Evaluation of IT modernisation in the NHS

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Executive summary

1. Background

Capturing information accurately, communicating and using it promptly to improve the effectiveness and efficiency of health care, is central to the UK Government's vision to modernise the NHS. It has been widely assumed that these goals will benefit patients, health care professionals, managers and planners in the NHS.

The Government's plans for NHS modernisation have evolved over time, from electronic 'patient' and 'health' records to a unified National Programme for Information Technology (NPfIT) with the creation of Connecting for Health to manage the programme. This evolution included a fundamental policy change from delegation of responsibility for implementing IT modernisation to local NHS organisations, to a policy of centralised specification and procurement.

The size and complexity of national programme make it the largest outsourced IT project from the public sector ever untaken. In view of previous difficulties in implementing large scale health service IT projects, progress in achieving the National Programme became a key focus of interest of this project.

2. Objectives

Following the changes to government policy, our revised objectives were to:

1. Describe the context for implementation of the NPfIT in England, examining actual and perceived barriers, and opportunities to facilitate implementation.
2. Explore how new IT applications are experienced by end-users (NHS staff), describing any impact on working practices.
3. Estimate quantitative effects of implementing specific IT applications proposed by the NPfIT.
4. Review evidence about the cost-effectiveness of IT systems in health care.

3. Methods

The study sample consisted of four NHS Acute Trusts. We used a combination of qualitative and quantitative methods to address our objectives, making comparisons both within and between organisations. We used review methods to summarise existing evidence for objective 4.

A qualitative researcher interviewed a range of stakeholders involved in implementing and using IT applications, and addressed objectives 1 and 2. Two levels of interviews were conducted in three stages. Level 1 interviews (objective 1), took place between July and October 2004 (stage A; n=24); and between February and April 2006 (stage A; n=25). Level 2 interviews (objective 2) took place between January and October 2005 (n=44). Baseline information was also collected for each study site data.

Level 1 interviews investigated (a) the influence of contextual factors (historical or current, facilitators or barriers) on the implementation of IT applications, and (b) the impact of recent Connecting of Health policy changes on implementation processes. Level 2 interviews investigated (a) experiences of NHS staff of specific IT applications (electronic test ordering and browsing, or computerised physician order entry, CPOE; electronic booking; picture archiving and communication systems, PACS), and (b) the impact of these applications on working practices. Interviews were semi-structured on a one-to-one basis and took about one hour. Interviews were taped and transcribed.

We applied a modified grounded theory analytic strategy to present an analysis of processes over time. This strategy combined drawing on the literature on organisational change, and more user-centred sociological theories of innovation adoption and implementation, with themes emerging from the data.

The quantitative research used a quasi-experimental ‘controlled before-and-after’ design to quantify the effects of implementing CPOE and PACS. Indicators were compared between trusts that did and did not implement these IT applications during the period 2000 to 2005, taking into account data for a baseline period prior to implementing changes. Indicators were also compared within Trusts between specialties that did and did not implement the applications during the same period.

To estimate the effects of CPOE, we considered three tests: full blood count, urea and electrolytes, and urine culture. For PACS, we considered three radiological modalities: plain film X-ray, computed tomography (CT), and ultrasound.

Indicators were derived from a large set defined *a priori*, based partly on the NHS Efficiency Map and were classified as primary or secondary depending on the plausibility of a direct causal pathway between implementation and the outcome.

We analysed inpatient and outpatient data from the Commissioning Data Set (CDS) for 2000 to 2005, linked with data about target pathology and radiology tests carried out during the same period. Secondary outcomes were derived directly from the CDS data. Individual patient data were analysed for specialties common to all four trusts. Effects were estimated by multiple regression modelling, calculating robust standard errors to take into account clustering of records within trusts and specialties.

4. Findings

Implementation of the NPfIT did not progress as expected during the study period. Findings from Level 1 of our qualitative study were able to track the impact of this delay on the trusts.

CPOE and PACS applications were also implemented infrequently during the project. Three of four Trusts implemented aspects of PACS system, but only one Trust implemented a 'full' PACS. Two Trusts implemented CPOE but, in one trust, the system was so poor it was hardly used so, in effect, had not been implemented. None of the applications studied were officially compliant with the NPfIT.

Our quantitative and qualitative evaluations of PACs and CPOE were constrained to some extent because implementation of IT applications was not as widespread as expected when the research was commissioned. Nevertheless, our findings provide useful lessons as the roll-out of IT modernisation in the NHS gathers pace.

4.1 Qualitative findings: Level 1 – Implementation of NPfIT at local level

Stage A interviews, with senior managers and clinicians, highlighted four key issues:

(a) Trusts varied in their circumstances, affecting their ability to implement the NPfIT.

(b) The process of implementing the NPfIT was suboptimal, leading to low morale among NHS staff responsible for implementation.

(c) The timetable for implementation was unrealistic, causing uncertainty. Renewing Patient Administration Systems (PAS) was a bottleneck and this rate-limiting step could not be reconciled with targets for implementing substantive IT applications.

(d) Short term benefits of IT modernisation are unlikely to be sufficient to persuade NHS staff to support the programme unreservedly.

These interviews were too early to assess the success of the NPfIT but demonstrated concern among interviews about the process of implementation.

In stage B, senior managers and clinicians felt that the NPfIT is a highly desirable objective. Interviewees were enthusiastic about, and supportive of, the goals of the NPfIT but still had serious concerns, several of which were the same as before.

Continuing uncertainty was making key managerial decisions about IT implementation more difficult, given the current need to make financial savings and achieve efficiencies. Although IT modernisation should facilitate these goals in the longer-term, senior managers still did not know: (a) what the local costs of implementation will be; (b) when a replacement patient administration system compliant with the programme will be available; (c) the timetable for delivery of interim applications; (d) the features of these applications; (e) the likely benefits and efficiencies from new systems.

These uncertainties made it difficult to prioritise local implementation of the NPfIT. Concern was expressed about threats to patient safety from a ‘patch and mend’ approach to maintain existing systems. Trust managers wanted concrete information about implementation timetables, system compatibility with the long term goals of the programme, value-for-money and better communication with Connecting for Health.

4.2 Qualitative findings: level 2 – Process and impact of implementation of PACs and CPOE

We found four factors which influenced the adoption of CPOE and PACS:

(a) The attributes of the application; the speed, ease of use, reliability and flexibility of the application were key issues.

(b) The characteristics of the adopter; these were most important early during implementation and persuading users who were unfamiliar with IT was a challenge.

(c) Implementation processes; user consultation during implementation, the quality of training and IT support; and creation of a 'critical mass' of benefit were crucial to their use.

(d) organisational factors; the most important were that the designers and implementers of the application understood the business process which the IT was supporting, availability of a strong project management team with high level management support, good team working within and between departments and the ability of the organisation to work as a whole.

The perceived impact of IT innovations varied according to the specific application, how they had been implemented, and relate to patient experiences, working practices and safety/governance. In all cases, interviewees reported positive and negative examples in these areas but, overall, for PACs in all three Trusts and CPOE in one Trust, the positives appear to outweigh the negatives. Very little formal measurement of these consequences was carried out by the Trusts. These consequences are important, not least because the perceived positive and negative impacts of the application influenced its continued use and wider adoption.

4.3 Quantitative findings: Impact of implementation of PACs and CPOE

The size of the effects estimated for primary outcomes, e.g. a change in the volume of test ordering of 10 to 20%, was certainly potentially important, in that such effects would have major implications if observed across the NHS during roll out of the NPfIT. However, there were challenges in distinguishing real effects from background variation and in attributing effects to CPOE or PACS.

The main effects of CPOE were to reduce the proportion of patients who had any pathology test at outpatient appointments and the number of patients who had the same test at their next outpatient appointments. These effects were observed to a greater or lesser extent for all tests that were investigated. These effects are also plausible. For some tests, CPOE also reduced the proportion of inpatients having pathology tests but this effect was not consistent between and within trusts.

Similar effects were observed when PACS was implemented with respect to repeat plain X-ray films and ultrasound scans on subsequent visits. However, there was no consistent effect on the overall proportion of patients who had a plain X-ray film, CT or ultrasound scans at outpatient appointments.

Various changes in secondary outcomes were observed but could not be attributed confidently to implementation of CPOE and PACS. There appeared to be a consistent reduction in the proportion of patients discharged at outpatient appointments after both applications were implemented.

5. Future research agenda

This study has shown that it is possible to use routinely collected patient-level data as a basis for assessing the impact of technological changes on indicators of clinical activity and operational efficiency. Our technique of joining CDS data with these specialist datasets could form the basis for operational research in the UK NHS on a nationwide scale. Our study also shows that smaller studies, designed to measure effects at a much finer level of detail, are also necessary to understand fully the impact of IT systems in health care.

The importance of studying a large number of trusts should not be underestimated; this will improve statistical precision but, more importantly, will allow variation between implementing and non-implementing trusts to be estimated much better. It is important that future studies of the impact of IT modernisation include qualitative analyses of the implementation process, in order to understand what the quantitative data are indicating. Multiple case studies, such as this one, provide useful analyses, both within and across case studies. Longitudinal studies are important in studying implementation processes and, when implementing complex innovations in large organisations, studies need to be conducted over at least 5 years.

Development of appropriate outcome measures is one example of how qualitative and quantitative methods should be combined. One way to choose outcomes is to study indices which are available, easily derived from routine sources or which are expected to change for reasons of face validity. A second approach is to choose outcomes on the basis of feedback from users experienced with IT applications, to reflect aspects of service delivery which users consider important to their ways of working and which they believe are influenced by IT modernisation.

One major evidence gap is the absence of high quality evaluations of the economic implications of implementing organisation-wide IT applications. There is an urgent need for better evaluations of the economic and financial consequences of IT

modernisation to help plan implementation but it is not clear that conventional methods are applicable to such large scale and complex interventions. In planning future economic evaluations, we recommend that, researchers should: (a) be clear about the exact question that needs to be addressed; (b) define precisely the nature of the intervention; (c) study and value health as well as resource consequences of IT implementation; (d) study the transition from the existing method of providing health to the new method based on the innovation being studied; (e) study the intervention for long enough to describe longer term effects.

This study has taken place at the very beginning of the process of implementing a national IT system at local level. However IT policy develops in the future, it will be important to continue to study the processes of implementation and the impact they have on organisations, teams, and patient care.

6. Implications for a national IT system

An important lesson from our study is the difficulty in achieving an appropriate balance of responsibility between government and local health care systems. Devolving control of IT to local managers results in a lack of standards, and disparate functionality. However, with central control, the sheer size of the task makes communication and realistic goal setting difficult. The NPfIT has not made the progress that was expected and senior NHS staff warned of the continuing challenges ahead. The process of implementation needs to change rapidly for NHS staff to feel optimistic and to embrace IT changes with enthusiasm.

A third strategy is now in place, setting central standards but with local implementation. The role of Connecting for Health is shifting from implementation towards providing a national infrastructure and standards-setting body. Implementation will be devolved more locally. Even with these changes, the issues raised in our study still need to be addressed. Connecting for Health still needs to involve local end users in discussions about the form the national infrastructure and national standards; these should not be imposed. Further, devolving responsibility for implementation locally raises questions about the degree of local customisation permitted. We found that local customisation is an important factor in successful adoption. However, too much customisation might weaken national standards and

the ability to pass data between providers. Finally, a national infrastructure needs to help trusts to prioritise IT modernisation against competing financial pressures, e.g. by its inclusion in performance management frameworks. New plans need to be communicated throughout the NHS with clear timetables to end the uncertainty.

7. Implications for local implementation of IT innovations

Both studies, of NPfIT implementation at local level and end users' views of specific IT applications, have implications at the local level in the NHS. The importance of the attributes of the innovation, characteristics of the adopter, implementation processes, and organisational factors need to be addressed.

The CPOE application in one Trust, and the PACS in another, were considered by managers and end-users to have been successful implementations, preceding by several years the roll-out of similar applications under NPfIT. It is possible that CPOE and PACS, when fully integrated with the other IT systems which comprise NPfIT (national electronic health records, PAS, electronic booking, etc), will contribute to more dramatic quantitative changes.

In the longer term, the issue of where responsibility for local implementation lies, at national or local level, remains. In the meantime, evidence to support the procurement and implementation of IT systems by health care providers falls far short of that required to inform changes in clinical practice by these same providers.

8. Conclusions

This study is one of the few carried out on the early stages of implementation of the national IT programme for the NHS in England. It provides useful insights into the challenges of attempting this very ambitious programme, from the perspective of the local level. It also provides data on the processes and impact of implementing specific IT applications on a scale not achieved before. The study has significant implications for the future direction of NHS IT policy. We have also raised important methodological issues for future studies of large scale IT implementation in health care.

Contents

Table of abbreviations

Abbreviation	Description of abbreviation
A&E	Accident & Emergency
ADE	Adverse drug event
AHP	Allied health professional
CDS	Commissioning Data Set
CfH	Connecting for Health
CPOE	Computerised physician order entry (USA); electronic test ordering and browsing (UK)
CPRS	Computerized Patient Record System
CRS	Care Record Service
CT	Computed Tomography
DoH	Department of Health
DOI	Diffusion of Innovations
EHR	Electronic health record
EPR	Electronic patient record
EMR	Electronic medical record
ERDIP	Electronic Record Development and Implementation Programme
FBC	Full blood count
GP	General Practice
HES	Hospital Episode Statistics
ICP	Integrated care pathway
IT	Information Technology
ITU	Intensive therapy unit
IM&T	Information Management and Technology
LIS	Laboratory Information System
LoS	Length of Stay
LSP	Local Service Provider

Abbreviation	Description of abbreviation
MIT	Massachusetts Institute of Technology
MeSH	Medical Subject Heading
NCRS	NHS Care Record Service
NHS	National Health Service
NPfIT	National Programme for Information Technology
NPV	Net Present Value
NSF	National Service Framework
NSW	New South Wales
NWCS	NHS-wide Clearing Service
PACS	Picture archive and communication system
PAS	Patient Administration System
PC	Personal computer
PCIS	Patient Care Information System
PF	Plain Film
RIS	Radiology Information System
RCT	Randomized controlled trial
SUI	Serious untoward incident
UC	Urine culture
UE	Urea and electrolytes
US	Ultrasound
VA	Veterans' Affairs
VISNs	Veterans' Integrated Services Networks

1. Introduction

1.1. Original conception of the project

Capturing information accurately, communicating and using the information promptly to improve the effectiveness and efficiency of health care, is central to the UK Government's vision of modernising the NHS.[1] In the White Paper published in 1998, *Information for Health*, IT modernisation was described as focusing on the establishment of high quality information systems within institutions, to capture data "describing the record of periodic care provided mainly by one institution", i.e. the electronic patient record (EPR). Implementation of EPRs is a crucial step towards the longer term goal of electronic health records, which will provide "a longitudinal record of patient's health and health care – from cradle to grave."[1]

The White Paper identified five key functions of EPRs:

(a) Electronic booking (out-patients, elective surgery and emergency referrals);
(b) Electronic ordering of tests and investigations and electronic access to, or 'browsing' of, test results (i.e. described here as "computerised physician order entry", or CPOE, following the North American literature);
(c) Electronic communication within and between acute Trusts and between secondary and primary care sectors;
(d) Prescribing (e.g. automatic prescribing /dispensing of medications specified in discharge summaries);
(e) Picture Archive and Communication Systems (PACS; providing the same the functions as electronic ordering of tests)

At this time, EPRs were considered to bring benefits to patients, health care professionals, managers and planners in the NHS. **Table 1** describes our original framework setting out potential quantifiable consequences of implementing EPRs and the potential benefits of these consequences for the different groups. Additional potential benefits span these functions, for example:

- Electronic integrated care pathways (ICPs): more effective clinical management through implementation of structured care pathways, improved Clinical Governance, high quality data to demonstrate these benefits.
- 'Seamless' care: secure but accessible information to all caregivers involved in health care delivery.

