bulk of urgent tests emanate from critical care units and emergency departments where the treatment of a patient may often be reliant on laboratory results. This makes issues like the turnaround time (the time it takes for a test request to be processed and a result issued) important to how the laboratories undertake their work processes.

3.3. ‘Middleware’ communication
While there are similarities in the bulk of tests received, the nature of the laboratory work implies significant differences in how the two laboratories undertake their tasks. In Haematology it was described in the following way:

Most of our work is ordered as a standard group of say, 20 tests. But from the initial results of those 20 tests, we have rules in place that decide what else we might do, and that’s why we’re different from [Clinical Chemistry] – they again have the huge volume that we do, but whatever is requested is done and that’s where it stops. We’ve got other systems in place that need to make decisions, based on the initial result as to what to do next. The example being – you’ve asked for a full blood count. For 30% of those patients we’d look at a blood film, 70% you might not, so we need systems in place to identify that, and then systems in place to allow us to process that. So that’s what makes us very different. (Haematology participant)

This difference is highlighted by the divergent information requirements of the two laboratories. Clinical Chemistry reported less reliance on clinical notes. These notes are provided by doctors on the test order and supply information that can be relevant to the patient’s condition along with the choice and interpretation of the laboratory test. Generally, clinical notes do not impact on the Clinical Chemistry’s analysis, except in some situations which may be relevant in explaining an abnormal result. However within Haematology, a clinical note supplied by a doctor about a patient (eg, their present or past condition) will often impact on the decision about the test required.

Both Haematology and Clinical Chemistry utilise ‘middleware’ which sits in between the departments’ analysers and the Laboratory Information System (LIS). For Clinical Chemistry it was described as a communication interface between their department analysers and the LIS for result interpretation and handling. The Haematology department’s ‘middleware’ has a different emphasis related to the task of validating test results:

Eighty-five per cent of our work gets validated by [pre-defined software] rules so there’s no lab intervention. It goes through the machine, the rules in place look at the instrument errors, the previous patient’s results and then makes the results available to the clinicians at the other end. 15% of that, we have to have an intervention in before they’re available to the clinician. It’s identifying that 15% and processing them that the middleware helps us with. (Haematology participant)

The issue of ‘middleware’ and how the new electronic ordering system replaced or handled the existing ‘middleware’ was therefore an important one for both departments with major work flow implications on the ordering of tests and the upload of results from analysers to the LIS patient files.

3.4. The development of the Specimen Orderable Status (SOS) system

With a vast amount of specimens to process, across different automated laboratory processors, the efficient and safe monitoring and tracking of specimens is a vital component of laboratory functioning. This figured prominently in both departments’ planning and preparation for the new system.
We identified this issue on probably day one of the whole Cerner project back in 2002. Tracking is a fundamental thing for chemistry. We have so many specimens and aliquots [daughter tubes], and urines—all different specimen types, which we just need to know where they are… We just can’t line things up and put them in numerical order. So tracking and knowing where things are for retrieval and for safe storage is critical. (Clinical Chemistry participant)

The previous sample tracking system within the lab was a home grown system that complemented Hoslab. It allowed laboratory staff to scan the laboratory number and then provided them with information about what processes the specimen had been through, what further processes and remaining tests needed to be undertaken and where the specimen had to be stacked at the appropriate analysing resource or stored (final storage). As one participant explained:

Cerner had nothing like that. They had a tracking system but you had to select the rack, and follow the next empty hole, and say—OK—I’m putting this tube into this spot, which works well at the final storage process, but we have requirements in between.” (Clinical Chemistry participant)

The pathology department was forced to negotiate the addition of a new program, “Specimen Orderable Status” to compensate for the loss of previous system functionalities. Participants explained that with their previous system the task of changing aspects of the software was relatively straightforward. This is because they had a much greater level of control and dealt with personnel that were familiar with their needs. Under the new Cerner system it involved a lot of negotiation and effort.

It was a complicated thing to get this SOS program written because the Cerner tracking solutions weren’t going to be the entire answer for us. Their final way of storing things, and their way of reading tests off labels in order to know where they go in the lab weren’t going to work for us, and coming from a computerised system, which did work for us, we weren’t going to go backwards. (Clinical Chemistry participant)

Within Haematology the experience of the new system was expressed in a different way:

Senior Laboratory Scientist: We had middleware previously and we’ve lost that functionality. We do not have middleware at this point. We still have those manual processes we discussed prior to even going online.

Researcher: So you actually have to go through it all yourself?

Senior Laboratory Scientist. That 15% we have to find, identify, and process.

Researcher. So how do you find 15%?

Senior Laboratory Scientist. With the SOS program. So every time a specimen comes off a machine, any automated piece of equipment we have, as it comes off, we need to have the barcode read through the SOS program and it indicates to us whether the results have been validated or not. So when they haven’t been validated, which is that 15%, we then need to go into Cerner and see why not, and then perform the manual validations. We then go back into SOS to see that it has actually happened. (Haematology participant)
Figure 1 provides a screen shot view of the SOS that is currently in use in Pathnet. The screen differentiates between the “Service Resources” (laboratory instruments and work areas) that each specimen is designated to travel in order of priority. It also provides a report of the specimen’s “Status” (completed or not) and “Laboratory status” (physical location in the laboratory). “Aliq” indicates if an aliquot (daughter tube) was required. And “Collected” to the time the specimen was scanned into SOS, an important feature for Haematology which needs to complete its testing procedures within certain time frames. SOS took the place of two previous Hoslab applications, Hoslab Specimen Reception (SPR) (Figure 2) and Hoslab Specimen Tracking (SPT) (Figure 3). SPR was used by Clinical Chemistry to direct specimens to appropriate analysers in order of priority. SPT was used after each specimen was finished at each analyst/work area. It determined the next rank/location of the specimen according to priority along with a rack position for easy location.

Figure 1. Screen shot view of Specimen Orderable Status developed in Cerner Pathnet
Figure 2. Screen shot view of the previous Hoslab Specimen Reception system
4. Discussion

This comparative study has brought to light a number of features of pathology laboratory organisation that can impact (directly and indirectly) on the implementation of electronic ordering systems. We draw attention to three areas that featured in this study, and offer the following guides to assist the task of implementation.

4.1. One size does not fit all - the importance of context and setting in pathology laboratories

The results of this study illustrate some of the organisational similarities of the Haematology and Clinical Chemistry departments. They are large departments with heavy workloads with a large proportion of urgent tests which require immediate attention. It appears apt to describe them as pathology’s frontline where clinicians often turn first for important initial information relevant to the patient’s condition and treatment.

The study showed that there are important organisational differences between the departments that impact on what decisions need to be made about the test process. For
instance, our results showed that the test processing stage within Clinical Chemistry is mostly geared to providing results on tests, at which point the process usually ends. In cases where further investigative tests are indicated the laboratory will issue comments that accompany the initial results as a recommendation to the doctor. In the Haematology department the test process does not necessarily end with the provision of an initial set of results. The department is often required to investigate further. These decisions can be based on the initial test results or on patient information provided by the clinician, or incorporated into the system. This is an example of where clinical information contributes to the effectiveness of the laboratory’s contribution [36, 37] to patient care.

These contextual variations point to important existing differences between pathology departments [38]. The impact of a new system can vary considerably on different departments [4] and often represent a major challenge for system designers and implementation teams who are often required to engineer different solutions to suit different situations, sometimes in locations that can even be adjacent to each other. It also underscores the value of undertaking comparative studies across sites and departments as a way of adding to our understanding about the impact of contextual and organisational features on electronic ordering systems [27]. A literature review of clinical decision support systems undertaken by Kaplan, draws attention to the need for a greater diversity of approaches to investigate the actual processes involved in using these systems. These include the pervasive impact of social, cultural, political and work life factors [39].

Accordingly, there are circumstances where traditional research and evaluation techniques like randomized controlled trials will not be ideal for assessing the interactive effects of multiple factors on systems implemented in complex environments consisting of many confounders [40]. Hence the need for multi-method approaches that can incorporate quantitative and qualitative methods to address the interdependent and interrelated social and technical aspects of health information systems [2, 41].

4.2. The capacity for technology to affect and be affected

One of the frequent criticisms of evaluations of information systems in health is that there has been an over emphasis on the technological artefact (ie, the software and/or hardware) [42] and its affect on organisations, to the detriment of the interpretive, collaborative and reactive components of the clinical and laboratory process. Whilst it is apparent that a new CPOE system in a hospital will involve new ways of planning and organising the laboratory test order process, it should not be forgotten that new technology needs to be implemented in the context of existing systems and social practices [43] many of which may be the legacy of previously existing technology.

In this study we identified the role of two existing systems each with their own set of unique practices. Firstly we saw the role of ‘middleware’ in the laboratory processes of both departments. ‘Middleware’ plays an important intermediary role in the laboratories helping to bridge any shortfalls between the information system and the processing and output of results. The ‘middleware’ in Clinical Chemistry remained operational with the introduction of CPOE, but not so in Haematology where it failed. The second system involved a home grown specimen reception and tracking system (operated in conjunction with LIS) which was used by both departments in different ways and for different purposes. The new Cerner Pathnet system did not replicate this
role. This situation required the laboratories to undertake a complex set of negotiations with the software vendor (Cerner) to build an addition to Pathnet, Specimen Orderable Status (SOS) to compensate for this lack of functionality.

4.3. The usability of a system is a dynamic and negotiated process

One of the key factors that makes the introduction of new electronic ordering systems so complex is that their impact is spread out over many facets of the hospital and across disciplines [44]. In the past cooperation and collaboration of different departments in the implementation process has not always been present. This has often been cited as a reason for lack of user acceptance [45]. Building such collaboration requires a move away from silo-based implementation strategies which view each department as a separate implementation task, toward integrated strategies that cross departmental and disciplinary divides [46]. In this study we drew attention to some aspects of the effort taken to ensure the establishment of new software. The success or otherwise of a new system does not lie in the technology itself but in a complex web of social and technical factors, including how the department adjusts and adapts to change [43].

4.4. Limitations:

This study focused on the circumstances, dynamics and complexity of two departments in one hospital. The advantage of such comparisons is the richness and granularity the research findings provide. However, the generalisability of the findings may be offset by factors unique to the study site that may not be replicated in other settings. Nevertheless, the findings provide valuable evidence of the type of effects new systems can have with lessons that can be transferable to other settings. The formative design of this study enabled the research team to identify major issues as they arose, and to witness how each department responded. The potential disadvantage with this approach is that it lacks the benefit of hindsight and overview that the passage of time often grants participants and researchers.

5. Conclusion

This study has drawn on the initial experiences of two pathology laboratories confronted with the impact of CPOE implementation, to highlight a number of socio-technical consequences of new technology each with their own design and implementation implications. Such comparative studies can play an important role in uncovering and drawing attention to the complex and challenging tasks involved with new electronic ordering systems in healthcare.

6. Acknowledgements

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7. References


Information and Communication Processes in the Microbiology Laboratory - Implications for Computerised Provider Order Entry

Andrew Georgiou\textsuperscript{a}, Joanne Callen\textsuperscript{b}, Johanna Westbrook\textsuperscript{a}, Mirela Prgomet\textsuperscript{b}, George Toouli\textsuperscript{c}

\textsuperscript{a} Health Informatics Research & Evaluation Unit, University of Sydney
\textsuperscript{b} Faculty of Health Sciences, University of Sydney
\textsuperscript{c} South Western Area Pathology Services, Liverpool, Sydney

Abstract

The aim of this multi-method study based at a microbiology department in a major Sydney metropolitan teaching hospital was to: i) identify the role that information and communication processes play in a paper-based test request system, and ii) examine how these processes may affect the implementation and design of Computerised Provider Order Entry (CPOE) systems. Participants in this study reported that clinical information can impact on the urgency and type of tests undertaken and affect the interpretation of test results. An audit of 1051 microbiology test request forms collected over a three-day period showed that 47% of request forms included clinical notes which provide a variety of information often vital to the test analysis and reporting process. This transfer of information plays an important role in the communication relationship between the ward and the laboratory. The introduction of new CPOE systems can help to increase the efficiency of this process but for that to be achieved research attention needs to be given to enhancing the provision and communication of clinical information.