- Automated and secure audit trail for decisions, using electronic fingerprints/signatures.
- More accurate, and more readily available, information for planning and performance monitoring purposes locally; more accurate data returns for national purposes achieved more efficiently.

Our original aim was to evaluate the implementation of electronic patient records (EPRs) in four main areas: processes; consequences, both intended and unintended; the associated costs and savings of the processes and consequences; lessons for future implementation. We described two specific objectives:

(a) To evaluate the consequences and costs/savings of implementing EPRs in a range of secondary acute Trusts;

(b) To evaluate the processes and impact of implementing EPRs on the organisation, all levels of staff and patients.

Information for Health required all acute Trusts to implement EPRs.[1] At the time of finalising the project in 2003, the target date for achieving full implementation was rescheduled to December 2007,[2] with the Government acknowledging that EPRs had "not yet been adopted on a national scale". At the time, we saw a clear opportunity for the study to identify important lessons for implementation. EPRs were also being implemented in "different ways" across acute Trusts. Some Trusts had the advantage of 'new build' projects, which allowed the 'hardware' and 'software' infrastructure for EPRs to be installed in an optimal fashion. Other Trusts were establishing EPR functionality by modifying existing IT systems.

1.2. Changes to the conception of the project

In November 2003, the SDO agreed that changes to the project protocol were required. These changes were needed because the government's original plan for implementing electronic patient records (EPRs) in the NHS (on which our application and original objectives were based)[1,2] had been abandoned during the period between submission of the application and contracting of the project.

Table 1: Illustrative consequences and potential benefits to patients, health care professionals and managers of implementing EPRs. Adapted from information provided by participating Trusts.

EPR functions (operational change)	**Potential consequences (intended 'benefits') for:** **Patient**	**Professional**	**Manager**
2 Booking (out-patient and in-patient) • patient history available for OP appointments • date and time allocated at time of referral • allow booking of urgent / next day OP appointments • allow emergency admission to ward	• referral at time to suit patient • patient notified of date at earliest possible time • reduce / avoid OP wait • information available for clinical decision-making • avoid A&E wait; more appropriate / timely management	• reasons for referral always available • more timely clinical decision making • referral against agreed protocols reduces time reviewing referrals • clinics scheduled in accordance with protocols • avoid inappropriate admissions • avoid A&E attendances	• reduce time spent by OP staff in searching for patient history, preparation of notes, etc. • fewer missed appointments • reduce administrative time dealing with referrals / bookings • avoid inappropriate admissions • avoid A&E attendance
3 Test ordering and browsing of results (Biochemistry, Pathology, Microbiology, *text* results for Radiology) • tests ordered electronically • test results available electronically	• avoid unnecessary tests • tests carried out more efficiently • avoid duplicate testing • more timely clinical decision making	• reduce time spent ordering tests • introduce ICPs at the earliest point in the patient's care • avoid clinical delay / re-ordering when test results missing • more timely clinical decision making	• reduction in the number of tests and investigations ordered • allows test protocols to be established, e.g. for preadmission • elimination of test order paper forms • reduce re-ordering of tests when results are missing • elimination of paper results
4 Inter-professional communication • 'automated' clinic letters produced 'automatically', with added free text • automated discharge summaries, with added free text	• avoid duplicate testing • information about clinic decisions available to GPs, etc. quicker • information about after-care available to GPs, etc. quicker, with quicker implementation of after-care plan • discharges occur promptly • GPs can implement after-care quicker	• time reduced dictating letters • information quickly available to others, e.g. GPs • time reduced dictating letters • information quickly available to others, e.g. GPs	• less requirement for time of medical secretaries • less requirement for time of junior doctors
5 Prescribing • highlight contra-indications • apply prescribing guidelines, e.g. NSF • co-ordination with discharge plans	• avoid adverse drug interactions • ensures appropriate medication • avoids delay in discharge	• avoid adverse drug interactions • promotes effective and efficient care • reduces time spent chasing / collecting medications	• avoid adverse drug interactions • promotes effective and efficient care • avoids delay in discharge
6 PACS • same changes for radiological images as for other tests, see 2 above	• benefits as for other tests (see 2 above)	• benefits as for other tests (see 2 above)	• benefits as for other tests (see 2 above)

By the spring of 2002, just 3% of trusts were set to meet this target of achieving some EPR functionality.[3] The Treasury's Wanless report in 2002 suggested two main reasons for this: budgets for information technology (IT), allocated locally, were being used to relieve financial pressures elsewhere, and the process of setting of central IT standards was inadequate.[4] The report recommended ring fencing and doubling the IT budget. The government responded with £2.3bn for a new National Programme for Information Technology (NPfIT) in the NHS in England.[5] In November 2003, there were still considerable uncertainties about the NPfIT.

The first progress report for this project covered the period from October 2003 to June 2004. It was extended to cover nine months with the intention that the research team should propose changes to the study protocol in light of (a) the government's emerging new IT strategy and (b) discussions with participating Trusts about how the new strategy would impact on their local plans for implementation of EPRs.

Originally, the government drew a clear distinction between EPRs and electronic health records (EHRs). The former were intended to cover the management and documentation of single health care episodes, whereas the latter were intended to be summary longitudinal records ("cradle to grave") of key health information for individuals. In the NPfIT, this distinction was dropped, with aspects of electronic management and documentation of care integrated and referred to as the NHS Care Record Service (NCRS).

A more fundamental change was the switch from a policy of delegating responsibility for implementing IT modernisation to local NHS organisations, to a policy of centralised specification and procurement.[5] Key features of the NPfIT were stringent national data and IT standards, procured and paid for nationally. Implementation in acute trusts was through one of five geographic partnerships with industry, called "clusters", with IT applications being provided by a local service provider (LSP) for each geographic area contract by the NPfIT through a process of national competitive tendering. The main national features were a new national networking service providing broadband, called "N3"; electronic booking, called "choose and book"; electronic transfer of prescriptions; and a nationally accessible, "cradle to grave" summary patient record called "the spine"(**Figure 1**). The provision of

electronic functions at acute trust level formed part of the NCRS, a collective term for all aspects of clinical IT support applications, from clinical decision making tools to digital X-rays.

The size, complexity, and innovation of the NPfIT made it the largest outsourced IT project from the public sector ever untaken.[6] In view of previous difficulties in implementing large scale health service IT projects, both in the United Kingdom and other countries,[7,8] progress in achieving the NPfIT became a key focus of interest. In 2004, the Department of Health established a new agency, Connecting for Health, with responsibility for managing the delivery of NPfIT.

Figure 1: Elements that make up the National Programme for Information Technology

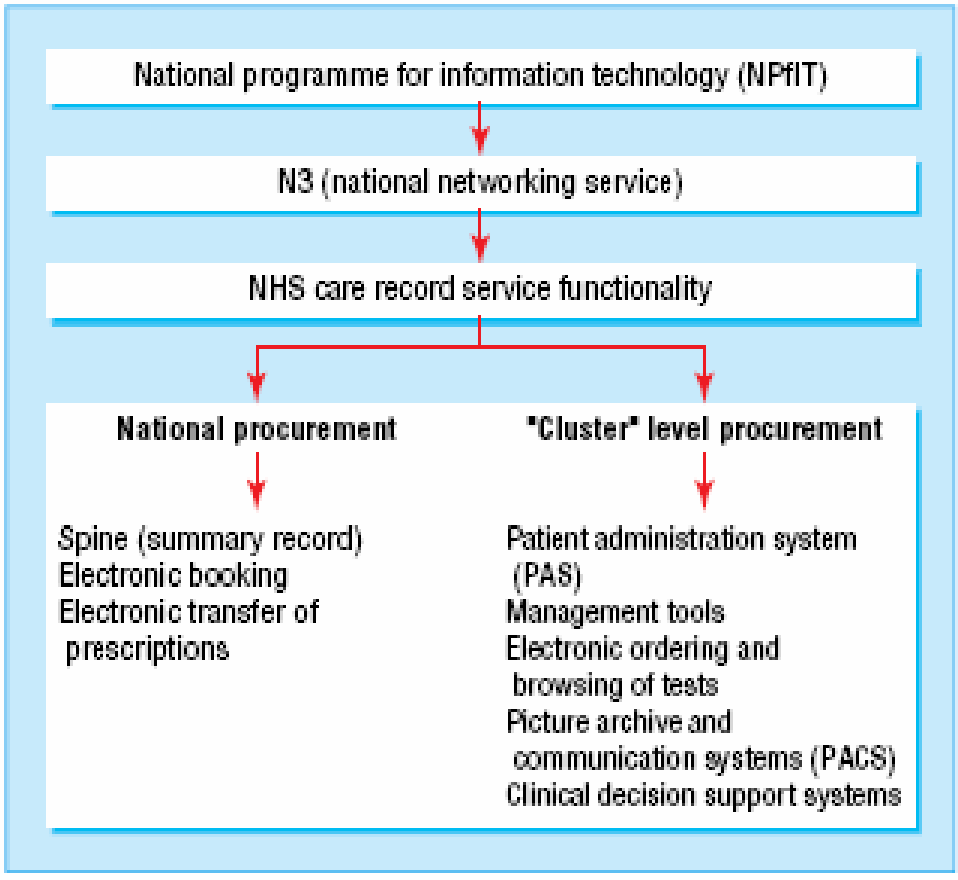


Table 2: Relationship between original and revised protocols

Policy change	Consequence	Plan in original protocol	Revision to study protocol	Impact on study outputs
NCRS implementation is now under the remit of the NPfIT and IT applications are to be supplied via the LSP	Organisational uncertainty	Two levels of qualitative analysis: 1. Staff (use of EPRs) 2. Patients (care process)	Include a third level of qualitative analysis - 1. Management team (organisational context) 2. Staff (use of NCRS) 3. Patients (care process)	Evaluation of the organisational impact of NPfIT policy changes, on NCRS implementation, at acute trust level.
	Low levels of NCRS implementation	Evaluate 5 EPR functions 1. e-booking 2. e-test ordering 3. PACS 4. e-communications 5. e-prescribing	Evaluate 3 NCRS – those functions most widely in place during the study time-frame. 1. e-booking 2. e-test ordering 3. PACS	The reduction in the number of functions evaluated means some macro level (across Trust) analysis will be replaced by micro (within trust) evaluation, both for quantitative and qualitative aspects of the study.
	Low levels of NCRS implementation	Qualitatively evaluate the impact of EPRs on patients by examining two types of patient journey, hip replacement and stroke.	Qualitatively evaluate the impact of e-functions by targeting patients whose care has taken place in areas in which e-functions have been deployed.	Evaluating the process of patient care via specific NCRS e-functions expected to influence care will optimise the probability of capturing change.

NCRS – NHS Care Record Service; NPfIT – the National Programme for Information Technology; IT – information technology; LSP – local service provider; EPR – electronic patient record; PACS – picture archiving and communication system.

Revisions to the study protocol necessitated by the policy change in modernising IT in the NHS are set out in **Table 2**. Our revised objectives were to:

1. Describe the context for implementation of the NPfIT in England, examining actual and perceived barriers, and opportunities to facilitate implementation.
2. Explore how new electronic functionality is experienced by end-users (NHS staff), describing any impact on working practices.
3. Determine any quantitative benefits achieved by implementing specific IT systems proposed by the NPfIT.
4. Evaluate the economic evidence for the cost-effectiveness of IT systems in health care.

1.3. Additional changes during the course of the project

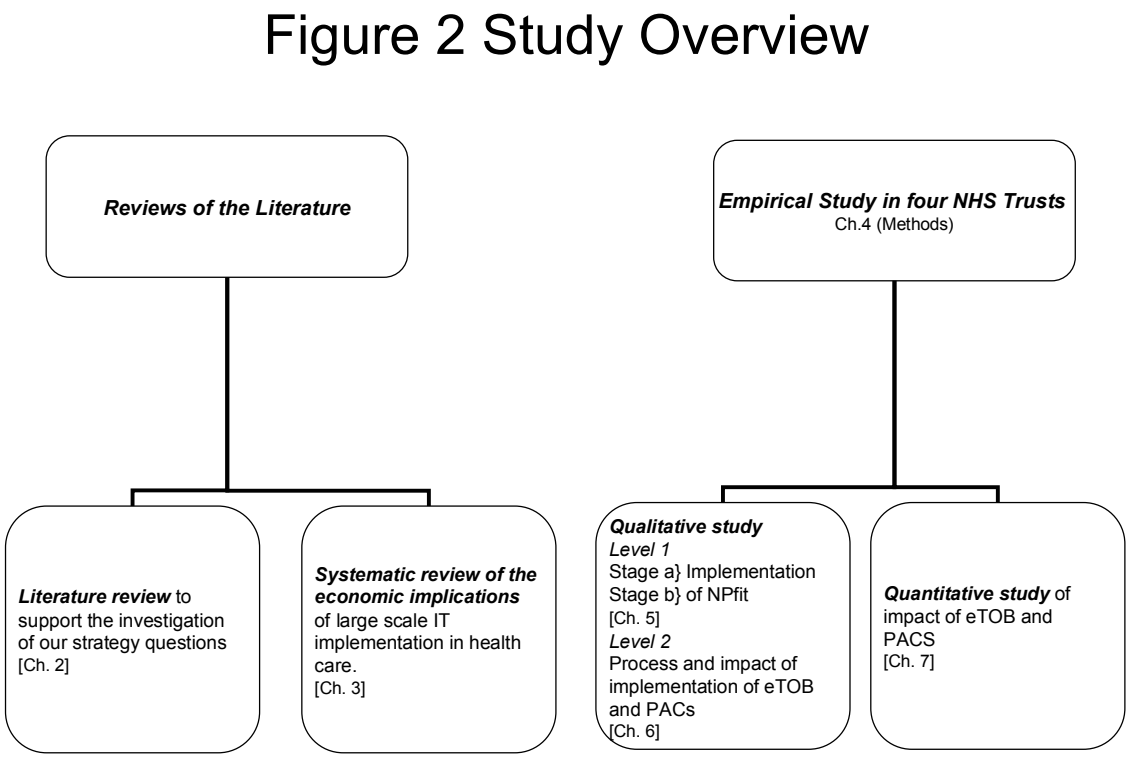
The level of implementation of applications during the course of the project was low (see **Tables 3, 4 and 5**). In the original specification of the NPfIT, IT applications such as picture archiving and communication systems (PACS) and e-test ordering and browsing (i.e. computerised physician order entry, CPOE) at the level of acute trusts were to be founded on new, replacement PAS designed to be compliant with the national IT structure required to make the NPfIT a reality. However, no replacement PAS were installed during the time course of this research project.

Because of the low level of implementation, we had to drop our intention to evaluate the processes and consequences of electronic booking, “choose and book”. Only one trust in our study attempted to implement electronic booking, as a pilot. Unfortunately, implementation was slow due to technical difficulties, a lack of GP buy-in to the scheme, and wider problems with the interface between primary and secondary care. Comments about electronic booking made by interviewees during interviews were noted, but this IT application could not be studied quantitatively.

The switch from a local to national focus meant that our original intention to study the business cases set out by participating trusts to justify the investment required for EPRs was no longer relevant. The creation of the NPfIT meant that the main costs were intended to be shifted from acute trusts to the NPfIT, with decisions about

implementation effectively taken out of the hands of trust boards. Therefore, we decided to carry out a systematic review of economic evaluations of large-scale health care IT implementations to meet our fourth objective, to evaluate the economic evidence for the cost-effectiveness of IT systems in health care.

Figure 2: Study Overview



1.4. Outline of the report

Figure 2 provides an overview of the study. In chapter 2, the literature to support our study is reviewed. In chapter 3, we report the methods and findings of the systematic review of the economic implications of large scale IT implementation in health care. In chapter 4, we describe the methods used for the qualitative and quantitative empirical elements of the study. Chapter 5 presents the findings of 'level one' of the qualitative study analysing the implementation of the NPfIT at two different points in time. In chapter 6, we present findings from 'level 2' of the qualitative study on the implementation of specific IT applications. Chapter 7 presents findings from the quantitative study of the impact of the implementation of PACS and CPOE. Finally, in chapter 9, we summarise and discuss our findings, suggest implications for policy and practice, and areas for future research.

Table 3: Implementation of Patient Administration Systems (PAS) during the project. Unshaded cells represent the "before" implementation period, light shaded cells the "during" period and "dark" rows the "after" period.

	Trust 1		Trust 2		Trust 3	Trust 4
	Site 1	Site 2	Site 1	Site 2	Single site	Single site
2000	PAS type A	No PAS	PAS type B	PAS type C	PAS type D	PAS type E
2001						
2002						
2003			PAS type F	PAS type F		PAS type G
2004						
2005						

All sites had a trust-wide PAS in 2000 except for Trust 1. Site 2 of Trust 1 had a legacy system which did not include all patients and which did not operate in 'real-time'.

Trusts 2 and 4 implemented new PAS in 2003.

Table 4: Implementation of Picture Archiving and Communication Systems (PACS) during the project. Unshaded cells represent the "before" implementation period, light shaded cells the "during" period and "dark" rows the "after" period.

PACS	Trust 1		Trust 2		Trust 3	Trust 4
	Site 1	Site 2	Site 1	Site 2	Single site	Single site
2000	RIS only	None	PACS type A, part only	RIS only	RIS only	RIS only
2001					PACS type B, part only	PACS type C, A&E and orthopaedics.
2002						PACS type C, all other specialties
2003			PACS enhanced, part only			
2004						
2005						

All sites had a radiology information system (RIS) in 2000, i.e. a database for logging tests ordered/carried out, except for Trust 1. Site 2 of Trust 1 had no RIS.

Trust 2 had a PACS only on part of one site. This PACS implementation existed at the start of the study period and remained unchanged throughout, except for an enhancement in 2003 to allow web viewing. Trust 2 attempted to implement a new system for ordering radiology tests in 2002 but this was not successful and the system remained predominantly paper-based throughout the study.

Trust 3 opened a new building in 2001 for paediatrics, with a limited implementation of a PACS (less than <10% of the whole Trust)

Trust 4 implemented a new PACS in 2001 in A&E and orthopaedics. This PACS was implemented across the whole trust in 2003.

Table 5: Implementation of e-Test Ordering and Browsing (CPOE) during the project. Unshaded cells represent the "before" implementation period, light shaded cells the "during" period and "dark" rows the "after" period.

	Trust 1		Trust 2		Trust 3	Trust 4
	Site 1	Site 2	Site 1	Site 2	Single site	Single site
2000	LIS only	None	LIS only	LIS only	LIS only	LIS only
2001	CPOE type A		New LIS	New LIS		
2002	Roll-out complete except maternity		CPOE type B (ordering) attempted			
2003			CPOE type B (browsing) attempted	CPOE type B (browsing) attempted		
2004						
2005						

All sites had a laboratory information system (LIS) in 2000, i.e. a database for logging tests ordered/carried out, except for Trust 1. Site 2 of Trust 1 had no LIS. Trust 1 implemented an e-Test on site 1 in 2001. The roll-out of this system on site 1 was completed across all specialties except maternity by 2002.

Trust 2 implemented the LIS component of a larger eTest in 2001 on both sites. Trust 2 attempted to implement the ordering component of a new e-Test in 2002 but this was not successful and the system remained predominantly paper-based throughout the study. Trust 2 implement the test browing component of a new e-Test on both sites in 2003 but this was not successful and the system remained predominantly paper-based.

Trusts 3 and 4 had a LIS only throughout the study period, although Trust 4 had a facility for communicating individual test results to general practitioners electronically.

2. Literature to support the investigation of the study objectives

2.1. Literature search strategies

For the literature review of quantitative and qualitative evaluations of IT systems in health care, an initial search was conducted at the start of project between October 2003 and March 2004. (The literature review for the economic objective was conducted separately at a later date; see **chapter 3**.) After the initial review, additional sources of information (from journals, media sources, conferences and expert contacts) were synthesised into the review as the study progressed.

The review sought to capture evaluations of IT systems in health care and, more particularly, electronic patient records and e-test ordering and 'browsing' of test results (known in the United States as computerised physician order entry, or CPOE). The initial databases searched were: Medline, Web of Science, Embase, Serfile, Sigle, HMIC, Kings Fund and Ulrichs. MeSH and free text words were used in a variety of combinations (with *).

Medline MeSH terms used were:-

- Information Systems
- Medical-Informatics-Applications
- Medical-Records
- Qualitative
- Knowledge
- Attitudes
- Practice

Free text words used were:-

- Electronic patient records
- Computerised patient records
- Electronic health records
- Computerised physician order entry
- Patient administration system
- Master patient index
- Integrated care record system

Specific qualitative literature search terms used were:

- Ethnography
- Phenomenology
- Grounded theory
- Discourse analysis
- focus group
- hermeneutic
- narrative analysis or narrative psychology or narrative method
- human science
- new paradigm
- action research
- co-operative inquiry
- humanistic
- existential
- experiential &
- conversation analysis

The search also included checking references in references lists of papers already identified, identifying main researchers in the field and searching under author names, and searching general internet sites (Google). The articles retrieved included 380 MEDLINE abstracts and 325 Web of Knowledge abstracts. The results of this initial search and subsequent additional sources of information are synthesised below.

2.2. Difficulties in evaluating the impact of EPRs

There is considerable evidence that the implementation of large-scale health service IT projects is extremely difficult to achieve.[9] The problem of achieving interoperability, the cornerstone of any integrated record system, still appears elusive. Hospitals often have small 'own brand' IT systems that will not link to wider networks. The issue of confidentiality and security is another IT problem in hospital medicine that has not been completely resolved[10]. These factors, amongst others, have led to IT implementation failure rates of around 30%, although this may be higher; many negative results are likely to be seen as

politically unacceptable and do not become public.[11,12] This said, examples of UK IT 'disasters', such as the Wessex Regional Health Authority initiative ending in losses to the taxpayer of £43M,[6] and the failed Computer Aided Dispatch Service System for the London Ambulance Service,[13] are not hard to uncover. Managers at the Edinburgh Royal Infirmary, Scotland's flagship hospital, were subject to a political inquiry, with questions raised in the new Scottish Parliament about the cost of the £30m McKesson system that was scheduled to be running in April 2002, and was never put in place.[14] In understanding why the introduction of EPRs in UK Hospitals has proved to be so difficult, and identifying how potential obstacles might be removed, evidence is scarce.[15] Analysis of IT failure is remarkably rare.[12]

Results from economic analyses and randomised controlled trials of 'successful' IT developments are limited, in that they cover a fraction of the total number of health care applications developed, and address a limited number of questions.[16] Two recent systematic reviews assessed the impact of health care IT in general, and the impact of pathology test ordering systems in particular.[17,18] Both reviews concluded that, although the potential benefits of IT in health care remain clear, further research into actual gains is urgently needed.

Our research should inform those responsible for allocating often scarce funds to IT systems procurement, and should help to create realistic expectations about the benefits of these systems, but EPRs are not likely to be a magic bullet. It may take many years of heavy investment before any patient benefits or financial savings are visible enough to be evaluated.[19] Equally, IT can only improve clinical practice in areas where lack of data or poor information processing is the main problem. It cannot magically solve issues of a lack of staff or lack of capacity.[20] Even if quantifiable benefits are demonstrable, this is only half the story. Economic accountability does not mean that end-users accept the system, or maximise the potential of the system in their working lives.[11,21]

IT systems acquisition is not solely a technical and economic choice, nor is it a question of staff persuasion and acquiescence. Even if hospital doctors were offered financial or professional incentives to use computer technology, as has been the case for GPs, the unique complexities of working in hospital medicine presents huge challenges.[22] Medical work is characterised by deep

unpredictability that pre-empts the kind of standardisation and automation found in other bureaucracies and industries.[23] Hospital medicine has complex workflows, job specialisation and a division of labour that creates knowledge-intensive and diverse patterns of information use and record keeping. Yet, if IT is going to support the 'core business process' of health, record keeping routines must be standardised in the first instance.[23]

The difficulty of understanding and managing this organisational complexity, whilst implementing new levels of standardisation, is apparent when examining the spectacular IT failure that occurred in the public health system of New South Wales (NSW), Australia.[9] The essence of this case study concerns the mismatch between the facilities provided, i.e. the new IT system, and the social organisation it was supposed to support.[12] In 1996, the NSW health care system embarked on an IT strategy to achieve better resource management. (The NSW health care system is large by world standards.) After a rigorous selection procedure, a PAS/clinical system was chosen that had been successfully implemented in over 100 sites in the US, and a few sites across Europe. Despite careful system selection, after a period of increasing staff dissent and protest, the system had to be withdrawn. Losses were substantial and took several forms, including considerable financial losses, the considerable distrust generated, and delays in future strategic planning. To uncover what went wrong, a research team interviewed a total of 64 people across five implementation sites. Factors that led to the failure were identified as organisational, cultural and technical. The system did not meet staff expectations in terms of ease of use, flexibility and the range of services offered, with staff roles and expectations being very different in NSW than in the US. In sites that had a more developed IT infrastructure, many clinicians found that they were actually losing important functionality. This factor generated considerable discontent. In addition, the programme was so novel that nearly all the key decision-makers were well outside their area of expertise.[12]

2.3. Organisational research examining EPR implementation

In attempting to unpack how IT can be successfully implemented, the scientific literature spans a diverse range of disciplines and journals and covers a huge breadth of issues.[13] Yet despite this wide interest, very little evidence on the

impact of EPRs is available. A review of 1832 papers on EPR implementation by Moorman and van der Lei[24] found no obvious trends regarding impact, except an increased interest in confidentiality. The field of inquiry is so scattered and diverse, with different stakeholders both conducting and commissioning research, that little in the way of a coherent message emerges. A diverse range of methodologies have been used, with a lack of theoretical focus, and experts have been largely divided on what states are necessary for implementation success.[7] Even more surprisingly, in the review conducted by Moorman & van der Lei, none of the 1832 papers reviewed actually involved an implementation of an EPR itself.

A small coherent body of work focuses on understanding the sociological process of implementing EPRs, in small groups of health care workers.[25] For example, varying resistance to using computerised care systems was investigated qualitatively by Timmons.[26] Twenty eight nurses and 3 project managers were interviewed across three UK District General Hospitals. The researcher found that refusal to engage with the systems was best understood in terms of nursing culture, with non-compliance expressed in largely passive ways. Postponement rather than outright refusal was used to negotiate nurses' work patterns. Another study used observational methods, studying 8 doctors and 2 nurses, to identify patterns of hospital IT communication.[27] The authors concluded that communication technology was most favoured by the medical staff when it actively interrupted their work, with a preference for information that encouraged delivery via face-to-face communication. In an ethnographic study of the use of pre-operative risk-assessment forms, the researchers demonstrated how the practical use of documents by medical professionals can be fundamentally at odds with how the organisation at large wants them used.[28] These types of micro studies are extremely informative in the local context in which they are undertaken and increase our understanding of how a small group of health workers react to, and shape the process of implementing a specific IT innovation. However, this micro level research is less applicable when attempting to understand the multiple processes involved in large-scale implementation of EPRs, both within and across a number of acute trusts.

Research that addresses more macro levels of implementation of IT systems in health care is scarce, with most studies in medical care settings tending to involve

small piecemeal development. Presumably, practical reasons of cost and disruption prevent larger scale projects occurring. Larger studies are mostly of North American or Australasian origin and focus on 'users' experiences.[29] Currently, the only large study of EPR implementation is the deployment of 22 Veterans Integrated Services Networks (VISNs) in the US department of Veterans Affairs (VA).[30] The implementation programme involved the adoption of a national computerized patient record system (CPRS) in 173 VA hospitals. Findings from research into the programme highlight 'success' factors such as a having a strongly supportive team, user empowerment, and system flexibility. Researchers also emphasise the need to incorporate users' specialist needs into any software development.[31]

Another relatively large study was conducted in five community hospitals in British Columbia, Canada,[7] examining the implementation of a patient care information system (PCIS) from the perspective of health care professionals. The researcher conducted 85 interviews across a range of staff. The study highlights the complexity of implementing IT innovations, with many unexpected consequences occurring and many expected benefits not being realised. It was anticipated that increased productivity would free up time but, in reality, any excess time was re-directed to new work programs and activities. This contributed to decreased job satisfaction. Workload and turnaround time for processing medical orders also increased, due to the additional information required; this was described by the authors as a "productivity paradox". Overall, role changes and a number of other practical problems meant that the implementation was far from 'successful'.