Keywords

Evaluation studies, Hospital information systems, Laboratories, Microbiology, Pathology, Qualitative research

Introduction

Computerised Provider Order Entry (CPOE) systems pose major challenges for hospital pathology laboratories [1], with important implications for a range of laboratory processes including inter-department functions, work organisation and laboratory effectiveness [2-5]. CPOE systems provide clinicians with the ability to enter orders directly into a computer [6]. The incorporation of functions such as clinical decision support and patient database linkage provide the potential to significantly impact on the quality of health care delivery leading to improved patient outcomes [7-9].

However, within the research and medical literature there has been relatively little attention given to the effect of CPOE on pathology laboratories [10]. These services play a crucial role in overall patient safety and outcome, accounting for an estimated 70% of all information used in decision making for admission, treatment and discharge [11, 12]. Pathology services are information intense units reliant on the efficient management and timely communication of relevant information to maximize the delivery of health care [13]. Moreover, the pathology department is comprised of a number of organisational structures and bodies each with its own unique and highly complex way of performing tasks and interacting with other departments. The aim of this study was to: i) identify the role that information and communication processes play in a paper-based test request system in the microbiology department; and ii) examine how these processes may affect the implementation and design of CPOE systems.

Methods

Design and research setting

A multi-method study (using quantitative and qualitative data collection techniques) was conducted in a microbiology department based at an Australian metropolitan teaching hospital. The department receives 131,000 microbiology test requests and specimens annually and employs 55 staff. It is divided into bacteriology, molecular biology, serology, virology, mycobacteriology and parasitology sections. The department is part of a pathology service involved in the introduction of Cerner Millennium PowerChart (Version 2004.01). The pathology service is responsible for a large metropolitan area and provides diagnostic services to a number of hospitals (including teaching hospitals) and clinics. This study forms part of a large multi-
Qualitative data relating to existing information and communication processes connected with test ordering and reporting within the microbiology laboratory were collected by observations, interviews and a focus group. Quantitative data collected from the microbiology department consisted of the volume of tests ordered and measured the presence of additional clinical information provided by doctors. The results provided a baseline indication of the existence of clinical information on test request forms by the requesting doctor.

Selection and sampling logic

The site was chosen because it was about to introduce an electronic ordering system that was mandatory for all inpatients. Qualitative data collection began with a focus group consisting of four laboratory scientists and one laboratory manager (n=5). These participants were chosen for their suitability (i.e., the department manager attested to their experience and knowledge of microbiology laboratory processes). The aim of the focus group was to discuss participants’ views and expectations of the impact of a new CPOE system that was due to be introduced within the next three months. A set of semi-structured questions were used to gather impressions about the current system of paper-based test requests and what changes participants thought the new system would introduce. Participants were asked to raise both positive and negative features of the current laboratory processes. The participant base was extended using purposive sampling techniques [14], whereby participants directed us to other key informants. This increased the number of participants to eleven. Overall it included two senior laboratory scientists, one laboratory business manager, three technical officers and five laboratory scientists. Interviews were repeated with participants for clarification and further exploration of issues raised, with a total of 20 interview sessions conducted. This process provided a valuable feedback mechanism which enhanced our confidence in the validity of emerging themes [15]. One researcher conducted all the interviews and the focus group. Eight observation sessions were conducted by two researchers with each session lasting on average 1.5 hours (total of 12 hours of observations). One researcher conducted five of the observation sessions and the other conducted the remaining three.

Data collection

In the course of our analysis of the qualitative data, the research team undertook the collection of microbiology test request data. This provided the study with an important triangulation technique to investigate emergent themes [16]. Request forms were audited by one researcher over a three-day period between 29 June 2006 and 1 July 2006. No details related to patient identification were collected. The data collected included the number of test request forms received with and without the inclusion of clinical notes. For the purposes of this study clinical notes refers to patient specific clinical information written on the laboratory request form by the doctor requesting the test. Clinical notes therefore, may include: signs and symptoms; the site from which the specimen was obtained; medical history; physical examination; medications and the reason for the test request. One of the above pieces of clinical information was needed for the test request form to satisfy the criteria of “test request contained clinical notes.”

The observations, interviews and focus group were conducted between August 2005 and October 2006. A letter outlining the study, its voluntary nature, the confidentiality of findings and participants, and a consent form, were provided to all participants. The research was approved by the University of New South Wales Human Research Ethics Committee and the relevant Area Health Service Research Ethics Committee.

Data analysis

The quantitative data were entered into SPSS (Version 12.0.1 for Windows 2004) and analysed using descriptive statistics. The focus group and one interview were recorded and transcribed. The remaining interviews and observations were recorded by the researchers in note form. The qualitative data were interpreted using a grounded theory approach [16] to derive themes that explained the information and communication processes within the microbiology department. Triangulation of analysis involved a number of iterative sessions involving a total of five researchers discussing and analysing the data: two who had collected the data and three others from the research team [14].

Results

The results are presented in two parts: firstly the qualitative data about laboratory information and communication processes related to the test ordering process, and secondly the volume, type and inclusion of clinical notes on microbiology test requests.

Laboratory information and communication processes related to the test ordering process – qualitative analysis

Three themes relating to information and communication processes surrounding test requests were identified:

- Theme 1: The context of the microbiology department
- Theme 2: Communication of clinical information
- Theme 3: Expectations of the new electronic ordering system

The context of the microbiology department

Participants explained that microbiology departments have their own specific requirements and needs that are not always applicable to other departments. For instance, the issue of timeliness has a particular context-dependent meaning for microbiology that is not identical to other pathology departments (e.g. biochemistry) for whom the optimisation of turnaround times for the processing and issue of results
is an important performance indicator. Microbiology deals predominantly with diseases caused by infectious agents (e.g. bacteria, viruses, fungi and parasites) requiring time to grow before an appropriate test result is available.

**The communication of clinical information**

Participants highlighted the provision of relevant and appropriate clinical information by doctors ordering tests as a key area that directly impacts on their efficiency. In hospitals where electronic ordering has not been implemented this means the provision of a handwritten test request form, including clinical notes, from the requesting doctor. If clinical information is not included the request may be judged to be incomplete or inadequate and in need of some form of follow up, often through direct telephone contact with the requesting doctor. This point was described by one participant in the following way:

“As a whole the request that we receive, we need to know what the specimen is. We need to know what they want us to do with it, and it needs to be legible, so it really is an error, because we have to use our time to verify what they actually want.” (Focus group participant)

Clinical notes are very important to laboratory staff. This is because they play an important role in setting the context for the test. Laboratory managers explained that this contextual information improves the laboratory’s input. For instance, it may help a pathologist detect the need for more tests, or perhaps identify when a doctor may have asked for an inappropriate test.

“They don’t tell us what they want and we process what we think. If we didn’t get the correct clinical details we may not necessarily make it up for the right thing….” (Focus group participant)

A salient example of this is for the disease tuberculosis, which the laboratory may not routinely test for unless it is either specifically requested, or when relevant clinical information is provided.

“There are times when we process a specimen, then they [clinicians] ring up and say: have you done TB [tuberculosis] on this? We say – well you didn’t ask for it. They should have given us the clinical details that would have allowed us to do that.” (Focus group participant)

**Expectations of new electronic ordering**

The introduction of electronic ordering was expected to alter the way the department communicates with clinicians. In particular, laboratory personnel would not be required to decipher handwritten notes anymore, which should eliminate instances of unclear or illegible requests. Participants described the potential of more effective exchange of valuable and relevant clinical information.

“There should be some benefits to the laboratory, in that there will be less data entry, I guess. The patients’ demographics etc, will come across. There should be less confusion, as to what tests are requested by the medical staff. We are hoping to get a lot more clinical details…” (Focus group participant)

**The volume and inclusion of clinical notes on test request forms – quantitative analysis**

The total number of microbiology specific tests requested within the 1,051 test request forms received were 1,078 as some request forms contained multiple test requests (Table 1). A large proportion of test request forms (47%) contained clinical notes documented by the clinician on the request form. The average number of tests requested per day, over the 3 day period, was 359 (range 338 to 374).

Table 1: Number of microbiology specific tests requested with and without clinical notes

<table>
<thead>
<tr>
<th>Test categories</th>
<th>No of tests (n=1078)</th>
<th>With Clinical notes (n=506)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>1</td>
<td>374</td>
<td>186</td>
</tr>
<tr>
<td>2</td>
<td>338</td>
<td>146</td>
</tr>
<tr>
<td>3</td>
<td>366</td>
<td>174</td>
</tr>
<tr>
<td>Average</td>
<td>359.3</td>
<td>168.7</td>
</tr>
</tbody>
</table>

Table 2 highlights the results of the most frequently ordered tests. The most requested tests were urine cultures (35%) followed by blood cultures (21%) and specific site swab cultures (8%). The majority of urine culture requests (n=233 [62%]) and blood culture requests (n=142 [62%]) did not contain clinical notes. However most wound culture requests (n=42 [75%]) did contain clinical notes.

Table 2: Frequency of a selection of the most ordered microbiology requested tests

<table>
<thead>
<tr>
<th>Test categories</th>
<th>No of tests (n=1078)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-specific site swab cultures</td>
<td>27</td>
<td>3</td>
</tr>
<tr>
<td>Stool cultures</td>
<td>35</td>
<td>3</td>
</tr>
<tr>
<td>Infection control cultures</td>
<td>38</td>
<td>4</td>
</tr>
<tr>
<td>Fluid cultures</td>
<td>44</td>
<td>4</td>
</tr>
<tr>
<td>Sputum cultures</td>
<td>52</td>
<td>5</td>
</tr>
<tr>
<td>Wound cultures</td>
<td>56</td>
<td>5</td>
</tr>
<tr>
<td>Genital cultures</td>
<td>74</td>
<td>7</td>
</tr>
<tr>
<td>Specific site swab cultures</td>
<td>81</td>
<td>8</td>
</tr>
<tr>
<td>Blood cultures</td>
<td>230</td>
<td>21</td>
</tr>
<tr>
<td>Urine cultures</td>
<td>379</td>
<td>35</td>
</tr>
<tr>
<td>Others</td>
<td>62</td>
<td>6</td>
</tr>
</tbody>
</table>

**Discussion**

The comparison of results collected from the audit of microbiology test requests with the themes identified from the interviews and focus group session provides a means to triangulate different types of data, and encourages a better understanding of the meaning and significance of different findings. The results showed an important proportion (47%) of microbiology test requests received by the microbiology department contained some clinical notes provided by clinicians. This indicates that clinicians often need to
communicate further information to the microbiology department beyond simply identifying the test to be performed. There are cases, as in most blood and urine cultures, (which make up the bulk of tests requested), that do not contain any clinical notes. In some instances, (as suggested in the interviews and focus groups) this may require laboratory staff to follow up the missing information using telephone communication.

The translation of data into clinically meaningful information

The results highlight the role that the supply and processing of clinical information plays in the microbiology laboratory. The traditional format through which this information is communicated has been the hand written request form. Aside from their obvious clerical function, these forms also represent an important link between doctors and the laboratory [17] through which contextual patient data are communicated. This information can impact on the urgency, choice and even interpretation of pathology tests and results. The laboratory process involves the translation of data into clinically meaningful information. This role can be described as a core function of the laboratory service [18] and represents an important contribution to the patient care process [19]. For some commentators, such as Marques and MacDonald the absence of clinical information in certain situations can be misleading and even potentially dangerous [20].

Communication and the transfer of information

This study also demonstrates that the exchange of information across the hospital is a two-way process through which clinicians not only provide clinical information to laboratories, but also receive it back in an enhanced form. This relationship demonstrates the importance that communication plays in this process. The ordering process can be conceptualised as part of a collaborative effort of multidisciplinary groups [21]. For Toussaint and Coiera every information exchange is a communication act including a simple exchange between two people or even two machines [22]. Communication systems are important parts of the information structure [23] and can play a major role in the decision making process.

Most information transactions within health services occur without the involvement of electronic data or systems [23], usually in conversations or through paper exchange. In reality, hospital communication systems form a collection of differing components and types [24]. Electronic systems like CPOE will impact significantly on existing channels and relationships [2]. The results of this study suggest that CPOE systems can be expected to enhance communication ensuring legibility and clarity in the ordering process and contribute to improvements in the clinical decision making process [4, 7]. However, there is also evidence that CPOE systems may disrupt previous channels of communication and replace them with inadequate or unsuitable alternatives often involving workarounds and extra tasks [25]. As Gorman et al. have stressed, incomplete or incorrect models of the process can lead to problems in the uptake and operation of CPOE [21]. Figure 2 depicts the importance of clinical information for the communication exchange between the laboratory and the clinical setting. The broken lines highlight the potential for this flow to be disturbed by design inconsistencies and barriers. It is important therefore that information and communication processes (at times unique to each hospital) are clearly identified as a means of maximizing the benefits of CPOE systems.

Limitations of this study

This study was undertaken at one site, using a microbiology laboratory department during the lead up to the implementation of a new CPOE system. The experiences of this one site will not be identical to other laboratory departments in other hospitals. Nevertheless the issues outlined will have wider resonance. The multi-method design adopted by this study has the advantage of providing rich contextual qualitative data about how the department’s information and communication requirements are perceived along with descriptive data summarising the existing arrangements using hand written requests. This multi-method approach helped to enhance the findings and inform the discussion with participants. The results provide a useful evaluative framework with which to approach the question of CPOE implementation. But it also suggests the need to closely examine and quantify the impact different types of clinical information provided for different test requests can have on the laboratory process and their subsequent communication with doctors. While this task was beyond the scope of this study, it remains a natural area for follow up.

Conclusion

This study underscores the important role that the provision, processing and exchange of clinical information plays in microbiology laboratory processes. Clinical information helps to inform the laboratory of the type and urgency of tests required as well as assisting pathology staff to add interpretative value to the information provided back to medical staff. The exchange and transfer of clinical information is underpinned by a complex variety of communication channels within the hospital. New CPOE systems can increase the efficiency of this process and enhance the rich-

![Figure 2: The laboratory/ward information and communication relationship](image-url)
ness of the information exchange. To date, little attention has been provided to this issue. We recommend that more research into this area be undertaken so as to make these channels of communication and information exchange more explicit, and as a means of providing information to enhance the design and implementation of CPOE systems.

Acknowledgements

This study was part of an Australian Research Council Linkage Grant project that funded the evaluation of the impact of information and communication technologies on organisational processes and outcomes. The project was undertaken with the collaboration of the New South Wales Health Department. The authors also acknowledge laboratory personnel for their participation in this study.

References


Cumberland Campus, University of Sydney,
PO Box 170 Lidcombe NSW 1825, Australia
Andrew Georgiou (Senior Research Fellow)
Telephone: + 61 2 9036 7331 Email: a.georgiou@usyd.edu.au
The impact of computerised physician order entry systems on pathology services: A systematic review

Andrew Georgiou*, Margaret Williamson, Johanna I. Westbrook, Sangeeta Ray

Centre for Health Informatics, University of New South Wales, UNSW, Sydney 2052, Australia

Abstract

Purpose: Computerised physician order entry (CPOE) systems hold the promise of significant improvements to health care delivery and patient care. The implementation of such systems is costly and complex. The purpose of this paper is to review current evidence of the impact of CPOE on hospital pathology services.

Methods: This paper presents a review of the literature (1990–August 2004) about CPOE systems and identifies indicators for measuring the impact of CPOE on pathology services.

Results: Nineteen studies which contained some form of ‘control’ group, were identified. They featured a variety of designs including randomised controlled trials, quasi-experimental and before and after studies. We categorised these into three groups: studies comparing pathology CPOE systems (with no decision support) to paper systems; pathology CPOE systems (with decision support) to paper systems; and pathology CPOE systems with specific pathology features compared to systems without those features. We identified 10 areas of impact assessment and 39 indicators used to measure the impact of CPOE on different stages of the pathology test ordering and reporting process.

Conclusion: We conclude that while some data suggest that CPOE systems are beneficial for clinical and laboratory work processes, these data are limited, and further research is needed. Few data are available regarding the impact of CPOE on patient outcomes.

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1. Introduction

Many potential benefits of computerised physician order entry (CPOE) in hospitals have been identified. These include improvements to physician ordering patterns, increased compliance with guidelines, optimisation of clinical time, and facilitation of communication processes in health care [1–14]. If realised, these benefits would logically lead to improvements in patient outcomes, as well as major cost efficiencies. CPOE systems are an integral part of hospital information systems and constitute an important building block for the establishment of the electronic medical record [2,7,15]. For these reasons, CPOE systems have been strongly promoted in the United States, Europe and Australia as a means of improving the quality of care, reducing errors and increasing efficiency in health care delivery [16–22].

Pathology order entry allows physicians (or other authorised staff) to enter laboratory orders directly into a computer [4,11,14,23]. Such systems may include decision support mechanisms such as defined order sets for particular conditions in order to support the selection and appropriate use of tests and treatment; parameter checks to ensure that orders are within agreed test time frames, frequency or dose limits; and more complex rule based alerts that prompt clinicians with information about previous test results, patient characteristics and available test choices [16,17,24–29].
CPOE systems remain costly and complex to design and implement [9,13]. Despite the potential benefits, there are very few evaluations of the effect of CPOE on clinical outcomes [1], and evidence of the effectiveness of CPOE has focused predominantly on medication order systems in hospital settings [9]. One of the reasons for this may be the limited funding available for such studies. Outside of medication orders a large proportion of orders processed through a CPOE system relate to pathology and imaging services that can have a potentially significant impact on clinicians’ test ordering decisions and pose a new set of challenges and opportunities for pathology managers.

Relatively little research has focused specifically on the impact of CPOE on hospital pathology services, order patterns or patient outcomes. The purpose of this paper is to review current evidence of the impact of CPOE on hospital pathology services and to identify the indicators, which have been used to measure impact.

2. Methods

A literature review was undertaken to identify all evaluation studies of computerised pathology order entry systems published between 1990 and August 2004. The following databases were searched: MEDLINE, CINAHL, EMBASE, SocScience Index and Cochrane Database of Systematic Reviews. Web-based searches using Google and hand searches of international health informatics journals were completed. The reference lists from relevant articles and additional articles by key authors were also reviewed [30]. The search terms and subject headings used are listed in Table 1. Papers were selected and reviewed by two reviewers (AG, MW). We applied only one quality criteria to select articles, namely that the study project headings used are listed in Table 1. Papers were selected and reviewed by two reviewers (AG, MW). We applied only one quality criteria to select articles, namely that the study.

<table>
<thead>
<tr>
<th>Table 1 – Concepts and terms used in search strategies</th>
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<tr>
<td>Literature search for empirical studies on the impact of CPOE on pathology services</td>
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<tr>
<td>Concept 1: order entry</td>
</tr>
<tr>
<td>Order entry (T), order management (T), electronic health records (T), medical records systems, computerized (*SH), clinical laboratory information systems (SH), laboratory information systems</td>
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<tr>
<td>Concept 2: decision support</td>
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<tr>
<td>Database management systems (T, SH), computer-assisted decision support (T), decision making, computer assisted (*SH), clinical decision support systems (T), decision support systems, clinical (SH), decision support techniques (T, SH), expert systems (T, SH)</td>
</tr>
<tr>
<td>Concept 3: electronic or computerised</td>
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<tr>
<td>Computer (T), electronic (T), microcomputer (T, SH)</td>
</tr>
<tr>
<td>Concept 4: pathology/laboratory</td>
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<tr>
<td>Laboratory (T*, SH), Pathology (T*, SH)</td>
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</tbody>
</table>

T denotes text, SH denotes a subject heading. * SH denotes subject heading exploded.

The results of the review are discussed under three headings, which relate to stages in pathology test ordering and reporting (see Fig. 1). These stages are: (1) test ordering process including the physician decision to order a pathology test; (2) test processing within the pathology department; and (3) application of pathology test results which includes the delivery of results and the subsequent actions which may impact upon patient outcomes. A further dimension, which warrants measurement is the flow of information through the three stages.

3. Results

The review identified 19 studies of the impact of CPOE systems on pathology. Eleven studies compared CPOE for pathology orders (with and without decision support) to no CPOE (Tables 2 and 3). Of these, four studies compared CPOE without defined decision support mechanisms to settings where there was no CPOE. Eight studies compared CPOE with specific decision support features to CPOE without these features (Table 4). The studies comparing CPOE with no CPOE were conducted in the USA (5), United Kingdom (UK) (2), Canada (2), Norway (1) and South Korea (1). The eight studies examining the impact of decision support systems on CPOE were carried out in three US hospitals. Across all studies there were a variety of designs used including seven randomised controlled trials (RCT), two non-randomised controlled trials, eight before and after studies, one laboratory-based quasi-experimental study and one interrupted time series study. Tables 2–4 summarise the interventions and comparisons, indicators, designs and results of these studies.

3.1. Stage one-test ordering

The pathology process is initiated by a physician’s decision to order a test. It includes documenting the decision on a test order form, either paper or electronic. The decision to order is an area where CPOE systems are likely to have a major impact upon. This can occur through decision support mechanisms such as clinical alerts, reminder systems and standard test order sets designed to improve the appropriateness of tests ordered and minimise the number of redundant tests. These features could impact upon test volumes and total pathology costs [12,31–37].

Potential indicators of impact at this stage of the process are rate of unnecessary or redundant tests ordered, the number or volume of orders and associated test costs. Tests should comply with agreed clinical guidelines or accepted medical practice (given the patient’s condition and treatment) to ensure safe and efficient care. Redundant tests occur when a test is reordered within an inappropriate time frame and provides no additional information [34,38]. Some physicians reorder tests to verify the results of a previous test. It may also be a mechanism to ensure that necessary tests are not missed [39,40]. But in many cases repeat testing is a convenience rather than a reflection of a belief that it improves patient care [39]. There is evidence that repeat and redundant tests are areas where major improvements are needed [41]. A retrospective study of test orders by Bates et al. [34] showed that 8.6% of 10 target repeat tests were judged
<table>
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<tr>
<th>Reference</th>
<th>Setting/Country</th>
<th>Intervention (I)/comparison (C)</th>
<th>Study description</th>
<th>Areas of impact (measure/indicators)</th>
<th>Results</th>
<th>Design</th>
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<tbody>
<tr>
<td>Hwang et al. [2]</td>
<td>Inpatients tertiary teaching hospital, South Korea</td>
<td>I: CPOE (all orders), C: before CPOE</td>
<td>A study of patients with four ICD diagnosis (medical and two surgical) in the month prior to CPOE implementation (73 patients), 3 months after (60) and 6 months after (36)</td>
<td>Test volume (number of diagnostic tests per patient per day)</td>
<td>Significant decrease (blood count, chemistry, serum, stat)</td>
<td>Before and after study</td>
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<tr>
<td>Mekhjian et al. [5]</td>
<td>Inpatients two ICUs, Ohio State University Health System, USA</td>
<td>I: CPOE (all orders), C: no CPOE</td>
<td>A 2-month study of a surgical intensive care unit (1142 laboratory orders) with a CPOE system and a medical intensive care unit (683 laboratory orders) without a CPOE system</td>
<td>Laboratory turn around times (average time between receipt of specimen and order in laboratory to time of electronic results posting)</td>
<td>25% faster with CPOE (23 min vs. 31 min (p = 0.001)</td>
<td>Non-randomised controlled trial</td>
</tr>
<tr>
<td>Ostbye et al. [47]</td>
<td>Inpatients two surgical wards at Central Hospital of Akershus, Norway</td>
<td>I: CPOE (clinical chemistry test ordering and reporting), C: no CPOE</td>
<td>Clinical chemistry test volumes and turn around times were monitored on two surgical wards, one randomly assigned as the intervention and the other as the control for 17 weeks pre CPOE and 11 weeks after CPOE</td>
<td>Total turn around time</td>
<td>Decrease in total TAT from 270–350 to 90–180 min</td>
<td>Randomised controlled trial</td>
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<tr>
<td>Shu et al. [50]</td>
<td>A study of medical interns, Massachusetts General Hospital, USA</td>
<td>I: CPOE (all orders), C: before CPOE</td>
<td>Comparison of physician time spent ordering and doing other activities, in the 3 months before implementation of CPOE and a 2 month period 6 months after CPOE implementation</td>
<td>Test volume (total number of laboratory tests per week for all tests and 10 most frequent tests)</td>
<td>No change in total volume of tests ordered before and after CPOE. Slight increase in some frequent tests</td>
<td>Before and after study</td>
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Physician time (proportion of physician time spent writing orders)