2.4. Organisational research examining CPOE implementation

One of our study aims was to explore how innovative pathology and radiology systems, proposed by Connecting for Health, are experienced by NHS staff, and to describe any impact on working practices. A body of work closely aligned to these aims has been conducted in the United States by Joan Ash and her team. Ash studied CPOE extensively across three large health care sites (University of Virginia, The VA Puget Sound campuses encompassing five hospitals, and the El Camino Hospital site). CPOE allows a clinician to sit at a computer and directly enter care orders or browse test results. Observations, oral histories, focus

groups and interviews enabled a comprehensive picture of a diverse range of 'users' experiences to emerge. Findings from the team's initial studies[32] outlined unexpected problems. Initial introduction of CPOE led to an increase, not a decrease, in the amount of paper generated, with staff having a sense that CPOE interrupted their workflow and decreased decision-making and educational opportunities.[32] Implementation also caused a disruption in the balance of power within the organisations, with users often feeling the organisation gained more than they did.[33] In addition, a separate study conducted on the same hospital sites[34] found that CPOE had an adverse impact on team relationships, with team spirit and cohesion undermined.

Apart from uncovering these number of unexpected and unwanted disadvantages to implementation, the researchers also found that qualitative evaluation of CPOE led to a complex array of methodological problems.[33] First, when interviewing staff, the researchers found it was difficult, and often impractical, to isolate CPOE implementation from other work processes. Secondly, the researchers found it could not be assumed that people were always talking about the same thing, even when they used the same words, with existential differences in perceptions and meanings. Lastly, the researchers found there was often a lack of consistency between what they observed and what they were being told, making firm conclusions difficult.

Despite these problems, later work by the group[35] reported recommendations for successful CPOE implementation based on four major themes. The first theme concerns organisational issues, and indicates that a strong organisational culture of trust, collaboration and teamwork, combined with supportive leadership, leads to success. The second theme concerns clinical issues, and emphasises the role of system customisation and flexibility. A third theme, technical issues, cites the need for system speed. The last theme concerns the organisation of information, with people wanting information to be organised in a manner that mimics their own thinking. People did not want to be forced to 'think like a computer'. Further research into successful CPOE implementation at Ohio State University Health System served to reinforce these conclusions. Similar factors emerged; the need for a user-friendly interface, senior management support, physician efficacy, regarding the perceived ability to use the systems, and effective teamwork. In

addition, the researchers in Ohio suggested that the elimination of alternative methods of ordering, and the abolition of all paper forms is useful; clinicians cannot revert to manual ordering if it is not available.[36]

The findings from this body of work are generalisable to our study, when evaluating the impact of EPR implementation in the NHS, in highlighting potential precursors for success and suggesting potential obstacles. However, as discussed earlier in relation to the New South Wales study, it would be a mistake to assume that these factors will automatically translate to a different context. There are important differences between North American health care systems and England's current NHS EPR strategy. Some of these differences are a question of organisational configuration, such as private and public sector finance and cost allocation, and the more rigid demarcation of clerical and clinical roles in the US and Canada.[9] Other differences concern fundamental transformations in organisational structure and strategy.[37] The CPOE studies involve implementing a single form of electronic function across 7 or 8 hospitals. The NPfIT is likely to impact on, and transform, every part of England's current health care system. The research reviewed tends to ignore wider issues of organisational and transformational change, preferring to concentrate on the utility of the innovation to the individual consumer. Research addressing innovation on the scale of the current NPfIT is simply not available anywhere because the national program is the largest and most ambitious public sector IT project ever undertaken. Nothing on this scale has been attempted before.[10]

2.5. Research examining implementation of IT in the UK NHS

Current research specifically concerned with the evaluation of implementation of EPRs and IT in the UK NHS is limited. A review of this literature undertaken in 1999 generated over 2000 citations, yet few instances of independent external evaluations were identified, with comparative quantitative studies virtually unknown.[38] The authors concluded that few reports gave a full account of the costs involved, and that many evaluations were 'simplistic, inadequate or precipitate'. The messages that emerge are again general; most problems relate to human rather than technical factors, work processes must adapt as IT is introduced, realistic expectations and timescales should allow for greater benefit

realisation, users should be involved, and that flexibility and communication capabilities are key technical requirements. These messages, although useful, may not prove decisive. Many of the factors outlined could apply equally well in any organisation, and may not be prescriptive enough to address specific challenges attached to the NPfIT.

In 2003, the NHS Information Authority commissioned a large scale EPR pilot study in 16 NHS sites across England (ERDIP project),[39] perhaps in recognition that the implementation of widespread EPRs in the NHS might be challenging. The aim of the pilot study was to learn valuable lessons for the main EPR drive commencing in 2004. Unfortunately, the qualitative and quantitative rigour of the evaluation is questionable, appearing to yield little apart from the most basic anecdotal evidence. As the final report comments, without a targeted set of benefits, it is difficult to judge if an IT initiative has been successful: "quantification of benefits by the ERDIP sites has been disappointingly limited resulting in little concrete evidence."

A more systematic approach to EPR evaluation is available from The Bayswater Institute, which for three years was part of a commissioned programme evaluating electronic patient records and the integrated clinical workstation in five UK hospitals.[40] The team aimed to capture the experience of living and working at the implementation sites. They reported that, after EPR implementation, many staff tasks had become easier. However, staff also found that making a department or function more effective generated more work, and more paper. For example, when the EPR system for path lab orders went live, requests went up. In response to this increase in work load, the pathology lab 'defended itself' by making test ordering more difficult again. Staff also found that the formality of computer records made it difficult to express uncertain responses such as an instruction to 'keep an eye on him'. Much of the information used by staff was incomplete and informal, and paper seemed better suited for these more open-ended and nebulous massages.[41]

A project on the use of EPRs in UK maternity services has also found that paper records are valued, with current EPRs seen by staff as too rigid and inflexible.[42] In this study, at least half of the respondents questioned had problems accessing the kind of information they needed to support patient care. Paper records have

what Klein has coined the 'Martini factor'; once found they can be used any time, any place, anywhere.[40,41] This potential advantage of paper records may be one reason why the authors concluded that, although EPRs were in certain cases beneficial, on balance time saved versus time spent was at best equal. The authors propose that future EPR systems will have to do considerably better in recognising and balancing the potential conflicts between time saved and time spent. They also warn that current euphoric claims regarding the effectiveness of EPRs are likely to result in widespread disappointment amongst NHS staff and patients.[42]

Whether this prediction will be realised when implementation of the NPfIT is completed is unknown. A report by the Institute for Public Policy Research[43] described how the benefits of EPRs to health services could be huge, but the risks could also be substantial, because of the failure to provide evidence of impact. The research, based on examining large EPR pilots in the NHS, concluded that public and political support for unprecedented spending on IT investment in health services will not be realised without better planning and evaluation. Trials of electronic patient records failed to demonstrate that they would lead to more flexible services, cost savings or improvements in treatment of patients. In addition, pilots of electronic appointment booking systems failed to show clearly that they helped to facilitate greater choice for patients about where, when and by whom they are treated. A more recent National Audit Office report also raised concerns, with the current roll out of NPfIT reported as less than optimal.[44] The report highlighted that the programme faced significant challenges in delivering systems to agreed timescales, ensuring involvement of NHS organisations in implementation and, importantly, gaining the support of NHS staff and the public.

2.6. Conclusions

One aim of this study is to determine which organisational factors impact on the implementation of electronic patient records in the UK NHS. Current research reviewed offers some useful insights, in suggesting that factors such as having an organisational culture of trust, plus good teamwork, supportive leadership, system customisation, flexibility, userability and speed, will aid success. However, as

Berg points out, 'what a successful implementation is can only be discovered in the very process of doing the implementation'.[45] Success is determined by, and reliant on, so many dimensions that no simple formula will work for every case. There is no 'recipe' that guarantees success. In order to develop a detailed account of the processes underlying EPR implementation within our study sites, we drew on both the current organisational literature and themes which emerged from our data.

3. Systematic review of the economic implications of large scale IT implementation in health care

3.1. Introduction

The scarcity of available health care resources means that they need to be allocated so that they generate the maximum possible health benefit. The goal of economic evaluation is to provide a comprehensive assessment of potential costs and benefits to provide the necessary support in this decision making process. Drummond et al. define economic evaluation as "the comparative analysis of alternative courses of action in terms of both costs and consequences".[46] A comprehensive economic evaluation should contain a number of key elements. These include the identification, measurement, valuation and comparison of all relevant costs and consequences relating to the alternative technologies under consideration. A competent economic evaluation will also assess the level of uncertainty surrounding these results so that the decision-maker can assess the robustness of the results with respect to alternative assumptions.[47]

In theory, all health care technologies should be subject to economic analysis. However, the need for robust and comprehensive economic evaluations becomes even greater when the implementation of particularly costly technologies is being debated. The current National Programme for IT (NPfIT) for the NHS, with an estimated investment outlay of £6.2 billion over ten years, certainly satisfies this criterion.[48]

3.2. Background information on IT implementation

The economic implications of the integration of information technology (IT) into health care and its consequences have been studied widely. Although the amount of literature on this subject is vast, it is difficult to find a consensus among researchers on the methods of evaluation and the effects of the implemented technology.

The majority of the studies in this review compared the impact of an IT intervention, by studying various outcome measures (e.g. costs, time saved, change in productivity) before and after introduction of the intervention. A small

number of studies[49-52] used financial methods of evaluation, such as return on investment and net present value, both of which are a standard method for financial evaluation of long-term projects. As with the methods of evaluation, the types of IT interventions evaluated in the existing literature varied. We chose to focus on three broad categories; PACS, electronic medical/patient records (EMR) and CPOE. PACS refers to computers or networks dedicated to the storage, retrieval, distribution and presentation of images. EMR refers to several different types of electronic health records. Considerable confusion still exists in the literature with respect to the scope of electronic record systems designated by different terms, e.g. electronic *medical* or *patient* record. CPOE is "… the element of a clinical information system that enables a patient's care provider to enter an order for a medication, clinical laboratory or radiology test, or procedure directly into the computer and 'browse' the results of investigations".

The dispersion in evaluation methods, paired with clear heterogeneity of the intervention types, creates difficulties in assessing and drawing conclusions based on the reported findings. While some researchers acknowledged these difficulties[53], they also recognised the potential for substantial improvements in the quality of health care associated with the introduction of a new IT system and potential cost-savings.[17,48]

The aim of this study was to conduct a systematic review of the literature on the economic implications of large scale IT implementation in a hospital or cross-departmental setting.

3.3. Methods

The focus of this review was on economic evaluations and cost analyses of large scale IT implementations in a hospital, or cross-departmental settings in a number of hospitals. The methods and findings reported in such studies are most likely to be relevant to the NPfIT. Therefore, we were not interested in studies that reviewed the effects of technologies such as telemedicine, clinical decision support interventions, internet advice-based interventions, or those that were implemented on a small scale, such as within a single department or general practice. The decision was also made only to review studies that contained at

least some primary data analysis, and which compared two or more IT systems or one setting before and after introduction of an IT system. Due to the rapid changes in IT, it was agreed that studies published in the last decade would best inform the aim of the review. In the process of developing the scope and methods for this study, it became clear that there is little consensus on the definition of large scale IT intervention. Therefore, we used a broad set of terms in order to maximize the sensitivity of our search.

We accepted at the outset that we were not aiming to estimate the size of a specific effect. Studies were likely to be very heterogeneous, e.g. in different settings, implementing different IT systems, evaluating implementation against diverse outcomes etc., so calculating a pooled answer was, *a priori*, not appropriate. However, given the anticipated benefits of IT modernisation in the NHS,[54] we wanted to identify the extent to which empirical evidence might support these anticipated benefits.

A further source of heterogeneity is the different methods used in empirical studies. Thus a second objective of our review was to describe the diversity of methods used in the empirical evaluation of large scale IT implementation in health care. Although we intend to describe the empirical findings of the most relevant papers, we were equally interested in the methods that have been used.

3.3.1. Inclusion / exclusion criteria

The abstracts or titles of the complete set of references were reviewed by two reviewers (EP and AH). The main exclusion criteria at this stage of the review were studies reporting findings on micro-interventions, clinical decision support interventions, internet advice-based interventions, telemedicine, opinion papers and letters. Furthermore, reviewers classified all abstracts on the basis of the perceived likelihood that papers (a) contained empirical data (empirical: probably empirical: possibly empirical. not empirical) or (b) used innovative methodology (methodological; probably methodological; not methodological). All abstracts classified as being neither empirical nor methodological by both reviewers, or “neither” by one reviewer and “possibly empirical” by the other, were excluded at this stage.

A short pro-forma checklist, completed by two reviewers, was used in reviewing full papers. The aim of the checklist was to categorise the types of IT intervention and setting evaluated and whether or not a comparator (another technology, or a comparison over time) was identified. When the classifications of the two reviewers differed, a third reviewer was consulted (AM or BR). Based on the checklist, only studies that identified all three parameters clearly (i.e. eligible IT intervention, implemented at least 'across departments', and with a comparator) were included for data extraction. Following the completion of the checklist, the reference list from an included paper was searched for any additional studies that might have been missed in the initial search. Agreement between the two reviewers was described by the kappa statistic.

3.3.2. Search strategies

Studies were identified by searching the Medline electronic bibliographic database and the electronic Cochrane Library economic evaluation database. The Medline search was conducted using the following MeSH terms: 'medical informatics applications' (major heading only), combined with any of 'cost control', 'cost-benefit analysis' or 'health care costs'. The Cochrane Library was searched using similar key terms. We limited our searches to English language publications between 1995 and August 2006.