Proportion of physician time associated with ordering

Proportion of time spent writing orders increased from 2.1 to 9.0%

Total time associated with ordering increased from 6.8% to 13.5% as time spent in some activities reduced
<table>
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<th>Reference</th>
<th>Setting/Country</th>
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<th>Results</th>
<th>Design</th>
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<tbody>
<tr>
<td>Bansal et al. [46]</td>
<td>Inpatients Intensive care units, Vanderbilt, University Medical Centre, USA</td>
<td>I: CPOE plus ordering advice and restrictions, C: before CPOE</td>
<td>Eight ICU studied (six with CPOE, two without) over 12 weeks (5 pre-and 7 post). Computer based intervention providing patient ABG values and limits to test orders placed more than 24 h in advance</td>
<td>Test volume (total number of ABG tests for a period)</td>
<td>No significant change pre and post</td>
<td>Before and after study with control group</td>
</tr>
<tr>
<td>Kamal et al. [48]</td>
<td>Ohio State University Medical Center, USA</td>
<td>I: CPOE (laboratory orders) + EDS: order sets, C: before CPOE</td>
<td>A study comparing laboratory order rates in the 3 months before CPOE was implemented and the same 3 months 18 months after CPOE implementation</td>
<td>Test volume (number of lab orders per patient per diagnosis related groups—DRG)</td>
<td>Fifty percentage increase for most DRGs. Up to 200% increases for some cardiology related DRGs</td>
<td>Before and after study</td>
</tr>
<tr>
<td>Mutimer et al. [42]</td>
<td>Inpatients Liver Unit, Queen Elizabeth Hospital, UK</td>
<td>I: CPOE + computerised decision support: computerised protocol for laboratory tests for 'Liver Unit' patients, C: before CPOE</td>
<td>Three-month evaluation of transplant and non-transplant patients in a 'Liver Unit' before (113 patients) and after (109 patients) implementation of the system</td>
<td>Test volume (number of laboratory tests requested per patient per day)</td>
<td>9.5% decrease (p &lt; 0.01) in transplant recipients; 28.8% (p &lt; 0.01) decrease for non-transplant recipients</td>
<td>Before and after study</td>
</tr>
<tr>
<td>Nightingale et al. [43]</td>
<td>Inpatients Liver Unit, Queen Elizabeth Hospital, UK</td>
<td>I: CPOE + computerised decision support: computerised protocols for laboratory tests, C: before CPOE + written protocols</td>
<td>Further evaluation of system assessed by Mutimer et al. [42]. Examined data for 1 year before and after system implementation. Patients were transplant and non-transplant patients in a ‘Liver Unit’.</td>
<td>Test volume (number of laboratory tests requested per patient per day) No of lab tests ordered out of hours per patient per day Order appropriateness (% of patients requiring a particular test who actually receive it), Laboratory costs (direct laboratory costs)</td>
<td>Declined by 17% (p &lt; 0.001) Reduced by 48% (p &lt; 0.001) Increase in usage of 10 previously less often used tests for patients with specified conditions, reduction in direct laboratory costs of 28% (p &lt; 0.001)</td>
<td>Before and after study</td>
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<td>Reference</td>
<td>Setting/Country</td>
<td>Intervention (I)/comparison (C)</td>
<td>Description</td>
<td>Areas of impact (measures/indicators)</td>
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<td>Smith et al. [44]</td>
<td>General practitioners laboratory based Canada</td>
<td>I: CPOE with computerised decision support: Laboratory Advisory System. C: paper based requisitions and reports</td>
<td>Six general practitioners with 10–20 years experience were invited to present their diagnostic approach to 14 vignettes of standard clinical problems (seven using just paper based requisitions and results and seven using the Laboratory Advisory System)</td>
<td>Test volume (average number of laboratory tests per physician)</td>
<td>Decreased from 32.7 to 17.8 with LAS ($p&lt;0.01$).</td>
<td>Laboratory-based experimental study</td>
</tr>
<tr>
<td>Thompson [65]</td>
<td>Inpatients Intensive Care Unit, St. Paul's Hospital, Canada</td>
<td>I: CPOE (laboratory orders) + computerised decision support: order sets, C: before CPOE</td>
<td>Comparison of turn around times for STAT laboratory tests for two 1 month periods, 10 months before CPOE and 2 months after CPOE was implemented</td>
<td>Total turn around times</td>
<td>Decreased from 148 to 74 min ($p&lt;0.001$)</td>
<td>Before and after study</td>
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<tr>
<td>Wang et al [45]</td>
<td>Inpatients Intensive care unit, Massachusetts General Hospital, USA</td>
<td>I CPOE with admission orders plus Guidelines and educational efforts C: before CPOE</td>
<td>Comparison of test utilisation during a 3-month intervention period compared to the same months a year prior to intervention: The hospital’s ICU, which did not receive the specified intervention, provided control data</td>
<td>Test volumes (Number of tests per patient per day)</td>
<td>Statistically significant reductions for all chemistry tests</td>
<td>Before and after study with control group</td>
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<td>Test Costs (total test costs for a period)</td>
<td>Reduction in expenditure for routine blood tests and chest radiographs was 17% ($p&lt;0.001$)</td>
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<td>Length of stay (mean)</td>
<td>No significant change</td>
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<td>Adverse events (ICU readmission rate; Hospital mortality rate; average number of days ventilated per ventilated patient)</td>
<td>No significant change</td>
<td></td>
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<td>Reference</td>
<td>Setting/Country</td>
<td>Intervention (I)/comparison (C)</td>
<td>Study Description</td>
<td>Areas of impact (measures/Indicators)</td>
<td>Results</td>
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<td>Bates et al. [32]</td>
<td>Medical and surgical inpatients, Brigham and Women's Hospital, USA</td>
<td>I: CPOE + computerised decision support: computerised display of charges for laboratory (and radiology) tests; C: CPOE alone</td>
<td>This laboratory study involved two prospective controlled trials that included all medical and surgical inpatients during a 4-month study period with 3536 intervention and 3554 control inpatients in the group with laboratory tests</td>
<td>Test volume (mean number of tests per admission; total number of clinical laboratory tests)</td>
<td>No significant differences</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>Bates et al. [36]</td>
<td>All inpatients, Brigham and Women's Hospital, USA</td>
<td>I: CPOE + computerised decision support: reminders to physicians about redundant tests; C: CPOE alone (reminders suppressed)</td>
<td>The study included all inpatients at a large teaching hospital during a 15-week period</td>
<td>Test costs (cost of tests per admission, total costs of tests)</td>
<td>No significant differences</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>Kuperman et al. [35]</td>
<td>Medical and surgical inpatients, Brigham and Women's Hospital, USA</td>
<td>I: alert for critical results via page + review system for 12 conditions based on critical laboratory test results; C: critical results telephoned to ward by laboratory</td>
<td>A 2-month study of medical and surgical inpatients at a large academic medical centre. One hundred and ninety two alerting situations were studied</td>
<td>Order appropriateness (redundant tests rates); Hospital costs (estimated total annual savings)</td>
<td>Nine hundred and thirty-nine apparently redundant tests in the 77,609 study tests ordered in the intervention (5700 patients) and control (5886 patients). Fifty-one percentage of redundant tests were performed in the control group and 27% of ordered redundant tests in the intervention group (p &lt; 0.001). The authors used the results to estimate an annual savings of $35,000, but noted that the overall effect was limited because many tests were performed without corresponding computer orders, and many orders were not screened for redundancy</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>Reference</td>
<td>Setting/Country</td>
<td>Intervention (I)/comparison (C)</td>
<td>Study Description</td>
<td>Areas of impact (measures/Indicators)</td>
<td>Results</td>
<td>Design</td>
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<tr>
<td>Neilson et al. [37]</td>
<td>All medical staff using CPOE, Vanderbilt University Medical Center, USA</td>
<td>I: CPOE + computerised decision support: test order confirmations and constraints, C: CPOE alone</td>
<td>A 3-year study of metabolic panel component tests by all staff using the CPOE system, starting and continuing through the intervention period until 1 year post interventions</td>
<td>Time to resolution of critical condition (average time interval from availability of critical result until time critical condition resolved) Adverse events (number of adverse events and rate per patient)</td>
<td>The median and mean times were no different between groups (median 8.4 h vs. 8.9 h, ( p = 0.11 ); mean 14.4 h vs. 20.2 h, ( p = 0.11 )) No significant differences</td>
<td>Interrupted time series study</td>
</tr>
<tr>
<td>Overhage et al., [12]</td>
<td>Inpatient general medicine ward, Wishard Memorial Hospital, USA</td>
<td>I: computerised decision support: automated guideline based reminders to physicians about recommended corollary orders, C: paper-based corollary order guidelines</td>
<td>Computerised reminders about corollary orders were presented to three intervention teams (48 physicians) and withheld from three control teams (41 physicians) in a 6-month trial</td>
<td>Order appropriateness (immediate, 24 h and hospital stay compliance to corollary orders guidelines i.e. number of times a physician ordered the corollary orders divided by the total number of corollary orders) Length of stay Total costs (average charge per admission) Adverse events (number of pharmacy interventions for life threatening, severe, or significant errors) Average maximum serum creatinine levels</td>
<td>Improved compliance with computerised decisions support: immediate compliance: 46.3% vs. 21.9%; 24 h compliance: 50.4% vs. 29.0%; hospital-stay compliance: 55.9% vs. 37.1% all, ( p &lt; 0.0001 ) No difference No difference Pharmacists’ interventions: less with intervention (105 vs. 156) ( p = 0.003 ) maximum serum creatinine levels: no difference between the groups</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Setting</td>
<td>Intervention</td>
<td>Comparator</td>
<td>Study Design</td>
<td>Key Findings</td>
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<tr>
<td>Solomon et al. [49]</td>
<td>Inpatient units, Brigham and Women’s Hospital, USA</td>
<td>I: CPOE with post-test probability estimates designated serologic test. C: CPOE alone</td>
<td>Comparison of test cancellations of rheumatoid factor and antinuclear antibody and complement level tests ordered by house officers using CPOE</td>
<td>Number of cancelled tests</td>
<td>Higher rate of cancelled tests with CPOE: 11/99 vs. 1/236 (p = 0.001)</td>
<td>Non-randomised controlled trial</td>
</tr>
<tr>
<td>Tierney et al. [33]</td>
<td>Outpatients physicians, Wishard Memorial Hospital, USA</td>
<td>I: CPOE + computerised decision support: test charges displayed (outpatients) C: CPOE alone</td>
<td>Physicians (121) were randomly allocated into a control group and intervention group. The study was conducted over a 26-week period with 8392 patients.</td>
<td>Test volume (mean number of tests ordered per patient)</td>
<td>Intervention group ordered 14% fewer tests (p &lt; 0.005)</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>Tierney et al. [31]</td>
<td>House officers, medical students and faculty internists, Wishard Memorial Hospital, USA</td>
<td>I: CPOE (all orders) + computerised decision support: costs for tests; advice about cost-effective tests for common problems C: CPOE alone</td>
<td>Assessment of the healthcare resource utilisation of microcomputer workstations using computerised decision support. The study included 5219 internal medicine patients and 68 teams of house officers, medical students and faculty internists who care for them</td>
<td>Total costs (total charges per admission)</td>
<td>Intervention teams generated 12.7% lower charges per admission (p = 0.02)</td>
<td>Randomised controlled trial</td>
</tr>
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</table>

Test costs (diagnostic test charges) | Signiﬁcant (p < 0.05) reductions in diagnostic test charges with the intervention. The mean length of stay was 0.89 of a day shorter for intervention resident teams (p = 0.11). Interns in the intervention group spent an average of 33 min longer each day writing orders than the control group (p > 0.0001). |
to be redundant because they were performed too early to provide useful clinical information.