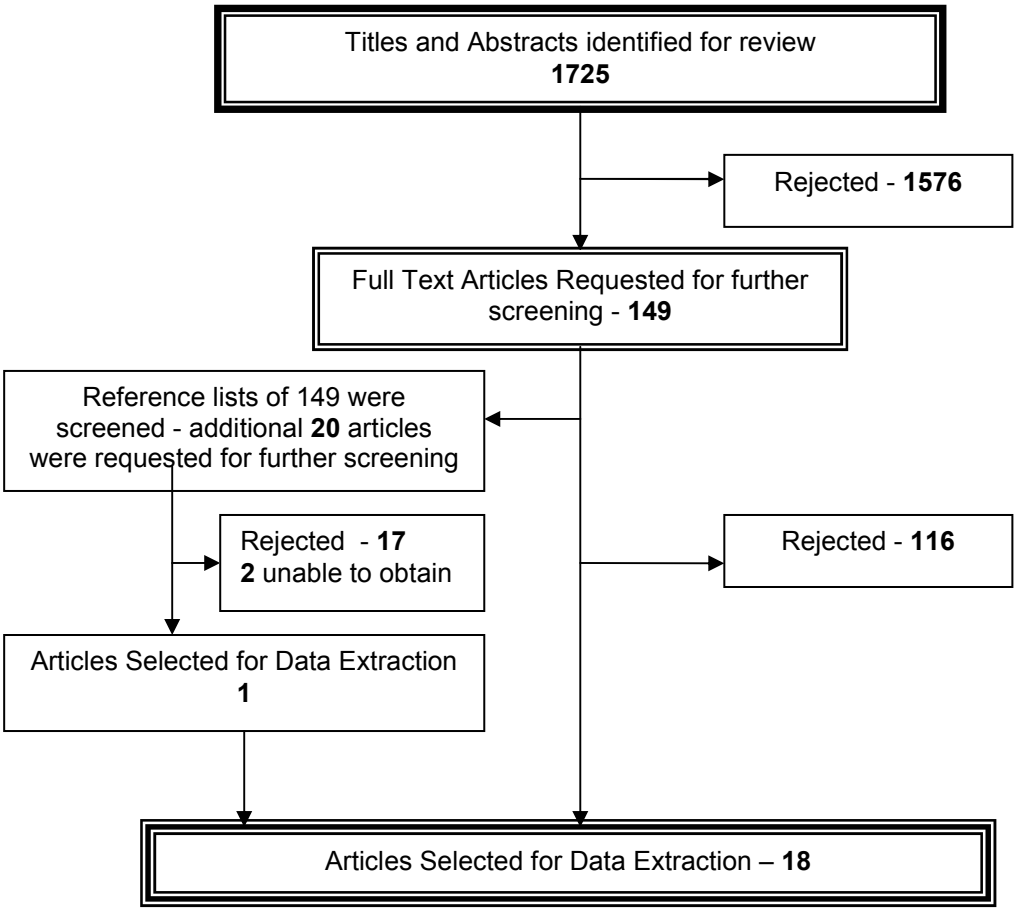
3.3.3. Data extraction and synthesis

The data-extraction table was designed to summarise the main attributes of each study, such as the setting, type of IT intervention evaluated, year(s) of empirical data etc. We also extracted data on costs associated with implementation (i.e. initial capital outlay), maintenance (system upgrades etc.), operation and staffing of a new IT system. All clearly defined outcome measures and reported cost offsets were extracted. We used a standard checklist for appraising the quality of economic evaluations.[46]. The findings of the review are reported in the form of a narrative synthesis because of the extreme heterogeneity between included studies.

3.4. Results

The initial search identified 1725 studies from the Medline database and 529 studies from the Cochrane Library. The combined list of references from Medline and the Cochrane library was checked for duplicates and 118 were removed. **Figure 3** summarises the selection process. A total of 149 papers were identified for full text review. An additional 20 papers were identified from the bibliographies of the included papers. Overall, 18 studies were identified for data extraction. Agreement between the two reviewers with respect to identification of papers for full text review was 'good'[55] (weighted Kappa=0.68, CI (0.641, 0.737)), with simple agreement on 98% of papers.

Figure 3 : Search results



The full text review identified a total of eighteen studies for inclusion. Of those nine evaluated PACS, five evaluated EMR and four evaluated CPOE (i.e. studies of CPOE in the United States). It is important to note that two of the studies were based on the same empirical data.[56,57] Furthermore, it was discovered that, apart from variations in titles and abstracts, three studies were virtually identical[58-60]; therefore, only one of these was included.

3.4.1. Study description

Table 6 summarises the studies included in the review. The majority were conducted in the US[36,50-52,58,61-66] (11 of 16), three[49,53,67] in Scandinavia (two in Finland and one in Sweden) and two in the UK.[56,57] All but one study of the effects of PACS were conducted in a hospital or medical centre setting. Two of the four studies that looked at the effects of CPOE were conducted at a departmental level across a number of hospitals [36,63] and the remaining two within a single hospital.[51,52] All studies evaluating the effects of EMR were conducted across a number of primary care practices.

The evaluation design varied considerably across the included studies. Four studies[49-52] used either an accounting or financial approach, such as activity-based analysis, return on investment (ROI) or value on investment. Two studies were cost comparison, before and after implementation.[53,64] One study only evaluated the effectiveness of IT implementation[65] and one study was a pilot RCT.[62] The remaining 8 studies used some form of 'before and after' comparison of costs or benefits.[36,56-58,61,62,66,67]

3.4.2. Methodological quality

Table 7 shows the results of the quality assessment of the identified studies. Ten studies clearly identified competing alternatives.[36,49,50,56-58,61,63,65,67] Apart from Bryan et al.,[56] the studies reported either partial incremental analysis (i.e. just costs or benefits) or no analysis at all; 7 studies reported incremental analysis of the effects, and one of costs.[67] The results of sensitivity analysis were reported in six studies.[49,53,56,57,63,66]

3.4.3. Economic findings and methods of evaluation

Apart from the studies that used a financial approach, other studies were partial economic evaluations because they only evaluated differences in costs, and not health benefits. **Table 8** further summarises the results of the included studies by intervention type. The perspective was identified in four studies and implied in the text for four other studies. One adopted a societal perspective[53] and the remaining seven adopted a hospital[52,56,57,63,65,67] or departmental perspective.[66] Only five studies applied discounting.[51,53,56,57,65]

The majority of studies compared pre and post implementation effects. All but two evaluations of the effects of PACS used a pre and post comparison with the pre-PACS comparator identified as film-based imaging. One study reported changes in the outcome measure during the implementation of PACS and once PACS was fully implemented, further comparing those findings with pre-PACS data.[65] Another study compared the effects of PACS versus PACS with the addition of CR (computer radiography).[50] Maass et al. evaluated the effects of implementing PACS in addition to a film-based system and used their findings to estimate the costs of a full-scale PACS implementation.[67] Similarly, studies evaluating the effects of EMR and CPOE implementations compared outcomes and costs before and after introduction.

3.4.4. Costs

All but one of the 7 studies of the effects of PACS reported the costs of maintaining and operating the new system. In addition, two studies[49,67] reported the initial capital cost of implementing PACS and staffing costs associated with using the system. Wagner et al. did not report any costs. Only two of the five studies of the effects of CPOE implementation reported data on costs. Both Wang et al. and Kaushal et al. included the costs of maintaining/operating and staffing associated with the new system; the former also reported the initial cost of implementing CPOE. Most studies of the effects of EMR included the initial costs of implementation; three also included the costs associated with EMR operation and maintenance.[53,61,62]

Table 6: Summary of the designs used, interventions and health care settings evaluated by included studies

Author	Study Year(s) Country (Currency?)	IT Intervention	Evaluation Design	Health Care setting
Arias-Vimarlund et al. 1996	1995 Sweden (SEK)	EMR	Comparative case study	Two urban primary health centres
Barlow et al. 2004	2002-2003 USA (USD)	EMR	Before and After Cost –Savings	Multi- Specialty Clinic
Miller et al. 2005	2004-2005 USA (USD)	EHR Electronic Health Records	Analysis of costs and benefits Before and after	A group of primary care practices
Sachs 2000	? USA (USD)	EMR	Cost comparison Before and After	Ambulatory clinics
Wang et al. 2003	5-year period (year not stated) USA (USD)	EMR	Financial costing and cost-offset analysis Before and after	A Hypothetical Primary care provider
Kaushal et al. 2006	1993-2002 USA (USD)	CPOE	Return on Investment Analysis	Women's hospital
Mekhjian et al. 2002	2000-2001 USA (USD)	CPOE	Analysis of benefits and cost-offset Before and After	Inpatient nursing unit
Overhage et al. 2002	1995-1996 USA (USD)	CPOE	A pilot RCT – value of access	Emergency department
Taylor et al. 2002	1999-2002 USA (USD)	CPOE	Value on Investment Analysis	Urban Medical centre

Table 6: continued

Author	Study Year(s) Country (Currency?)	IT Intervention	Evaluation Design	Health Care setting
Alanene et al. 1998	1994 Finland (FIM)	CR – mini-PACS	Cost analysis using activity-based accounting	Mid-size general hospital
Bryan et al. 2000	91/92-96/97 UK (GBP)	PACS	Analysis of costs and benefits Before and after	Secondary Care Hospital
Bryan et al. 1999	1996-1997 UK (GBP)	PACS	Costs and savings analysis Time series trend analysis	Secondary Care Hospital
Chan et al. 2002	1998-2001 USA (USD)	PACS	Return on Investment Before and after assessment of productivity and satisfaction	Hospital
Maass et al. 2001	1998 Finland (FIN)	PACS	Analysis of costs – before and after	University Central hospital
Siegel et al. 1998 (also pub. 1998 and 2003)	1993-1996 USA (USD)	PACS	Analysis of cost-offsets and benefit Before and after	Medical Centre
Wanger et al. 2002	1995-2000 USA (USD)	PACS	Assessment of benefits Before and After	Department of radiology

Table 7: Results of the quality assessment of included studies

Ref.	49	53	61	57	56	50	51	67	36	62	63	58	52	65	66	64
Was a well-defined question posed in answerable form?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y/NC	Y/NC	Y	Y	Y
Was a comprehensive description of the competing alternative given?	Y	NC	Y	Y	Y	Y	NC	Y	Y	NC	Y	Y	NC	Y	NC	NC
Was the effectiveness of the programme or services established (e.g. randomized, controlled clinical trial, overview of clinical literature etc.)?	Y	Y	Y	Y	Y	NC	NC	Y	Y	Y	Y	Y	NC	Y	Y	Y
Were all the important and relevant costs and consequences of each alternative identified?	P	Y	Y	Y	Y	Y	Y	P	P	Y	Y	Y	P	Y	Y	Y
Were costs and consequences measured accurately in appropriate physical units (e.g. hours of nursing time, number of physician visits, lost work-days)?	P	Y	NC	Y	Y	Y	Y	Y	P	Y	Y	Y	Y	P	Y	NC
Were costs and consequences valued credibly?	Y	Y	NC	Y	Y	NC	Y	Y	Y	Y	P	Y	NC	Y	Y	Y
Were costs and consequences adjusted for differential timing?	NC	Y	N	Y	Y	N	Y	N	N	N	N	N	N	N	Y	Y
Was an incremental analysis of costs and/or consequences of alternatives performed?	N	N	N	P	Y	N	N	P	P	P	P	N	P	P	P	N
Was allowance made for uncertainty in the estimates of costs and consequences?	Y	Y	N	Y	Y	N	N	N	N	N	Y	N	N	N	Y	N
Did the presentation and discussion of study results include all issued of concern to users?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	NC	Y	Y	Y	Y

Y – Yes; N- No; NC – Not Clear; P – Partially

Table 8: Summary of the results of the included studies

Ref	Perspective	Discount Rate	Comparison	Costs	Outcome Measure(s)	Cost Offset	Results
53	Societal	4%	Not clear	Implementation, Maintenance, Operational, Staffing	NA	Time saved	Total costs – SEK2,093,000 Time-saved SEK72,900 NPV - SEK2,020,100
61	NS	NS	Pre-EMR vs. Post-EMR	Storage and chart maintenance	NA	Space requirement; Transcription	Savings – space req. $248,000; transcription exp. $380,000
62	NS	NS	? before and after EHR	Implementation and Maintenance	NA	Compensation rates (records and staff)	Savings: Increased coding level - $16,929 Efficiency-related saving or revenue gains - $16,929 per FTE per provider; The total average benefit $32,737 per FTE per provider.
64	NS	NS	?	Implementation	NA	Paper and transcription	Saving: transcription - $9,967/provider (1st y); paper - $41,795; NPV – over 3 years $2,695
66	Health Care Org.	5%[2]	?	Implementation, Maintenance, and Staffing	NA	Averted costs and revenues	Present value of annual costs over 5-year period - $42,900 Present value of annual benefits - $108,500. Present value of net benefit - $86,400.
51	NS	7%	Not clear	Operating and staff training	ADE; dosage number	Drug costs	Saving: ADE prevention $3.7 million and $4.9 million - specific or expensive drug Decrease in the mean LoS by 0.2 days (p=0.009) Decrease in ADE by 0.81 /1000 patient days
36	NS	NS	Pre-CPOE vs. post- CPOE	NA	LoS	Time saved; admissions	Decrease in turn-around time decreased by 64% (p<0.001) Decrease in completion time by 43% (p<0.05) Decrease in lab results time by 25% (p=0.001) Decrease in LoS by 0.48 days (p<0.001
63	Hospital[1]	NS	Hosp. with CPOE vs. hosp. without CPOE	NA	Test order rate; charge per encounter	NA	Saving of $26 per encounter (p=0.03) Test ordering rates did not change; overall physician satisfaction rate - 70%.
52	Med. Centre[1]	NS	? before and after CPOE	NS	Rx errors	Time saved; staffing	Decrease in Rx errors– 50% Time saved (medication-ordering) by 225min (92%) Saving: Personnel - $4,185/; nursing $1,960/d; pharmacist- $5,600/d

NS- Not Stated; NA- Not Applicable; NPV – Net Present Value; ADE – Adverse Drug Event; LoS – Length of Stay

1 Perspective implied from the text; * - assumed; 2 Assumed.

Table 8: continued

Ref.	Perspective	Discount Rate	Comparison	Costs	Outcome Measure(s)	Cost Offset	Results
49	?	NS	PACS vs. Film	Implementation, Maintenance, Operational, Staffing	NA	Image processing	PCAS Image processing – FIM39 Film-based image process. – FIM25 The total cost of image process. – up by 9%
57	Hospital	6%	PACS vs. pre-PACS	Maintenance and Operational	NA	Time saved	Savings: Prep-time - £36,000 per annum and no Exam time £41,000 per annum. Image related time £9,000 per annum. Consultation time (4.3 versus 3.7 minutes).
56	Hospital	6%	PACS vs. pre-PACS	Maintenance, Operational and Staffing	Rate of image rejection and radiation dose; Physician Satisfaction	NA	Decrease in image repeat rate by 2.6% Decrease in radiation dose by 20% Increase in physician satisfaction with image quality by 10%
50	NS	NS	PACS vs. PACS+CR	Film imaging related and PACS maintenance, operating and financing	Physician satisfaction; change in productivity	NA	General productivity benefit – 91% Radiologist productivity benefit – 100% Increased in technologist productivity by 58% Saving of $500,000 per annum
67	Hospital[1]	NS	Film vs. Film+PACS	Implementation, Maintenance, Operational, Staffing	NA	Capital costs	Decrease in personnel costs - FIM 800,000 ; decrease in supplies costs - FIM 190,000 Increase in equipment expenditure - FIM 2,000,000 Overall increase of costs by 16%
58	NS	NS	Pre-PACS vs. Post-PACS	Maintenance	“unread” images; image retake rate;	Film, folders and chemicals; Personnel	Decrease in “unread” images by 7.7% Decrease in image retake by 4.2% Decrease in film costs by $190,000 Additional Saving in film folder and chemicals of $15,000. Savings in personnel costs - $100,000 per year.
65	Radiology Dept.[1]	NS	Pre-PACS vs. during/post PACS	NA	Rate of incidental finding; number of follow-ups	NA	Increase in the rate of incidental findings - 163% ($p<0.001$) Increased in follow-ups by 540% Increase in revenues - 218%

NS- Not Stated; NA- Not Applicable; NPV – Net Present Value; ADE – Adverse Drug Event; LoS – Length of Stay

1 Perspective implied from the text; * - assumed;

2 Assumed.

3.4.5. Results of cost-offset and other outcome measures

PACS

The results of studies of the effects of PACS implementation showed a positive effect on the quality of images taken.[50,57,58] Wagner et al. showed that the increased quality of images had a positive effect on the rate of incidental findings (i.e. clinical findings outside of the primary area of interest).[65] These results are supported by Maass et al.,[67] and Bryan et al.,[56] who reported positive changes in the productivity of physician and other staff and greater satisfaction due to PACS implementation. Studies that used cost-offset to measure their results showed a decrease in costs, which resulted from a decrease in the time allocated to image processing.[56,58] Two studies reported an increase in the total cost of imaging after implementation of PACS. Alanen et al. found that the total cost of image processing increased by 9% over the study period when compared to conventional film-based imaging.[49] Similarly, Maass et al. reported that overall costs increased by 16% after PACS implementation, as a result of a substantial initial capital outlay.[67]

EMR

Three of the four studies evaluating the effects of EMR[61,62,64] reported cost savings as a result of a decrease in the time needed for record transcription and space requirements. Arias-Vimarlund et al. reported a negative net present value (NPV) of EMR system implementation over the 12-month evaluation period, whereas Sachs et al. showed a small, but positive NPV over the study period (3 years).

CPOE

Four of the five studies examining the consequences of CPOE implementation[36] reported positive effects of the new system on the length of stay, adverse drug events (ADE) and prescription errors.[51,52] Two studies[36,52] reported positive cost-offsets as a result of a decrease in turn-around and order completion times, and savings from personnel and clinical staff. Wang et al. reported a positive net present benefit of CPOE implementation.[66]

3.5. Discussion

The finite nature of available resources mandates the need for thorough economic evaluation, which in turn will help a decision-maker determine whether a particular technology should be adopted. This need becomes even greater when implementation of a technology involves significant upfront investment. The aim of this study was to review the existing literature on the economic implications of large scale IT implementations in health care. Specifically, we were interested in the empirical results, methodological approach and rigour.

Key findings from the review included a positive effect on the quality of imaging with PACS, a decrease in the number of prescription errors and a decrease in adverse drug events (ADE) with CPOE, and a decrease in the time need for record upkeep with EMR. However, the results of the studies evaluating financial implications were mixed. Many studies noted that increasing the time period over which the evaluation takes place further increases the benefit and/or decreases costs. Overall, we found that there is lack of empirical data on this subject, which significantly impairs the quality of the research.

We found that none of the studies directly evaluated the effects of implementation of a new IT system on health outcomes. However, based on some of the findings, such as an increase in the rate of incidental finding[65] and decreased dose of radiation[57] associated with implementation of PACS, the potential exists for overall health benefits. Similarly, decreased rates of drug errors[52] and lengths of stay[36] reported in the studies evaluating the effects of CPOE implementation indicate potential health benefits.

With respect to methodological rigour, the review identified a number of technical concerns with the existing evaluations. The comparative technology was not clearly started in six of the identified studies.[51-53,62 ,64,66] Partial incremental analysis reported by the included studies detracts from the quality of the evaluation. More than half of the reviewed studies did not report results of sensitivity analyses, which further limits interpretation of the findings.

Reviews by Clapm et al.[48] and Chaudhry et al.,[17] which focused on the effects of health information technology on quality, efficiency, and costs of health care,

found similar results. They also highlighted that disparate evaluation methods and heterogeneity associated with the types of intervention causes significant difficulties in assessing reported findings and drawing conclusions.

3.5.1. Strengths and weakness

The main strength of this review is the systematic approach used to identify and assess the methodological quality of the literature. We protected against reviewer bias by using two reviewers to select studies. However, there are three limitations that need to be acknowledged.

Firstly, there is the possibility that relevant literature was not identified due to the search strategy we used. We excluded non-English publications and focused on the medical literature by using MedLine and the Cochrane library. However, subsequent searching of cited references produced little additional literature within or beyond the indexed medical literature. Therefore, we believe that it is unlikely we missed any rigorously conducted economic evaluations and that any empirical studies we missed would probably have been of lower methodological quality than those we identified.

Secondly, it could be argued that the potential for publication bias is high, particularly for retrospectively conducted studies. Possible reasons include (retrospectively) electing not to study 'unsuccessful' implementations, failing to submit or publish non-positive studies, or selecting outcome measures in order to obtain positive findings. We identified one case of multiple publication of the same study.[58-60]

Thirdly, we only considered studies that contained at least some element of primary analysis, so that purely hypothetical analyses were not reviewed. The rationale for this distinction is that empirical studies have demonstrated that the expected/theoretical savings assumed for non-empirical models are not typically realised.[68] However, it should be noted that these excluded analyses, if taken at face value, do suggest that IT programmes of this nature could be cost-saving.[69]

3.5.2. Conclusion

In conclusion, based on the studies we found, the economic consequences of integrating a major IT system into health care services are extremely uncertain. Moreover, we found no consensus among studies with respect to an appropriate methodological approach of evaluating a complex intervention (i.e. IT systems). Few studies assessed the potential for substantial improvements in the quality of health care associated with the introduction of a new IT system and potential cost-savings. Yet, decisions to implement such systems (e.g. NPfIT/Connecting for Health) are influenced by claims or expectations of health benefits as well as gains in the efficiency of the provision of health care. The need for a comprehensive assessment of the economic consequences of implementing large scale IT systems is necessary because such system have substantial financial implications. Until such an assessment is undertaken, considerable uncertainty will remain about the efficiency and health gains, and the cost-effectiveness, of such programmes.

4. Methods for the qualitative and quantitative empirical elements of the study

4.1. Ethics

Ethics approval for the study was granted by the Trent Multi-centre Research Ethics Committee in June 2003 (ref. **MREC/03/4/017)**. A subsequent amendment was submitted in October 2004, seeking approval for the study to obtain and analyse anonymised data for individual patients. This amendment was approved. Annual progress reports were submitted to the Multi-centre Research Ethics Committee in 2004, 2005 and 2006, and a final report in May 2007.

4.2. Methods for the qualitative study

Qualitative methods were used to provide an in-depth organisational analysis of the processes and impacts of implementing electronic patient records (i.e. local and national solutions that form part of the NPfIT) in four acute Trusts in England.

Specifically, the qualitative element of the study addressed the following two objectives:

1. To describe the context for implementation of the NPfIT in England, examining actual and perceived barriers, and opportunities to facilitate implementation.
2. To explore how new electronic applications, of the kind which will be implemented by the NPfIT, are experienced by end-users (NHS staff), describing any impact on working practices.

4.2.1. Theoretical framework

We intended to carry out the evaluation in a way that took into account the complexity both of the 'programme' (i.e. implementation of EPRs) and the 'context' within which it is introduced (i.e. a number of acute NHS Trusts). This approach is similar to that of 'contextualism' which takes account of the content, process and context in studies of organisational change and emphasises that the effects of organisational change are multi-layered and complex.[70,71] We have used methods based on those used by organisational process research[72] which explores patterns within organisations, and identifies

trends or tendencies over time. To address these complexities, multiple levels of analysis have been used to study process phenomena which are fluid in character and which "spread out over both time and space".[73] This type of research uses comparative and longitudinal case studies to explore variation in 'outcome' (i.e. consequences). In this case, the 'comparison' element of the study is within and between organisations implementing EPRs. In other words, we aimed to document and analyse change over time, and compare the impact of implementation of EPRs between different organisations using both quantitative and qualitative methods. Similar methods have been used successfully before.[68]

Research into the implementation of IT in health care is characterised by diversity. The field of inquiry is fragmented and suffers from a lack of cohesion and theoretical focus.[7] Sociological approaches to medical work offer some guidance, in providing shared starting points considered necessary for increasing scientific understanding of IT development. Primarily this approach sees technological innovation as a social process. The focus is on the nature of medical work and the interrelated and dynamic relationship between technology and the social environment.[74] In taking this approach when collecting and analysing our data, the 'the user' is seen as playing a central role – with technological development not seen as 'linear', but altogether more human and messy. The impact of the innovation on the organisation has repercussions that feed back on the shape, use and function of the IT, making it important to see EPR development in terms of a dynamic whole.[26] The technology and user interact and mutually transform each other, often in unexpected ways.

There were two sociological approaches to technology implementation that appeared particularly useful when attempting to focus our data collection and subsequent analysis. Theories of organisational change and strategic development have been developed to provide a better understanding of the full range of organisational factors affecting the strategic development of IT. They see IT as one key component of the wider organisational context. We drew upon a range of organisational process research in an attempt to address both individual and organisational patterns of change, within and

across our sites, and identify trends or tendencies over time.[75] However, in developing the first interview schedule (level 1), the work of McKersie and Walton (the MIT90s framework of organisational change and effective implementation of IT)[76] was particularly useful. Using this framework, the impact of EPRs is seen as being crucially affected by three central forces - the structure of the organisation, management processes, and the personality and roles of individual project leaders. The MIT90s framework also outlines factors - such as policies, the IT systems itself, and behavioural conditions (such as motivation) as determinant for success. In developing the interview schedules, the work of Pettigrew et al[77] is another key text. From studying strategic service change in the NHS, the author derived a set of eight interlinked contextual factors necessary for building receptive change:

- Environmental pressure
- Supportive organisational culture
- Change agenda and its locale
- Simplicity and clarity of goals and priorities
- Cooperative inter-organisation networks
- Managerial-clinical relations
- Key people leading change
- Quality and coherence of policy

Data collection from the second stage of analysis (level 2) draws on the diffusion of innovations theory (DOI).[78] This work is useful because it was developed to explain the acceptance, or otherwise, of product innovations by end-users or consumers. DOI primarily concerns the study of "the process by which an innovation is communicated through certain channels over time among members of a social system" (p.5). The first element that determines diffusion is the innovation itself, in our case the EPR. DOI theory sets out five attributes which are important in assessing the potential of this innovation i.e. how quickly and successfully it will be adopted. These include:

- The relative advantage of the innovation – such as the economic value, social value, convenience, and satisfaction the EPR affords.
- Compatibility - the extent to which the EPR is seen as consistent with existing values, experiences, and needs of the adopters (hospital staff).

- Complexity – the degree to which the EPR is difficult to understand and use.
- Trialability – the degree to which the EPR can be experimented with and tested and
- Observability – the degree to which the results of the EPR are visible to others.

The second factor in diffusion is communication, i.e. the process of sharing ideas. Time is the third element, i.e. the rate of spread of the innovation. The relative time at which an innovation is diffused is based on adopter categories – how quickly the individual takes on the new idea. The fourth main element is the social system in which the innovation is embedded. Findings from this theory are particularly useful when shaping questions such as why a particular health technology, or EPR, has not diffused more widely. Another advantage of this approach is its firm rooting in the perspective of the user, and its central focus is on the utility of the innovation to the individual consumer. Building on this approach, Greenhalgh et al,[79] developed a conceptual framework for the factors influencing the diffusion and implementation of innovations. In this framework, Greenhalgh et al[79] identified nine interacting elements relating to, for example: attributes of the innovation; characteristics of the adopter; system readiness for innovation; implementation process.

4.2.2. Design for qualitative study elements

As explained in chapter 1, following our original research proposal, Department of Health policy shifted from locally-suplied to nationally-supplied IT applications. To accommodate this change, and to take into account current levels of EPR implementation at the four study sites, the research team revised the original study design.

Baseline information for each study site data was collected through meetings with key IT, finance and clinical directorate staff, as well as document review, and from routinely published data. Two levels of interviews were conducted over three stages (see **Appendices 1-9**). Level 1 interviews took place over

two separate time intervals (towards the beginning of the project and eighteen months later):

- Level 1 (stage A) interviews took place between July and October 2004;
- Level 1 (stage B) interviews took place between February and April 2006;
- Level 2 interviews took place between January and October 2005.

Level 1 research questions:-

1. What contextual factors (historically and currently) act as facilitators or barriers to the implementation of IT applications?
2. How have recent Connecting for Health policy changes impacted on implementation processes?

Level 2 research questions:-

1. How are specific IT applications (CPOE and PACS), which have been proposed by the new NPfIT, experienced by end-users (NHS staff)?
2. How do these new IT applications impact on working practices?

Level 3 interviews outlined in the original proposal (how specific IT applications impact on patient care) were not conducted due to low levels of EPR function in our study sites.

4.2.3. Sample

The study sample consists of four NHS Acute Trusts. Qualitative data were collected over a two-year period mainly through semi-structured interviews with a range of stakeholders involved in implementing and using EPRs, including clinicians (medical, nursing etc.) and managers at both junior and senior levels (see **Table 9**).

Table 9: Total number of interviews conducted across the four study sites

Number of participants	Trust 1	Trust 2	Trust 3	Trust 4	Total
Level 1					
Stage a	6	6	6	6	**24**
Stage b	6	6	7	6	**25**
Level 2					
e-booking	0*	0	0	6	**6**
PACS	0	7	3	7	**17**
e-test ordering	10	11	0	0	**21**
Total	22	30	16	25	**93**

*Zero indicates that the application was not implemented in the study site

Level 1 interviews were conducted with the following personnel in each participating Trust:

Senior managers

- Chief Executive
- Director of IM & T

Middle managers

- Project Manager (IM & T)
- Clinical Director (Laboratory Medicine or equivalent); this job title varied as staff roles at this organisational level differ.

Senior clinicians and staff with a particular interest/ role in EPR implementation

- Medical Director
- Director of Nursing

In the 18 months between stages A and B there were several changes in personnel; of the 23 staff originally interviewed in 2004, only 11 were still in post in 2006 (2 out of 4 chief executives, all 4 directors of nursing, 2 medical directors and 3 directors of IM & T).

Level 2 interviews were conducted with NHS staff using the IT applications being studied, as follows:

- Project manager
- EPR Trainer
- Three clinicians (doctors, nurses, radiographers, pharmacists, or pathologists)
- Allied health professional
- Administrative/clerical staff

Tables 10 to 14 show the numbers of interviews conducted across the four study sites by staff occupation for the different stages of the project.

For each stage of the analysis, Trust staff were 'purposively' recruited. For the level 1 interviews, each role was matched as closely as possible across Trusts, i.e. the same set of questions being posed to the director of IM & T at each Trust. To gain an understanding of how the contextual-organisational factors changed over time, each staff member holding that role was interviewed twice, once in the early phases of implementation and again eighteen months later. For level 2 interviews about end-users' experiences, staff across Trusts were again matched as closely as possible; however, the primary consideration was recruiting staff with user-knowledge of the IT application being evaluated. Because some electronic applications were not implemented in any of our study sites across the study time frame, the number of participants recruited was lower than expected. This was particularly the case for electronic booking, which was timetabled to have been fully implemented in all acute trusts in England by 2005. However, at the time of this fieldwork, the roll out of this service was running a year behind schedule, which meant that front-line staff using this application were not available.