Our review of papers that assessed the impact of CPOE for pathology services identified 16 papers that had used one or more indicators applicable to the physician decision to order stage. Of these papers, 11 looked at the effect of CPOE on test volumes and/or total or average test costs. There were two papers that used redundant orders as an indicator, three that studied compliance with guidelines and three that assessed clinician work practices.

3.1.1. Impact on test volume
Of the eleven studies of the impact of CPOE on test volumes, seven reported a significant decrease in test volume [2,33,37,42–45], three showed no change [32,46,47], and one reported an increase in tests ordered [48]. The reduction in test volume varied between studies and according to measures used. Most studies measured test volume using total tests per patient or admission per day. Two of the studies examined test volumes on the same system, one comparing volumes 3 months before and after [42] and the other comparing them 12 months before and after [43].

Two RCTs which involved the display of test charges as part of CPOE decision support were carried out in the US. One found no difference in the mean number of tests per admission and no significant reduction in the total number of tests in the intervention group [32]. The other compared the mean number of tests per outpatient and reported that the intervention group ordered 14% fewer tests (p < 0.005) [33]. A quasi-RCT in Norway [47] compared two surgical wards, one with CPOE, the other without. It found no change in the total number of laboratory tests per week ordered before and after.

A Canadian laboratory-based study by Smith et al. [44] compared six general practitioners using 14 vignettes of standard clinical problems (seven using paper-based requisitions and seven using a Laboratory Advisory System). They found that the mean number of tests per practitioner was 32.7 tests versus 17.8 with the Laboratory Advisory System (p < 0.01). An interrupted time series study carried out at Vanderbilt University Hospital in the US between 1999 and 2001 used decision support constraints and restrictions to investigate test ordering behaviour. They found that orders for metabolic laboratories decreased by 24% (p = 0.02), while the unbundling of order sets to reduce unnecessary repeat tests produced an additional decrease of 51% (p < 0.001) of component tests [37].

Six studies used a before and after design, four without control groups and two with control groups. Bansal et al. [46] investigated the impact of a web-based educational text and restrictions on advanced ordering of arterial blood gases (ABG) in intensive care unit settings. The authors reported no significant change in the number of ABGs ordered citing limited power as the reason [46]. A study centred on test utilisation management to reduce unnecessary tests in the Coronary Care Unit in Massachusetts General Hospital reported significant reductions in the utilisation of all chemistry tests [45]. Mutimer et al. [42] and Nightingale et al. [43] evaluated a home grown system in England which used protocols defining all laboratory investigations for patients in a liver transplant unit. Physicians had the flexibility to add or delete tests or change other protocols. The 3-month study found that clinical chemistry tests requested per patient per day fell by 9.5% (p < 0.01) for transplant recipients and by 28.8% (p < 0.01) for non-transplant recipients [42]. Comparisons 12 months before and after implementation of the system, showed a 17% decline in the total number of tests per patient (p < 0.001) and 48% decrease for out of hours tests per patient (p < 0.001) [43].

A before and after study, between 1999 and 2000 at a tertiary teaching hospital in South Korea, selected patients from two diagnostic and two surgical procedure groups. The study reported a significant decrease in the average number of tests per patient per day for full blood count, chemistry, serum and stat tests [2]. Kamal et al. compared laboratory order patterns for 3 months before CPOE implementation and in the same 3 months, 18 months after implementation at the Ohio State University Medical Centre in the US. They found that regardless of the disease, the average number of orders per patient per Diagnostic Related Group increased by approximately 50% [48].

3.1.2. Impact on test costs
Five studies measured laboratory related test costs, of which four showed significant reductions [31,33,43,45], and one showed no change [32]. In most cases changes in test costs reflected underlying changes in test volume. Three RCTs examined the impact of including charges for diagnostic tests on the electronic order form. Tierney et al. [33] found that this intervention produced significant results with 13% lower charges in outpatients. A larger inpatient study undertaken later at the same hospital showed similar reductions in diagnostic test charges among the intervention group [31]. Bates et
al. [32] showed no significant decrease in costs, while Nightingale et al. reported a 28% (p < 0.001) reduction in direct laboratory expenditure per patient-day [43]. Wang et al. (2002) [45] used their findings of a decrease in test orders in arterial blood gases and chest radiographs to estimate a significant decrease of 17% in expenditure.

### 3.1.3. Impact on redundant test rates
The rate of redundant tests was the focus of a study at Brigham and Women's Hospital that investigated the impact of providing computerised reminders to physicians about apparent redundant tests. It reported a significantly reduced rate of redundant tests in the intervention groups (27%) compared with the control group (51%). The authors noted that the overall effect was limited because only 44% of redundant tests performed had an associated computer order; only 50% of tests ordered using the computer were screened for redundancy; and almost one-third of the reminders were overridden [36]. Neilson et al. reported a decrease in the number of discontinued tests per day following the introduction of CPOE reminders [37].

### 3.1.4. Impact on compliance with guidelines
Four studies found that CPOE systems with computerised decision support improved compliance with guideline advice. A study of the impact of clinical guidance provided by a Laboratory Advisory System (LAS) on the diagnostic approach of six clinicians in a laboratory setting found that physicians using the system arrived at the correct diagnosis in 100% of cases, as opposed to 66% using the conventional approach [44]. Another study of order appropriateness using computerised protocols for laboratory tests found an increase in usage of 10 previously less often used tests for patients with specified conditions [43]. An RCT carried out at Wishard Memorial Hospital in the US investigated the ability of guideline-based reminders of correlative orders to prevent errors of omission. It found that physicians in an intervention group ordered the suggested correlative orders in 46.3% of instances where they received a reminder, compared with 21.9% compliance for the control group, which did not receive a reminder [12]. Solomon et al. [49] compared the rate of test cancellations for a group of specified serologic test orders where the intervention group physicians were provided with displays of post-test probability estimates. The study reported a significant difference in the number of cancellations for the intervention group (11.1%) versus the control (0.4%).

### 3.1.5. Impact on work practices
Three studies examined the impact of CPOE on physician ordering time on pathology tests. A 1998 before and after study at Massachusetts General Hospital in the US compared the time physicians spent ordering in the 3 months before the implementation of CPOE with a 2 month period 6 months after implementation. The study reported that the total time spent writing orders increased from 2.1% to 9.0% (p < 0.001) and the amount of time spent using the computer rose from 6.8% to 13.5%. But 1.9% of time was recovered performing activities expected to take less time e.g., scheduling tests, completing forms, walking, travelling in the elevator, and looking for patients [50]. The RCT at Wishard Memorial Hospital (US) also found that interns in their intervention group (provided with CPOE plus computerised decision support) spent an average of 33 min longer during a 10 h observation period writing orders than the control group [31].

Employing a contrasting approach, Mutimer et al. (as described earlier) used computerised protocols defining laboratory investigations for patients in a liver transplant unit. The authors reported that the time spent by junior medical staff requesting laboratory investigations fell from 6.8 to 2.3 min (p < 0.001) and time spent on specimen enquiries and results decreased from 10 min per day to 4.1 min per day (p < 0.001). The authors suggested that this approach can be of substantial benefit in reducing the amount of time spent by medical officers on administrative tasks [42].

### 3.2. Stage two test processing within the pathology department
The test order process within pathology departments can be broken down into the preanalytical and analytical phases. In the preanalytical phase paper test orders and specimens are delivered to the pathology department and logged onto a laboratory information system [51]. Errors in this phase can include order or request errors (e.g. wrong test ordered, missing physician signature, missing patient identifiers, illegible information, and wrong location identifiers), laboratory transcription errors (i.e. where details about the patient record number, name or location; pathology test, or doctor, differ with the doctor’s original order and the laboratory information system) and specimen errors (e.g. incorrect sample collection procedures).

The analytical phase is when the test is performed; data are interpreted and results written in the form of a laboratory test report. Errors that may occur in this phase include analytical errors and laboratory report errors (i.e. keyboard entry errors, wrong test reference range and incorrect address details). Analytical errors include those related to the inaccuracy or imprecision of test results, analysis of the wrong specimen, performing the wrong assay; data misinterpretations and misjudgements; or broken specimen tubes during centrifuge.

Laboratory quality control processes focus on the test processing stage. They aim to ensure the accuracy and reproducibility of laboratory results [52]. Studies of the type and frequency of errors in laboratories have found that request, specimen and transcription errors, typically associated with the preanalytical phase contribute most to the total laboratory error rate [53,54] and cause most of the clinically significant laboratory errors [52]. Other research conducted in accordance with the Q-Projects quality assurance program of the College of American Pathologists estimated an average transcription error rate of 5% for 660 participating institutions [55]. An Australian study conducted in 1994 surveyed 18 large National Association of Testing Authorities-registered laboratories and found a mean transcription error rate of 13% (range 0–17%) [56]. This study also found analytical errors as high as 26% in one laboratory with an average of 11.4%.

Where a pathology CPOE system exists, it requires the completion of all relevant fields in the electronic test requisition form. It interfaces with the laboratory information system and
directly transfers this information. CPOE systems should have an important impact on errors in the pre-analytical phase, reducing errors arising from incomplete information, or illegible handwriting on test requisition forms. They also remove the need to transcribe information from requisition forms into laboratory computers thus reducing laboratory transcription errors and saving laboratory time.

3.2.1. Impact on number of physician–laboratory communication
One study from the Central Hospital of Akershus in Norway looked at telephone activity. They reported that the number of telephone calls from the intervention ward to the laboratory did not show any clear change after the installation of the new system, and the number of calls from the laboratory to the installation ward decreased after the system had stabilised (after 11 weeks) [47].

3.3. Stage three application of pathology test results
Once the pathology results are delivered to the clinician, they are interpreted and incorporated into the patient management plan. Often measures used in this stage of the test process focus on patient outcomes or can act as proxy measures of outcomes. It is at this stage that adverse events during the pathology ordering and reporting process will impact on patient care either through increased morbidity or inconvenience to the patient [57].

Research into adverse events relating to pathology services has been undertaken. A laboratory incident classification scheme developed by Astion et al. [58] identified preventable problems that were most likely to lead to patient injury. An adverse event is defined as an injury to a patient caused by medical management rather than by a disease process, which resulted in disability or prolonged hospital stay [12,58,59]. This classification was retrospectively applied to 129 incident reports in a US academic medical centre during a 16-month period. It found that 95% of incidents were potential adverse events, with the most common 110 (85%) being delay in receiving test results. The seven cases (5%), classified as adverse events, were phlebotomy-related injuries. The authors noted that a significant limitation to their study was the inadequacy of incident reports and the absence of information about patient care settings and patient outcomes.

An assessment of errors in STAT laboratories (where all tests are considered urgent) showed that 6.4% of errors were associated with adverse patient outcomes such as inappropriate patient care or inappropriate modification of therapy. A further 19% led to inappropriate investigations including repeat laboratory tests [53]. Other studies have shown that a small proportion of clinical laboratory and transfusion-related errors may result in delayed diagnosis, increased patient morbidity, increased length of hospital stay and even death [54,60].

Our review of CPOE pathology literature identified a range of measures that have been used to study this stage of the laboratory process. This included nine papers that considered one or more relevant measures. These papers are discussed below.

3.3.1. Impact on patient management and time following up results
Three papers using six different measures addressed the impact of CPOE on patient management and time following up results. Smith et al. [44] reported that the time taken to reach a diagnosis was 1 day for physicians that used a Laboratory Advisory System (LAS), and 3.2 days for those that did not. They also found that LAS users were more likely to arrive at a correct diagnosis in 100% of cases and made on average less venipunctures (bleeds) than those who did not use the system (mean 5.8 versus mean 7.5, p < 0.02).

Kuperman et al. [35] undertook a trial that used a computer system to detect critical conditions and automatically notify the responsible physician via the hospital’s paging system. The study recorded a 38% shorter median time interval (1 h versus 1.6 h, p = 0.003) until an appropriate treatment was ordered when an automatic alerting system was used for critical laboratory results. There was a shorter (but not significant) median and mean time to the critical condition being resolved (8.4 h versus 8.9 h; and 14.4 h versus 20.2 h).

One paper looked at the impact of CPOE on clinician time spent following up results. It found that the time spent by junior medical staff on specimen enquiries and results fell from 10 min per day to 4.1 min (p < 0.001) [42].

3.3.2. Impact on length of stay and costs
Five studies examined the impact of CPOE on length of hospital stay [2,12,31,37,45] and three looked at costs across the hospital using measures such as total charges per admission, estimated total annual savings and estimated savings per visit [12,31,36]. Most reported no significant impact on length of stay. A South Korean before and after study measured the appropriateness of length of stay using an appropriateness evaluation protocol. It found no change in appropriateness of patients’ hospital stay but did report a significant decrease (p = 0.049) in the length of stay [2]. Two further US papers, an interrupted times series study from Vanderbilt University Medical Centre, and a before and after study at Massachusetts General Hospital reported unchanged lengths of stay following system implementation [37,45].

Two separate studies were carried out at the Wishard Memorial Hospital in the US. Both found no significant change in length of stay. However one of these studies carried out by Tierney et al. [31] reported 12.7% lower hospital charges per admission (p = 0.02) from patients enrolled in an RCT at Wishard Memorial Hospital, where information on test charges and advice about cost effective tests was provided to clinicians via the ordering system. While the other study by Overhage et al. [12] calculated average charges per admission for their study of computerised decision support carried out at the same hospital and found no difference in length of stay. An RCT at Brigham and Women’s hospital in the US found significant reductions in redundant tests within their intervention group and used these results to estimate annual savings of $35,000 [36].

3.3.3. Impact on adverse events and safety
Our review identified nine different measures of safety and adverse events that appeared in four separate studies. Kuperman et al. [35] used an alert system for critical results
comparing CPOE alerts with telephone calls to the ward. The most frequent adverse events identified were death, dialysis, transfer to intensive care unit (ICU), and delirium. They found no change in the number of adverse events when compared separately. The total adverse event rate per patient was also similar in the two groups (31 events in 94 intervention patients [0.33 events per patient] versus 27 events in 98 control patients [0.28 events per patient], p = 0.41). Other studies, which look at specified adverse events such as mortality [37,45], rates of transfer or readmission to ICU [37,45] also found no significant changes. However, the failure to detect significant differences in these studies may have been due to insufficient sample size.

Overhage et al. [12] measured pharmacist intervention in their evaluation of corollary test order reminders. They reported that pharmacists made 105 interventions with intervention physicians and 156 with control physicians (p = 0.003) for errors considered to be life threatening, severe or significant.

The Vanderbilt University Medical Centre [37] study measured the proportion of patients with abnormal test results 48 h following the original abnormal test and reported no substantial differences before and after the intervention. However, they did report that the proportion of patients who had at least one abnormal value decreased (p = 0.02) after the intervention. Other adverse events used were the maximum serum creatinine levels (no difference between the groups) [12] and the average number of days ventilated per ventilated patient in a CCU setting (no significant change between before and after) [45].

3.4. Efficiency of the information flow between the three stages of pathology ordering and processing

The previous stages of the ordering process specified areas in the initiation, processing and application of tests. The speed with which information flows between and within the three stages can also provide valuable information about the efficiency of the test process. Turnaround time (TAT) is a frequently used measure by pathology services [61]. TATs may be reported for different aspects of the laboratory and laboratory-related process. Total TAT can be defined as the time of physician request to when the physician reviews the result. Laboratory TAT measures the time a specimen arrives at the laboratory to the time of results dispatch. Physician satisfaction with pathology services is frequently related to timeliness of test results because of its influence on time to diagnosis and/or treatment, especially for patients in intensive care units or emergency departments [62,63]. Two studies carried out in 1997 and 2001, respectively determined the length of time for each component of laboratory testing processes for an emergency department and concluded that the time for specimen collection and its transport to the clinical laboratory had the most significant effect on TAT [63,64].

An important component of patient care and patient safety relates to the efficiency in communicating Critical Laboratory Results (CLR) directly (usually by phone) to the requesting physician. Evidence shows that time to treatment can be adversely affected by delays in communicating critical results to physicians [36]. One study of physician satisfaction with Emergency Department laboratories concluded that effective communication channels needed to be established between laboratories and physicians to improve operational efficiency and patient care [63].

3.4.1. Impact on TAT

A 2-month comparison of a surgical intensive care unit using a CPOE system, with a medical intensive care unit without a CPOE system, reported a 25% shorter average reporting time between the receipt of the specimen in the laboratory and the electronic posting of the result (laboratory TAT) (p < 0.001) [5]. A before and after study compared TAT for urgent laboratory tests, 10 months before the introduction of the new system and 2 months after. It found a reduced median TAT from ordering to specimen collection of 77–21.5 min (p < 0.001) and a reduction in total TAT from 148 to 74 min (p < 0.001) [65]. A Norwegian study reported a decrease in total TAT from 270–350 to 90–180 min [47].

4. Discussion

There is a growing body of research which has examined either the impact on pathology services of CPOE alone, or with decision support mechanisms. We identified 19 empirical studies published between 1990 and August 2004. The geographical scope of the research spread from the USA and Canada, to South Korea, Norway and England, reflecting international interest in this area. Six hospitals (five from the USA and one from England) featured in more than one study. The hospital where most studies (four) were carried out was Brigham and Women’s Hospital in the USA [32,35,36,49].

Fifteen studies compared CPOE with and without specific decision support mechanisms. The rest compared settings with a CPOE system to settings without a system. Most studies (8/11) comparing hospitals with and without CPOE systems used a before and after design, while a greater proportion of the studies comparing CPOE with and without specific decision support mechanisms, were randomised controlled trials (6/8). The randomised controlled trials were more narrowly focused and concentrated on particular CPOE decision support features such as displays of charges, reminders and patient history. They were also the more rigorous in design and execution. This difference reflects the ongoing difficulty with implementing experimental study designs to assess large information systems in complex clinical settings.

The majority of non-RCT studies used simple analysis techniques to compare intervention and control groups or settings. It was unclear in many cases where other factors may have influenced the results, as little information was presented about consideration or adjustment for patient casemix, physician knowledge and experience of other potential confounders.

Many of the studies presented in this review are over 5 years old; four of them are now over a decade old. Some of the earlier CPOE studies assessed home-grown systems in large academic centres [12,31,33,42,43]. They played an important
Table 5 – Summary of pathology indicators used in CPOE evaluations

<table>
<thead>
<tr>
<th>Stage of the pathology process</th>
<th>Area of impact</th>
<th>Measures used</th>
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<tbody>
<tr>
<td>Stage 1</td>
<td>Test volume</td>
<td>Number of tests per patient per day [2,42,43,45]</td>
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<tr>
<td></td>
<td></td>
<td>Number of tests per patient/admission [32,33]</td>
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<td>Number of tests per DRG [48]</td>
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<td>Number of tests per physician [44]</td>
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<td></td>
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<td>Number of tests per week (total and for frequent tests) [46,47]</td>
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<td>Number of tests per day [37]</td>
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<td>Total number of tests for a period [32,37,46]</td>
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<td></td>
<td>Test costs</td>
<td>Total direct laboratory costs [43]</td>
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<td></td>
<td></td>
<td>Pathology test costs per admission [31–33]</td>
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<td>Total costs of tests for period [32,45]</td>
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<td></td>
<td>Redundant test rates</td>
<td>Redundant tests rate/total number of tests [36]</td>
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<td></td>
<td></td>
<td>Number of discontinued tests per day [37]</td>
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<td></td>
<td>Compliance with guidelines</td>
<td>% of patients who require a test that actually have the test [44]</td>
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<td>Rate of physician compliance with suggested corollary orders (immediate, 24 h, hospital stay) [12]</td>
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<td></td>
<td>Rate of cancelled tests for antinuclear antibodies, rheumatoid factor and complement level tests where decision support is provided [49]</td>
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<td></td>
<td></td>
<td>Order appropriateness [43]</td>
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<td></td>
<td>Work practices</td>
<td>Time spent ordering/requesting tests [31,42], Proportion of physician time spent writing orders/ordering [50]</td>
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<td>Stage 2</td>
<td>Test processing with in the pathology</td>
<td>Number of telephone calls from physician to laboratory [47]</td>
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<td>Physician–laboratory communication</td>
<td>Number of telephone calls from laboratory to physician [47]</td>
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<td>Stage 3</td>
<td>Application of test results</td>
<td>Average time from test order to diagnosis [44]</td>
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<td>Patient management and time following up results</td>
<td>Average time from test order to treatment change [35]</td>
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<td></td>
<td></td>
<td>Average time from availability of critical result until time critical condition resolved [35]</td>
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<td>% of patients with correct diagnosis [44]</td>
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<td>Number of venipunctures per physician [44]</td>
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<td>Time spent following up laboratory tests [42]</td>
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<td>Length of stay and total costs</td>
<td>Mean length of stay [2,12,31,37,45]</td>
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<td>Total charges per admission [12,31]</td>
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<td>Estimated total annual savings [36]</td>
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<td>Adverse events/safety</td>
<td>Number of adverse events and rate per patient (cardiopulmonary event, MI, delirium, stroke, renal insufficiency, acute renal failure, dialysis) [35]</td>
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<td>Proportion of patients with abnormal tests results 48 h following original abnormal test [37]</td>
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<td>Re-admission rate [37,45]</td>
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<td>Rates or number of intensive care transfer [35,37]</td>
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<td>No of returns to operating room [35]</td>
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<td>Mortality rate no of deaths [35,37,45]</td>
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<td>Average maximum serum creatinine [12]</td>
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<td>Average days ventilated per ventilated patient [45]</td>
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<td></td>
<td>Number of pharmacy interventions [12]</td>
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<td></td>
<td>Efficiency of information flow</td>
<td>Turn around time [47,65]</td>
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<td>Laboratory turn around time [5]</td>
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role in foreshadowing the early development of specialised CPOE systems. These studies were very sharply focused on specific wards or units, and displayed a technical novelty side to their investigation. The results from such studies may not be easily generalisable to other hospitals and indeed other countries where processes and preferences are different. In today’s environment, it is the “off the shelf” system that has the potential for wide application [66]. This is particularly as CPOE is more than just a niche computer system replacing handwritten orders, but has direct impact on the entire hospital-wide process of order management [3,16] and is a critical component of the electronic medical record [15].

This review found a number of areas of impact studied across the different stages of the pathology process. Most of
these areas of impact related to the physician decision to order (test volumes, test costs, redundant test rates, compliance with guidelines and work practices) and the application of test results stage (patient management, clinician time, length of stay, adverse events or total costs). Many studies concentrated on some aspect of clinical time or efficiency such as time spent ordering tests or time spent following up laboratory results. Only three studies [5,47,65] looked specifically at turnaround times—a traditional laboratory indicator [61]. We found only one study that used measures associated with the test processing stage. This may reflect the broad assumption that CPOE will virtually eliminate errors that are traditionally associated with the transcription of information on to paper orders (e.g., missing patient identifiers, illegible information, missing signatures). However, CPOE will not eliminate the physician making an inappropriate test choice (although decision support features may ameliorate this to some degree) and may generate its own class of errors by selecting the wrong test from unclear or ambiguous computer generated pick lists.