4.2.4. Procedure

NHS staff were recruited by the researcher, who directly approached the relevant person. Each potential participant was given an information sheet about the study, which described what participation involved. The researcher also explained the study in person and invited the person to take part. To help with recruitment, the researcher sent a global e-mail to hospital staff (outlining the study and what participation involved) and presented an informal overview of the study at a medical committee meeting of each Trust. Written informed consent to be interviewed was obtained in every case. The interviews were semi-structured, and conducted on a one-to-one basis at each Trust by a qualitative researcher (JH). The interview was conducted at the hospital at a time convenient to the participant, and lasted about an hour. Interviews were taped and transcribed. Participants were guaranteed that both they and their organisation would be anonymised.

Table 10: Level 1 stage A

Number of participants	Trust 1	Trust 2	Trust 3	Trust 4	Total
Senior managers	2	2	2	2	8
Middle managers	2	2	2	2	8
Senior Clinicians	2	2	2	2	8
Senior Clinicians	2	2	2	2	8

Table 11: Level 1 stage B

Number of participants	Trust 1	Trust 2	Trust 3	Trust 4	Total
Senior managers	2	2	2	2	8
Middle managers	2	2	2	2	8
Senior Clinicians	2	2	2	2	8
Senior Clinicians	3	2	2	2	9

Table 12: Level 2 e-booking

	Chief executive	Project manager	Clinical director	EPR trainer	Administrative staff
Trust 4	1	1	1	1	2

Table 13: Level 2 – Picture Archiving and Communication System

Number of participants	Trust 1	Trust 2	Trust 3	Trust 4	Total
Project manager	0	1	1	1	3
EPR trainer	0	1	0	1	2
Clinicians	0	3	2	3	8
AHPs	0	1	0	1	2
Administrative staff	0	1	0	1	2

Table 14: Level 2 – e-Test Ordering and Browsing

Number of participants	Trust 1	Trust 2	Trust 3	Trust 4	Total
Project manager	1	2	0	0	2
EPR trainer	1	1	0	0	2
Clinicians	7	6	0	0	1
AHPs	1	0	0	0	1
Administrative staff	1	1	0	0	1

4.2.5. Topics addressed

For the Level 1 interviews (stages A and B), we developed a set of core questions applicable across all the trusts (see interview schedule, **Appendices 1** and **2**). This generic approach allowed the researchers to gain a detailed overview of different factors influential to understanding why EPR innovation may have been difficult to achieve in the past, and to identify precursors for future implementation success. The following are examples of the contextual factors explored:

- Organisational structure: the physical, informational and organisational resources (costs) that facilitate or hinder IT use.
- Project management and staging: The perception of clear, reasonable goals, staff consultation and good planning, in particular perceptions of change management associated with preparing for the national solutions.
- Organisational commitment to implementation: The role of constant change in management teams and the NHS generally and exploration of whether this change has impacted on IT focus and staff commitment (seemingly exacerbated by the LSP appearing to poach NHS IT staff).
- Organisational 'fit' and the question of differing agendas, issues such as the perceptions of priorities and EPR implementation meeting the needs of 'everyman', i.e. the acute Trust, the SHA, and the NPfIT; the role of in-house IT innovations and their future, including any proposal to substitute stand-alone systems with standard, perhaps less immediately functional, LSP solutions.
- Conceptions of what constitutes EPR implementation success or failure: questions such as the meaning of success, at what level, and for whom, i.e. the Trust, the LSP or the NPfIT.
- The current relationship between Trust Managers and the information system in use.
- The impact of the IT innovation on the relationship between Trust Managers and other employees.
- Cultural/ social /organisational identity issues: past and current experiences and values, and the residual impact of previous implementations (e.g. previous in-house IT failures), and specific medical/ legal/ staffing problems.
- Perceptions of what the NPfIT should deliver, compared to what is currently perceived as being rolled out: exploring any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables.
- The role of leaders and super-users: the organisational impact of key players.

- Individual differences and categorisation of the person: levels of motivation, efficacy, involvement; the organisational impact of personal investment (or lack of it).

For the level 2 interviews, sample-specific questions were developed to capture organisational change in areas where implementation of specific IT applications has occurred, or is in the process or occurring (see interview schedules, **Appendices 3** to **9**). Using purposive sampling, staff with experience of using particular IT applications were recruited, i.e. Radiographers at Trust 4 using PACS (digital filmless radiology). Because the second level analysis was concerned with end-users' experiences (the process and impact of implementation) questions focused on:

- Knowledge of the IT application – training, support and information given.
- Technical capabilities - attributes such as the functionality, compatibility, complexity, 'userability', speed, and 'trialability' of the IT application.
- Nature of the change in behaviour – how easy or difficult was it to learn/do? Changes in cognitive processing – how they need to think?
- The relationship between electronic and paper records. Perceived advantages and disadvantages of each - regarding the availability, integrity, completeness, and compliance with best practice.
- Changes in working practices. Issues such as changes in communication patterns, decision-making, and role. Did the IT application impact on the clinician-to-clinician relationship, clinician-to-managers relationship, and clinician-to-patient relationship.
- The process of sharing ideas and learning the IT application – user acceptance, satisfaction and organisation of work.
- Users' organisational expectations of the IT application versus the current reality.
    - Individual differences - categorisation of the person – how motivated, efficacious, and involved are they. For example, certain groups of clinicians may resist changes in working patterns – not wanting to move away from standalone/existing systems to more standardised LSP solutions.

- The perceived impact of the IT application and changes to it from NPfIT on future working practices, clinical management and individual patient care. How can the positive effects of these IT applications be maximised? What are staff perceptions of the best way forward?

4.2.6. Analysis

Qualitative data from interviews and observations of meetings were analysed in accordance with the preliminary framework outlined above, with the analysis divided into two levels (organisational context and staff experiences). The aim of this division was to unpack the impact and processes of EPR implementation associated with each level. However, we also needed to present the 'messy' reality of association and causation that exists between the organisation, the IT, the EPR user and the patient. In reaching conclusions and untangling the effects of the structure of a system, from the effects of individuals that make up that system and use it, we applied a modified grounded theory analytic strategy,[80] which combined drawing on the literature on organisational change, and more user-centred sociological theories of innovation adoption and implementation, with themes emerging from the data, to present an analysis of processes over time.

According to grounded theory principles, the analytic strategy involved analysing the data at three separate time points, with different levels of analysis and types of process applied to each stage. This separation allowed developing categories to emerge in the first batch of texts, these ideas to be further compared, contrasted and developed in the second batch of texts, and the emerging theory to be tested against the data collected in the third batch. The final themes reported were further verified by another member of the team (NF) independently reading the transcripts, then the two team members working together (JH & NF) to agree final meanings.

Another requirement was to use a qualitative method that was complementary to the epistemological position of a multi-methods project. Few applied researchers would disagree that the question must be "which methodological approach is most suited to the research question or problem at hand"[81] (p.115). In applying Grounded Theory techniques there is "no fundamental

clash" between the purposes and capacities of qualitative and quantitative methods or data.[82] There is the belief that different methodologies pitched at different levels of analysis and types of research question, can uniquely contribute to measuring different facets of a given question. Each method is considered useful in the verification and generation of theory, with the main point of emphasis being the continued generation of ideas and knowledge.

4.3. Methods for the quantitative study

4.3.1. Study design

Our study used a quasi-experimental controlled design, i.e. a "controlled pre-post 'cohort' design",[83] also often called a "controlled before-and-after" design. The principle of the design is described in detail below. We tested for effects of implementing CPOE and PACS by making comparisons between Trusts (the control group comprised those Trusts in which CPOE or PACS had not been implemented), and by making comparisons within Trusts (the control group comprised those specialties in which CPOE or PACS had not been implemented).

4.3.2. Outcomes

The outcomes used in our study are summarized in **Tables 15a** and **15b**. These outcomes evolved from a larger set of indicators which had been defined a priori, based partly on consideration of the NHS Efficiency Map.[54] Our study outcomes evolved during data collection and analysis, as it became apparent which would meet the criteria of feasibility (data availability), reliability (data quality), and comparability (between and within Trusts, and with studies in other settings). The outcomes also had to be meaningful, in terms of interpreting the effects of implementing CPOE and PACS.

We classified outcomes as primary or secondary based mainly on a consideration of the causal pathway between implementation of an IT system and the outcome. Hence, an IT system which facilitates clinicians' access to previous pathology test results or radiological images, and which also reduces the likelihood of results or images being lost, might be expected to have a

direct impact on primary outcomes such as the number of tests ordered or exams requested per inpatient day or per outpatient appointment, and the interval between repeat tests or exams. Secondary outcomes such as inpatient length-of-stay, emergency re-admission following inpatient stay, or non-attendance at outpatient appointments, might be indirectly affected by improvements in pathology and radiology IT systems, but would also be influenced by operational changes within the hospital unrelated to implementation of these systems. All outcomes were defined prior to comparative analyses being carried out.

For the CPOE analysis, we considered three types of pathology test: full blood count (FBC), urea and electrolytes (UE), and urine culture (UC). For the PACS analysis, we considered three types of radiological examination: plain film (PF), computed tomography (CT), and ultrasound (US).

4.3.3. Data sources

Inpatient and outpatient data were obtained from IM&T departments in each Trust. These data were a subset of the Commissioning Data Set (CDS) which each Trust sends on a regular basis to the NHS-wide Clearing Service (NWCS), from which Hospital Episode Statistics (HES) and other statistics are generated for the Department of Health (DoH). We used the NHS Data Dictionary to identify variables relevant to our study (**Appendix 10**), and the data were extracted by IM&T staff from their archives.[84] Pathology and radiology data were obtained from the pathology and radiology departments in each Trust. All of these departments maintained electronic records from which data for the study period could be extracted. In two instances (Trust 2 pathology and Trust 3 radiology), data were extracted under a contractual arrangement with the commercial provider of the radiology/pathology system.

Table 15a: Primary study outcomes: derivation and interpretation

	Primary outcome	Derivation	Analysis (measure of effect)[1]	Interpretation of result
Inpatient	Tests per inpatient (non-zero vs zero response)	Likelihood of an inpatient having one or more tests/exams ordered/requested.	Logistic regression (odds ratio, OR)	OR<1 indicates a reduction in inpatient tests/exams
	Tests per inpatient day (continuous non-zero response)	Number of tests/exams per patient divided by length of stay (log transformed for purpose of regression), excluding patients who had no test/exam.	Linear regression (coefficient, Co)	Co<1 indicates a relative reduction in inpatient tests/exams
	Tests per day case (non-zero vs zero response)	Likelihood of an actual day case (i.e. zero length-of-stay) having one or more tests/exams ordered/requested.	Logistic regression (odds ratio, OR)	OR<1 indicates a reduction in tests/exams per day case
	Test within 48hrs of prior test of same type	Likelihood of an inpatient having a test/exam ordered/requested within 48hrs of having test/exam of same type during one hospital spell.	Logistic regression (odds ratio, OR)	OR<1 indicates a reduction in repeat inpatient tests/exams
Outpatient	Tests at outpatient appointment (non-zero vs zero response)	Likelihood of an outpatient having one or more tests/exams ordered/requested at an outpatient appointment.	Logistic regression (odds ratio, OR)	OR<1 indicates a reduction in outpatient tests/exams
	Same test at next outpatient appointment	Likelihood of an outpatient having the same test/exam ordered/requested at an outpatient appointment as was ordered/requested at the preceding appointment.	Logistic regression (odds ratio, OR)	OR<1 indicates a reduction in repeat outpatient tests/exams

[1] Measures of effect represent the relative outcome for patients in trusts that implemented the IT application (PACS or CPOE) after implementation compared to patients in control trusts, taking into account the outcome 'rate' for patients in corresponding trusts in 2000.

Table 15b: Secondary study outcomes: derivation and interpretation

	Secondary outcome	Derivation	Analysis (measure of effect)[1]	Interpretation of result
Inpatient	Length-of-stay (excluding day cases)	(Hospital provider spell end date - hospital provider spell start date) for all inpatients.	Cox regression (hazard ratio, HR)	HR>1 indicates shorter inpatient length-of-stay (i.e. greater likelihood of being discharged)
	Inpatient treated as a day case (i.e. zero length of stay)	Likelihood of an inpatient being discharged on the day of admission.	Logistic regression (odds ratio, OR)	OR>1 indicates increase in day case admissions
	Intended day case patient admitted overnight	Likelihood of an intended day case (i.e. intended management = "day case") being admitted overnight.	Logistic regression (odds ratio, OR)	OR<1 indicates fewer day cases admitted overnight
	Emergency re-admission (within 28 days)	Likelihood of an inpatient being re-admitted within 28 days with admission method = "A&E" or "GP Immediate".	Logistic regression (odds ratio, OR)	OR<1 indicates a lower emergency re-admission rate
	Deaths	Likelihood of an inpatient having discharge method = "died".	Logistic regression (odds ratio, OR)	OR<1 indicates a lower mortality rate
	Time-to-death	Hospital provider spell end date - hospital provider spell start date if discharge method = "died"; surviving inpatients were censored at discharge.	Cox regression (hazard ratio, HR)	HR<1 indicates a longer time to death
Outpatient	Attendance (Attended vs Did Not Attend)	Likelihood of an outpatient attending his/her appointment.	Logistic regression (odds ratio, OR)	OR>1 indicates a higher outpatient attendance rate
	Outcome (discharged vs follow-up)	Likelihood of an outpatient having the appointment outcome = "discharged" (no follow-up appointment).	Logistic regression (odds ratio, OR)	OR>1 indicates a higher outpatient discharge rate

[1] Measures of effect represent the relative outcome for patients in trusts that implemented the IT application (PACS or CPOE) after implementation compared to patients in control trusts, taking into account the outcome 'rate' for patients in corresponding trusts in 2000.

4.3.4. Data analysis

Each patient who received care from a Trust was routinely allocated a 'local patient identifier' which was unique within that Trust. This patient identifier typically comprised a six or seven digit number, preceded or followed by one or two characters corresponding to a hospital within the Trust. The inpatient and outpatient datasets comprised one row for each episode of admitted patient care or outpatient appointment. The radiology and pathology datasets comprised one row for each test or exam. All datasets contained the local patient identifier, which we used to join the inpatient and outpatient datasets with the pathology and radiology datasets, and so derive the primary outcomes. Secondary outcomes were derived directly from the inpatient/outpatient data. All analyses were performed using Stata v9 (StataCorp. 2003. Stata Statistical Software: Release 9. College Station, TX, USA).