None of the studies focused on the impact of CPOE on pathology work processes, even though CPOE systems often involve a significant change in work patterns of pathology staff, which may indeed impact on the quality and efficacy of pathology processes. This remains an important area for future research, which would benefit greatly from collaboration between clinicians, pathology laboratory scientists and researchers.

A number of studies looked at areas associated with direct (e.g., adverse events, re-admission rates and mortality) and indirect measures (e.g., time to diagnosis, time to definitive treatment, number of venipunctures, transfer to ICU) of patient outcomes. The results from these studies were inconsistent possibly affected by features of the different systems being compared and the differences in decision support mechanisms incorporated into these systems. Of five studies assessing impact on length of stay, only one reported a significant reduction following the introduction of CPOE for pathology [2]. Of the studies examining effects on patient safety, only one showed an improvement in adverse events/safety following the introduction of reminders for corollary orders [12]. A quasi-experimental study of experienced physicians using a pathology advisory system showed improved time to diagnosis and lower rates of venipunctures [44]. Kuperman et al. [35] showed improved time to treatment and resolution of condition following the introduction of a paging systems to inform physicians about critical results. Outcome measures are often difficult to measure and require large sample sizes in order to detect significant differences. Sometimes, the impact of CPOE is not always immediately apparent. Nevertheless, they remain important to monitor to ensure that new systems do not adversely impact upon patient outcomes and deliver expected benefits.

Most of the studies that looked at the cost benefits of CPOE concentrated on measures from the physician decision to order stage [31–33,43,45]. Nevertheless, all the impact measures summarised in Table 5 have potential cost implications. In some cases, such as changes in turnaround times, and reduction in test errors, the cost implications can be quantified in terms of staff productivity. In other cases e.g., time to treatment, the cost benefit will not be immediately obvious, even though its value for patient care is crucial. It is notable that there is not a comprehensive economic evaluation of the impact of CPOE that brought together a number of the immediate and long-term effects of the system.

Taken together the evidence in this area provides a useful start in evaluating the impact of CPOE on pathology services. Many of the current data come from a few institutions with homegrown systems. There are still many questions that remain to be answered. CPOE has great potential to improve the functioning of pathology laboratories, and for that potential to be realised more research is needed.

## Acknowledgements

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Computerised physician order entry systems and their effect on pathology laboratory services

Computerised orders have done away with cumbersome hand written orders and replaced them with timely and effective results. With everything looking so deceptively rosy, Andrew Georgiou and Johanna Westbrook ask why CPOE implementation is still below par.

Computerised physician order entry (CPOE) systems provide healthcare professionals with the ability to electronically submit orders (e.g., pathology, medications, medical imaging etc) and access test results. These systems replace hand written orders that can be cumbersome and inaccessible and have enormous potential for error. CPOE systems can also provide timely access to patient data, evidence-based clinical guidelines, and other resources, thus contributing to the improved efficiency and effectiveness of patient care.

For pathology services, CPOE systems have the ability to provide the electronic connectivity for “end-to-end” patient care, including the selection of the most appropriate test or investigation and the provision of clinical advice across the spectrum of clinical specialties.

While there has been enormous and widespread support for the implementation of CPOE systems, with strong evidence of their ability to improve the quality of healthcare delivery, their diffusion has remained disappointingly slow, with some of the initial enthusiasm waning particularly with the appearance of reports about the problems, risks and major challenges involved (including unintended consequences).

CPOE systems and the test ordering process

The majority of research into the impact of CPOE systems has focused on high-impact issues like their effect on medication errors. Pathology and medical imaging services have received considerably less attention. Our systematic review of studies investigating the impact of CPOE on pathology services for the period 1990 – August 2004 located only 19 studies containing some form of “control” group including randomised controlled trials, quasi-experimental and before and after studies. These studies investigated different aspects of the electronic ordering process including the impact of decision support systems (such as guideline based alerts, order sets and advice notification) on test volumes, order appropriateness and patient management outcomes.

The findings of this review, along with results from subsequent research reveals that CPOE systems are capable of contributing to major efficiency gains, particularly through improved turnaround times of laboratory test results to clinicians. There are also potential gains to areas of clinical effectiveness using indicators such as test volume and rate of redundant tests. Redundant test rates are widely recognised as one indication of laboratory utilisation that needs to be monitored and improved. The evidence in this area is very positive, showing a reduction in the rate of redundant tests particularly through the use of CPOE with decision support mechanisms to improve compliance with guidelines and order appropriateness.

The evidence of electronic ordering and electronic decision support (EDS) on the quality of patient care is not as strong, reflecting the difficulties involved in quantifying such measures and controlling for the presence of confounders.

Some attention has been given to measuring the time between the issue of a pathology report and the accessibility of the results and response by doctors. In one study, the time taken to reach a diagnosis was found to have varied from one day for doctors using a Laboratory Advisory System to 3.2 days for those that did not. Another study reported that an automatic alerting system for critical results led to a 38% shorter median time interval (1 hour versus 1.6 hours) for the order of an appropriate treatment.
Dynamics of work organisations
There is a growing field of research incorporating organisational studies and qualitative approaches based on interviews, focus groups and observations to examine how CPOE can act as a catalyst to change interactions with a hospital. One of the underlying problems revealed by this literature is that CPOE systems present the order process in a linear way whereby clinicians initiate orders, which are then processed by nurses, pharmacists and pathology departments. In reality the ordering process is not so simple nor straightforward. Indeed, it is a product of collaboration across many professions, affected by diverse influences and sources. This divergence between how CPOE presents the ordering process and the way it is actually carried out has the potential to disrupt previously existing communications and work processes leading to unintended consequences and potential dysfunction.

Using video observation, interviews and focus groups we found that CPOE led to initial confusion among clinicians and laboratory personnel about new responsibilities and changes in work process. For instance, prior to the introduction of CPOE, the laboratory was charged with the responsibility of cancelling unnecessary handwritten text requests (as in cases where a patient has been discharged, or a test was no longer required). This usually meant discarding the unnecessary form into the rubbish bin. But with the new system a cancelled order needs to be performed electronically, otherwise it remains within the system listed as an unfulfilled (possibly pending) order. Laboratory personnel and clinicians reported an initial period of uncertainty about who was now responsible for cancelling these unnecessary orders. The uncertainty (which lasted several months) prompted pathology management to establish a workaround to check outstanding orders and cancel them where necessary. This procedure consumed additional laboratory personnel time but was seen as an important measure to guarantee the integrity of the database and compensate for ambiguity in responsibilities.

Conclusions
Pathology services are a critical component of healthcare delivery. These services consist of unique and complex organisational structures, replete with their own rules and ways of working that are likely to be greatly challenged by new CPOE systems. The current status of available research evidence in this area remains variable. Moreover, it comes from a limited number of sites (many using homegrown systems) that suggest problems of generalisability and transferability of results, particularly as hospitals today are increasingly adopting off-the-shelf systems. There may be no simple formula for the success of CPOE, but there are some key imperatives. These include the adoption of rigorous evaluation methods that provide due attention to pathology laboratories, their specific requirements and tasks, and the crucial role they play as part of the healthcare delivery system.

References
Abstract

Computerised Physician Order Entry (CPOE) systems have been promoted in Australia and internationally for their potential to improve the quality of care. The existing research of the effect of CPOE on pathology laboratories has been variable, pointing to the potential to increase efficiency and effectiveness and contribute to enhancing the quality of patient care on the one hand, while leading to significant disruptions in work organisation with a negative impact on departmental relations on the other hand. In this paper we provide an overview of the research evidence about the impact of CPOE on four areas associated with pathology services; a) efficiency of the ordering process, e.g. test turnaround times, b) effectiveness as measured by test ordering volumes and test order appropriateness, c) quality of care, particularly its effects on patient care and d) work organisation patterns, which can be severely disrupted by CPOE. We discuss the possible ramifications of CPOE and offer three broad, but important recommendations for pathology laboratories, based on our own research experience investigating CPOE implementations over three years. Firstly, pathology laboratories need to be active participants in planning the implementation of CPOE. Secondly, the importance of building a firm organisational foundation for the introduction of the new system that includes openness and responsiveness to feedback. And thirdly, the implementation process needs to be underpinned by a strong commitment to a multi-method evaluation at every stage of the process to be able to measure the impact of the system on work practices and outcomes.

Introduction

CPOE systems allow doctors (and other authorised staff) to enter orders directly into a computer.1 Regarded as an essential building block for the electronic medical record,2 CPOE systems have been promoted for their potential to improve the quality of health care and patient outcomes.3-5 Benefits from CPOE can include improvements in ordering decisions, enhanced efficiency in test processing and increased compliance with evidence-based clinical guidelines.6-8 CPOE systems are high on the implementation agenda for health systems across Europe, the United States and Asia.9-12 These developments have been mirrored in Australia with state and territory health departments embarking on major CPOE implementation projects.13-15

Despite the great enthusiasm for CPOE, their spread within the healthcare system continues to be slow.16 A US survey in 2002 estimated CPOE to have approximately 10% market penetration.16,17 Other findings suggest that smaller hospitals may be particularly resistant to the prospect of CPOE.18 CPOE systems are a costly (and risky) investment,19 in some cases representing the largest single capital investment a hospital is likely to make in a five year period.18 Meanwhile, the attention given to failures of CPOE implementation involving physician resistance to the system,4 the appearance of unexpected errors20,21 and unexpected outcomes, including increased mortality at a paediatric regional referral centre in the US,22 has dampened enthusiasm and raised concerns that implementation processes and systems effects require close monitoring.

The introduction of CPOE systems poses a major challenge for pathology laboratories, which are likely to be among the groups most affected and to experience significant changes in organisational and work relationships.23,24 Research evidence about the impact and outcome of the introduction of CPOE continues to grow, but most of the attention has focused on medication orders where the ability of CPOE to reduce errors has been found to be significant.25,26 Less attention has been paid to pathology services, which together with medication
and imaging orders constitute a major proportion of orders handled by hospitals.

This paper provides an overview of key research findings about the impact of CPOE implementation on pathology services. In doing so we highlight a series of major challenges and tasks that confront pathology laboratory services and provide recommendations for the way forward.

**Areas of Impact**

There are a number of areas where CPOE systems can impact on the clinical/laboratory interface and affect the efficiency, effectiveness and quality of care. These aspects of the pathology ordering process and their intersection with clinical care, and impact on the patient are diagrammatically depicted in the Figure. Decision support mechanisms, including order sets, can facilitate the appropriate choice of tests by doctors and limit the rate of redundant or unnecessary test orders. Access to a broader range of clinical information can help to significantly reduce request errors and improve the laboratory’s capacity to provide accurate results for diagnosis and treatment. In addition, the ability to provide complex evidence based guideline alerts (using information about previous test results, patient characteristics and even available test choices) can also enhance treatment.

**Efficiency**

The most frequently used indicator of efficiency of the pathology test ordering process is turnaround time. Clinical satisfaction with pathology services is often related to the timeliness of test results, because of their effect on treatment particularly in critical care settings. Turnaround time can be defined using a variety of time points, including the times of requesting, collection, laboratory receipt, laboratory registration, laboratory reporting and clinician review. Measurements of the impact of CPOE on laboratory turnaround time (from receipt in laboratory to time of dispatch of result) in an intensive care setting and total turnaround time (measuring request and collection of specimens to their reporting times) for tests in intensive and surgical wards showed improvements after the introduction of the new system. Our own research in this area looked at data for eleven wards in a major teaching hospital during a two month period before and after system implementation. We found a significant decrease in the mean laboratory turnaround time per test assay from 73.8 to 58.3 minutes with significant decreases in turnaround times for prioritised and non-prioritised tests as well as for tests performed during and outside business hours.

While the evidence suggests that CPOE can provide faster results to clinicians, an investigation of the proportion of
time US doctors spend writing orders following CPOE implementation showed a significant increase from 2.1% to 9.0%. Some of this time may be recovered in other areas e.g. through less time taken to schedule tests or in looking for patients. One study looked at telephone activity between the laboratory and a ward after CPOE and found no clear change in the number of calls from the ward, but a decrease in the number of calls from the laboratory to the ward after the system had stabilised. The statistical significance of these findings was not reported.

Effectiveness

Many CPOE studies involving pathology laboratories have concentrated on the impact on test volumes using a variety of measures including the number of tests ordered per patient, per admission or per doctor. The results from these studies have been mixed. Most have reported an overall reduction of test volumes with CPOE, although some (including our own investigation and the only Australian study) reported no change. One US study reported major increases of up to 50% in the number of laboratory orders per patient per Diagnosis Related Group after the introduction of CPOE. However, this study did not provide a statistical measure of the significance of this result.

Redundant test rates (unnecessary diagnostic tests) are often seen as a modifiable component of laboratory utilisation, and as an important area for potential improvement following CPOE. One study by Bates et al. showed that CPOE led to a reduction in the redundant test rate, while Neilson et al. reported improvements in test ordering behaviour using CPOE reminders complemented by peer management. Other research has shown improvements in test order effectiveness drawing on the ability of CPOE decision support mechanisms to bring about improved compliance with guideline advice, or order appropriateness. Our own research showed that structured order screens and the manipulation of order sets enhanced the data provided to laboratories and the corresponding quality of test result information reported back to doctors, which may lead to improved patient care.

Quality of Care

Research papers about the impact of CPOE on the quality of patient care have been less numerous. Indicators of the quality of patient care are difficult to quantify and require large sample sizes to detect significant differences. Moreover, studies that look at indicators such as mortality rates and patient length of stay are prone to the effect of confounders.

There are some studies that have examined the impact of CPOE on time to treatment and diagnosis focusing attention on the interface between the time pathology laboratories issue reports and the accessibility and response to these results by doctors. One of these studies measured the impact of a computerised decision support Laboratory Advisory System on the time taken to reach a diagnosis. It found that the time taken was one day for physicians that used the system and 3.2 days for those that did not. Another study compared a computer system that automatically notified the responsible physician of a crucial condition via the hospital’s paging system. The authors reported a significant 38% shorter median time interval (1 hour v 1.6 hours) until an appropriate treatment was ordered when the automatic alerting system was used compared to when it was not used. This is an important area of study that requires wider consideration and attention.

A study carried out in the UK which investigated the impact of ward computers allowing access to laboratory results found a large proportion (45% for accident and emergency and 29% for inpatient wards) of urgent laboratory test results were never accessed. Of those results never accessed 3% were judged to require an immediate change of patient management.

Work Organisation

CPOE developed as home-grown systems are often reliant on the expertise of enthusiastic hospital IT departments and the backing of clinical champions and senior hospital management. In today’s environment CPOE is often an “off the shelf” system designed for wide application across hospital, regional and international boundaries. Such “vendor-developed” systems are not tailor-made and may have difficulty adapting to different environments. CPOE is no longer a niche system geared for the hi-tech enthusiasts but is targeted for widespread application and as such has major implications for hospital-wide processes of order management, work organisation and departmental relationships.

Studies of the impact of CPOE on organisational processes have shown that in some cases CPOE has the capacity to foster greater communication between clinicians, and across departments. This is often credited to the system’s ability to make information easily accessible across hospital departments with clear audit trails which can contribute to increased levels of accountability and reliability. At the same time CPOE implementation has been attributed as the cause of internal organisational conflicts. Our own research using focus groups and interviews recorded many laboratory staff feeling that the implementation of the new CPOE system had not taken into account their existing work relationships and ways of performing tasks, and had led to feelings of disenfranchisement. A study of the impact of CPOE by Dykstra using participant observation, focus groups and oral history techniques, found that a lack of accessible information about the implementation of the new system had placed stress on existing communication channels between staff across the
hospital, a situation that he suggests can lead to an erosion of morale. Other researchers have noted that changes in responsibility for tasks like “data entry” and the responsibility for the detection and correction of errors, can affect the sense of collaboration and trust within the hospital.

Many researchers have also highlighted the ability of CPOE to disturb traditional patterns of work organisation and disrupt previous work routines. The changeover to doctors placing electronic orders represents a major structural change in workflows with consequences across departments. This has led many to conclude that the challenges in implementing CPOE lie more in organisational than technological factors. One of the underlying problems identified with CPOE systems is that they conceptualise the order process as essentially linear where doctors initiate orders which are then processed by nurses, pharmacists, pathology departments etc. But the ordering process is far from linear; like patient care it is a product of collaboration across many professions, and the source of decisions may come from diverse influences and sources. This potential discrepancy between the way CPOE conceptualises the ordering process and the way it is carried out within hospitals, has prompted some to warn that CPOE implementation has its ups and downs, and hospitals need to be prepared to expect the unexpected.

Challenges for Pathology Services

There is a large and expanding list of research, opinion pieces and guidelines commenting on what is needed to achieve successful application of CPOE. They come from a mixture of academic, management-focused and policy institution sources. This literature provides a broad overview of the implementation process drawing on wide field experience and research. It is beyond the scope of this paper to summarise their findings and success factors. We do however present three broad (and interconnected) recommendations, which we offer not as a “solution” or “recipe for success”, but as a synthesis of some important lessons that have emanated from our experience investigating the impact of CPOE and pathology services in Australian hospitals.

Inter-department Functions

Over the past decade a substantial body of research about implementation of major Information Communication Technology (ICT) systems like CPOE has sought to overcome the one-sided technological approach where pre-existing organisational needs are expected to be reconciled to a technological solution, and implementation is seen primarily as a “technology roll out” devoid of any organisational issues. Pathology services are an integral and essential part of clinical service delivery and are made up of complex organisational structures with their own formalised rules, conventions and ways of working that have developed and evolved over time. It is often these structures, underlying assumptions and work behaviours which CPOE systems confront. Sometimes traditional ways of working are challenged by a commercial CPOE system developed in a foreign country using different assumptions about how work processes are undertaken. This can become a problem if the site is not adequately prepared for the changes or if pathology departments are given secondary or ancillary roles in the implementation process. Our research and field experience demonstrates that pathology departments must be centrally involved in the implementation process if these systems are to bring about improvements in efficiency and effectiveness. Successful implementation should become synonymous with the building of new relationships and improved levels of collaboration across the hospital. Formal communication channels between multi-disciplinary groups which support timely problem-solving as issues arise are crucial. Professional silo-based decision-making processes or two-way communication processes between IT staff and each professional interest group will not be sufficient to effectively solve the issues likely to arise.

Organisational Dynamics

The changeover to direct physician order represents a major change in the order management process with major implications for clinicians, laboratories and other services. The impact of CPOE on pathology laboratories can vary. There is an underlying tension between the potential for computer systems to either decrease interpersonal interaction (e.g. through greater access to remote terminals), or to promote integration with the ability to allow greater access to shared information. These tensions can lead to increased levels of task uncertainty or ambiguity, forcing staff to find new ways to incorporate changes into their daily work possibly accompanied by either co-operation or conflict.

Our research identified a number of areas where CPOE had contributed to shifts in organisational dynamics leading to changes in work practices and processes and the adoption of workarounds by laboratory staff to adjust to the new conditions. At one site clinicians and laboratory scientists reported that the new CPOE system created uncertainty about where responsibility for the cancellation of test orders as in cases where a patient has been discharged or a test is no longer required. Previously, when the laboratory carried out this function; it meant binning the redundant hand written requests. But with the new system a cancelled order needs to be performed electronically, otherwise it remains listed within the database as an unfulfilled order. Clinicians and laboratory staff reported an initial period of task uncertainty about who actually performs this task. This uncertainty prompted the laboratories to establish a workaround procedure to check all
outstanding orders and cancel them where necessary to ensure
the integrity of their database. For the laboratories this was a
way of compensating for the change in task responsibilities,
but also added to their workload.76

Even routine test ordering processes can be disrupted by the
new electronic system. For example, an add-on test occurs
when a clinician requires an additional test assay to be carried
out on a specimen that has already been delivered to the
laboratory. This used to be achieved by a phone call and a
new handwritten request signed and faxed to the laboratory.
However, with electronic ordering it is not always clear how
this procedure is to be carried out, or even if the new CPOE
system is able to cope with add ons. At one of our study sites
the CPOE system treated an add on as a new test order which
led to confusion and frustration in the laboratory, forcing
the hospital to revert to the previous status quo where doctors
were required to phone and then fax signed hand written
requests for add ons.77

It may be, as Aarts et al. assert, that the complexity and
unpredictability of socio-technical factors involved with
CPOE means that there is no simple formula for successful
implementation of the system.71 Certainly, any proposed
implementation must start with a recognition and under-
standing of the enormous challenges involved.24 This
implies the existence of a firm organisational foundation
for implementation with leadership that is open and
responsive to feedback62 and which strives to accentuate the
negotiating process by incorporating different communities,
interdisciplinary groups and departments.78

Evaluation Processes
The implementation of CPOE systems can benefit from an
ongoing commitment to evaluation of the system’s progress.
This requires attention to the functions of the system in
planning, development, implementation and operation.79
Performed rigorously, evaluation will provide important
feedback for decision makers and users who have much to
gain from data that can inform and guide decision making.80

Evaluation studies can differ widely according to the subject,
target or purpose of the study, and even to the perspective
and design and methods employed.81 The choice of evaluation
target will be influenced by the question being asked. In the
outline of efficiency and effectiveness detailed earlier, the
quantitative measures used are most suitable for establishing
the size, extent or duration of a certain phenomenon, generally
to work out how much (if any) of an effect was experienced.82
Table 1 provides a list of some key indicators which can be
used to measure the impact of CPOE on laboratory services.
This list is not exhaustive but does provide a starting point.

Qualitative research methods include interviews, observations
and document analysis. This type of research can help not only
to understand quantitative findings but also to comprehend
what is happening and why.83 Table 2 outlines ten important
questions that we found valuable to ask in the lead up to and
during CPOE implementation.82,84

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<th>Table 1. Key indicators of the impact of CPOE on pathology services.</th>
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<td>Test volumes (e.g. number of tests per patient, per day)</td>
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<td>Test costs (e.g. cost of tests per admission)</td>
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<td>Redundant test rates</td>
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<td>Order appropriateness (e.g. compliance with guidelines)</td>
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<td>Telephone calls (e.g. from laboratory to ward or vice versa)</td>
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<td>Turnaround time (e.g. laboratory turnaround time or total turnaround time)</td>
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<td>Time to treatment (average time from test order result to diagnosis or treatment)</td>
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<th>Table 2. Ten important questions to ask about the new CPOE system.</th>
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<td>What does the organisation/department expect to gain by introducing the new system?</td>
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<td>Who wants or needs this new technology and why?</td>
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<td>Which groups are most involved in the decision making about implementation and use?</td>
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<td>Will the system be technically compatible with current systems in use?</td>
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<td>Can it be tailored to fit the specific needs of professionals?</td>
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<td>How will the benefits of the new system be measured?</td>
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<td>What changes to work practices and processes are required?</td>
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<td>Are the lines of accountability for dealing with expected and unexpected problems clear?</td>
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<td>What are the drawbacks and risks of system implementation?</td>
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<td>Are they being addressed, and are there safeguards for dealing with problems?</td>
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Conclusion
Pathology laboratory services are likely to be significantly affected by the shifts in work patterns and relationships imposed by the introduction of new CPOE systems. There are a number of imperatives involved in the successful implementation of CPOE, including the participation of pathology laboratory services in preparing for the introduction of the new system, and involvement in the negotiations which will shape the new system. Multi-method evaluation techniques designed to provide timely and reliable data about the impact of the new system are critical to informing the decision-making process. In and of themselves, these strategies do not amount to a recipe for success. They do however provide a sound platform for dealing with the challenges and enhancing the potential of CPOE systems to deliver improvements in work practices and outcomes.

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