Between-Trust comparisons

The effect of an IT system on an outcome could be detected by comparing trends in that outcome in a Trust in which a new system had been implemented (the 'intervention' Trust) with trends in the outcome in Trusts in which no new system had been implemented (the 'control' Trusts). Models were based on time periods corresponding to the periods before, during, and after implementation of the IT system.

For primary outcomes, separate models were required for pathology and radiology systems. In each of these models, the effect of the new IT system is estimated by the regression model term for the interaction between the intervention Trust and time period, specifically by the interaction parameter corresponding to the post-intervention period. The baseline in this model is the outcome in 'control' Trusts during the pre-intervention period. The model also generates a parameter which estimates the change in the outcome comparing the post- and pre-intervention periods in the 'control' Trusts. This parameter

provides a context in which to assess the magnitude and direction of the change in the outcome attributable to the intervention.

For secondary outcomes, a single model with two such interaction terms was used; one interaction term estimated the effect of the new CPOE system (in Trust 1), the other estimates the effect of the new PACS system (in Trust 4). The time periods for implementation of CPOE and PACS in Trusts 1 and 4 respectively were, coincidentally, approximately the same (see **Tables 3 to 5**). The time period during which the systems were implemented was retained in the model but is not reported.

Between-Trust comparisons were controlled for case-mix differences between Trusts by including clinical specialty (CDS data element 'treatment function') as a categorical variable in the models, and by restricting our analyses to the main specialties common to all Trusts. Common inpatient specialties were general surgery, general medicine, urology, trauma & orthopaedics, accident & emergency, paediatrics, obstetrics & gynaecology. Common outpatient specialties were all of the above plus ENT, ophthalmology, endocrinology, haematology, cardiology, dermatology, nephrology, oncology, neurology, rheumatology, and geriatric medicine.

Effects on binary outcomes were assessed using logistic regression, and effects on continuous outcomes by ordinary least squares linear regression, with a natural logarithmic transformation to obtain a near-normal distribution. Continuous outcomes with a high proportion of zero values, e.g. test/exams per inpatient day, were analysed using logistic regression to model the probability of a zero response, and linear regression to model the non-zero continuous response.[85] Effects on length-of-stay and time-to-death were assessed by Cox regression, after checking the proportional hazards assumption. We analysed each type of pathology test and each type of radiological exam separately. Ultrasound was not an element of the PACS in Trust 4, but data on ultrasound examinations were analysed by way of comparison with trends in PF and CT examinations. Robust standard errors were calculated to take into account clustering of observations by Trust and by clinical specialty.

Within-Trust comparisons

The effect of an IT system on an outcome could also be detected by comparing trends in that outcome within a Trust in specialties which had adopted a new system (the 'intervention' specialties) with trends in the outcome in specialties which had not adopted the new system (the 'control' specialties). Models were based on time periods corresponding to the periods before and after implementation of the IT system.

The effect of the new IT system is isolated in the regression model term for interaction between the intervention specialties and time period. The baseline in this model is the outcome in 'control' specialties during the pre-intervention period. As with Between-Trust comparisons, logistic regression was used for binary outcomes, linear regression for continuous outcomes, and a combination of logistic and linear regression for zero-inflated continuous outcomes.

The following within-Trust comparisons were performed: for CPOE within Trust 1, a comparison of obstetrics with all other specialties; for PACS within Trust 4, a comparison of trauma and orthopaedics with all other specialties. In Trust 1, CPOE was never implemented in obstetrics, hence this specialty serves as a constant control. Within Trust 4, PACS was implemented first in trauma and orthopaedics, and then in all other specialties (see **Table 16**). For the purpose of our analyses, six time periods were defined corresponding to the intervals: before implementation of PACS (period#1 01/2000-05/2001), during implementation of PACS in A&E and orthopaedics, split into two periods (period#2 06/2001-11/2001 and period#3 12/2001-05/2002), during implementation of PACS in all other specialties, also split into two periods (period#4 06/2002-10/2002 and period#5 11/2002-03/2003), and after Trust-wide implementation of PACS (period#6 04/2003-12/2005). We compared outcomes in A&E and orthopaedics before and after implementation of PACS, adjusted for the underlying trend in the same outcomes in all other specialties, using period#1 and period#2 combined as the pre-intervention period (no PACS) and period#3 and period#4 combined as the post-intervention period

(PACS in A&E and orthopaedics, no PACS in any other specialties). We then compared outcomes in all other specialties before and after implementation of PACS, adjusted for the underlying trend in the same outcomes in A&E and orthopaedics, using period#3 and period#4 combined as the pre-intervention period (PACS in A&E and orthopaedics, but no PACS in any other specialties) and period#5 and period#6 combined as the post-intervention period (PACS in all specialties). Standard errors were adjusted for clustering by clinical specialty.

Table 16: PACS within-Trust 4 comparison periods.

Period	Start date	End date	PACS in A&E + orthopaedics	PACS in other specialties	"1st PACS" comparison	"2nd PACS" comparison
1	04/2000	05/2001	Pre-implementation	Pre-implementation	No PACS in any specialty	Data not used
2	06/2001	11/1001	During implementation			
3	12/2001	05/2002			PACS in A&E + orthopaedics	PACS in A&E + orthopaedics
4	06/2002	10/2002		During implementation		
5	11/2002	03/2003	Post-implementation		Data not used	PACS in all specialties
6	04/2003	12/2005		Post-implementation		

5. Qualitative findings from Level 1: Implementation of NPfIT at local level

This chapter presents findings from both stages of 'level 1' i.e. our study of the implementation of the NPfIT in four trusts over a two year period. Stage A, consisting of 24 interviews, took place between July and October 2004. Stage B, consisting of 25 interviews, took place between February and April 2006. These findings have been published or are about to be published[86 ,87] and this chapter draws heavily on these papers.

5.1. Stage a.: results

Table 17 shows the baseline characteristics of each trust and the expected date for replacing these with the NCRS/NPfIT. Data from the first round of interviews show the potential impact of the factors that emerged on implementing the NPfIT.

Table 17: Trust characteristics

	Trust			
Characteristic	**1**	**2**	**3**	**4**
Size	Large	Large	Large	Small
Number of main sites	2 [earlier merger]	2 [earlier merger]	1	1
Financial situation [a]	Moderate deficit <£5m	Small surplus	Large deficit <£10m	Small deficit <£1m
Performance indicators [b]	1 star	2 stars	0 star	2 stars
Expected date for PAS replacement	Unknown	2007	2006	2004/5 earlier adopter e-booking

[a] Annual accounts for 2002/3

[b] CHI Clinical Governance Review 2002/3

5.1.1. Multiple sites within trusts

Two of the trusts have multiple sites, resulting from recent mergers, and problems of poor communication and coordination between sites remain. Differences in working practices and organisational culture seem to have created tensions that may make the job of getting ready for the NHS care record service especially challenging (see box 1). Major changes resulting from the recent mergers seem to have affected staff morale, increasing the likelihood that staff will become resistant to the changes required during implementation.

Box 1: Issues of multiple Trust sites and change overload

"There's the difference in cultures between the two ends of the same Trust, the culture where the whole senior management team transported themselves over. And so I think at one end within the Trust, the [name] end, the clinicians and the nurses and others are all used to a different way of working, which the people here are not. So I think there is a big difference actually between—if you ask people at that end I think you'll find a very different philosophy there."—Clinical director, Trust 2

"One of the things that definitely makes life much easier is that we're a single site organisation, so there is a single culture around this place; we're not a difficult political being with eight or nine hospital sites spread around. From an IT point of view that's very difficult to support and manage."—IT manager, Trust 4

"So, like I said, I think the organisation, leaving aside the IT, has quite a few issues still in terms of the changes it's gone through. Then add in the national programme and that's just, just another thing on top, and that's going to affect working practices across the whole organisation … It is yet another change, and I think certainly people are fed up of change and people do identify the national programme as being yet another IT project that is probably not going to work, that's going to cost a great deal of money, and why should they really cooperate with it?"—Clinician involved in development of electronic patient records, Trust 1

5.1.2. Communication between the NPfIT and the NHS

The lack of clarity from the NPfIT about future developments—with poor communication between NPfIT headquarters, the local service provider, and Trust managers—was reported to be a major concern in all four Trusts. Managers felt that local needs and advice have been ignored and expressed sentiments in interviews of feeling ignored, being "done unto," and disempowered (box 2). Participants' views suggest a divide between the central NPfIT office and Trusts, with the latter perceiving the former as failing to understand local issues. This lack of communication seems to have filtered

down, with managers reporting a reluctance to communicate the benefits of the NPfIT to front line staff without having answers to questions about what IT services will be supplied and when (box 2).

Box 2: Issues of communication with NPfIT headquarters and lack of clinical engagement

"So I think we've not had, you know, we had some of the interaction, and I think what we've been asking for is clarity about, um, getting things done, what isn't coming, things like. There was really something last week about … the radiology systems, about the radiology information system and PACS, and in the application there's no radiology information system, there's just PACS."—Executive director, Trust 2

"The communication has been appalling, absolutely appalling. They've done some wonderful events, and I've met some people who are great, NPfIT, who are very facilitative and very enabling, and the next week you're told you're not allowed to talk to them. I've been to some meetings where I've met people who are very very good, and we've been ordered not, instructed, they've been ordered and we've been instructed that it's inappropriate to talk to them.—IT manager, Trust 4

"Despite what people say there's a lack of, there's a lack of engagement and, you know, even as chief executives, I think we've been involved and been asked to promote something they, we're promoting—we say it's a bit like trying to go and sell, probably in IT terms, vapourware and that's really what it felt like."—Chief executive, Trust 3

"I would say that the clinicians are sort of waiting to see what's going to happen before they commit themselves."—Assistant director of nursing, Trust 4

5.1.3. Financial circumstances of Trusts

Two of the Trusts had substantial financial deficits, which were reported as contributing to slow progress on local IT projects (box 3). Central funding does not cover all of the costs of implementing the care record service, and local IT spending must be sustained or increased to provide the infrastructure necessary to support it.[88] For participants, funding for the change management associated with the care record service was a key concern. Up to March 2004, instead of increasing spending, participants in "cash strapped" Trusts reported that scheduled IT implementation had been halted to await details of the NPfIT to be made public (box 3). Understandably, Trusts may be reluctant to spend on IT if some of the cost will be covered centrally. This lack of certainty seems to have created "planning blight," with participants reporting

that few IT initiatives have been championed (box 3), thus potentially widening the IT gap between "cash rich" and "cash poor" Trusts.

5.1.4. Performance ratings

For Trusts with a low performance rating (0 or 1 star), improving this rating was reported as a pressing concern (box 4). (Although the future of performance ratings is under review, performance indicators are likely to continue to be a key focus for Trust managers.) Benefits of the NPfIT (which has a 10 year roll out), such as financial savings and improved patient care, will not be realised until after money has been spent on implementation. This will probably require investment in staff training as well as the IT infrastructure, perhaps temporarily reducing staff time available for clinical care. Trusts are likely to avoid any activity that decreases rather than increases productivity unless sufficient extra financial and human resources are provided (box 4).

Box 3: Issues of financial deficits

"I mean our first, our number one priority in this Trust been stated by the [chief executive], and is quite clear to anybody, is money. We have to claw back our deficit, a huge deficit; [name] has an ever bigger one, and we are a very, um, broke strategic health authority, actually, but particularly this local health community. We're very strapped for cash, and we have to find millions and millions of pounds worth of saving this year alone and indeed over the next three years."—IT and NPfIT project manager, Trust 3

"And we have a senior management that have too much on their plate to cope with at the moment, and EPR [electronic patient records] and IT, as well as between [large figure] million pound underlying deficit. We're certainly not a Trust that can invest from our own resources."—Medical director, Trust 1

"We've made real progress, um, in the development of our EPR programme, and those who've done so much work in that particular programme are naturally quite distressed if our particular EPR programme is simply going to go on hold for two, three, or four years, while we wait for a national programme to be implemented."—Medical director, Trust 1

"You know, the abandonment, the abandonment of the EPR has had an affect on people's desire to get involved too much in that way—let's wait until a bit later … I think there's a 'Let's just not invest too much time' attitude at the moment and see how it goes from here."—Assistant director of nursing, Trust 4

Box 4: Issues of performance ratings

"At the moment, you know, a lot of chief [executives], a lot of your short term focus is on star ratings and performance management because that's where, you know, the carrot, that's why you're driven down that route. So, you know, we're paid to do that and keep the strategic vision going, but it depends how much pressure you get about where your focus could be."—Executive director, Trust 2

"So if that national programme wants this to happen they, the government, whoever, must make sure any moneys that come down through whatever route are ring fenced, and they're ring fenced right down to Trust level, so that creative finance directors and others cannot divert them for other purposes."—IT and NPfIT project manager, Trust 3

5.1.5. Supporting "legacy" IT systems

The NHS has traditionally devolved IT procurement, resulting in a proliferation of IT architecture. This approach contrasts with centralised standard setting and procurement under the NPfIT. Potential legacy problems reported by participants are the loss of existing electronic functionality and concerns over support for existing systems during any transition period.

All Trusts in our study reported having highly effective customised pockets of IT. If these systems cannot be integrated with national "standards" some functionality may be lost (box 5). Loss of existing IT function may stall progress and is likely to be resisted. IT literate clinicians in our sample reported working hard to develop systems that best support their needs and the needs of their patients (box 5).

Replacing existing systems will require contracts with existing suppliers to be redrawn. Maintaining goodwill and continued support for such systems may be difficult. Trusts that actively pursued the original plan for electronic patient records[5] may be particularly disadvantaged if they are bound into long term contracts with suppliers not awarded contracts under the national procurement process.

Box 5: Issues of loss of functionality and resistance from clinicians

"There's a feeling of loss of autonomy, um, and possibly lack of or loss of functionality, because some of the systems that we've got are, have been developed over a period of time, and they're pretty well customised and people get used to that level of customisation."—Chief executive, Trust 4

"Where it needs tailoring to local Trusts—I don't think that's being listened to at all, and that's where they're going to find the biggest amount of resistance, which is where local systems will always be better than the national solution."—Electronic patient records and NPfIT programme manager, Trust 2

"Our ITU consultant writes programmes: he wrote the ITU one here, and he's writing us a little program for duty doctor handover. It's like swimming in treacle to get it integrated into our system. You can't get it if you're in a, you know, in a regimented system that is becoming increasingly."—Medical director, Trust 1

"If we're saying to people, 'You have to drop what you've got to a lower function,' well that's going to be very hard to sell."—IT director, Trust 4

"Until we can get that level of functionality built into the national solution nobody is going to use it, well not from our Trust anyway."—Electronic patient records and NPfIT programme manager, Trust 2

"So, yeah, they may have been working overtime developing their own system and now are being told, 'No, you can't use it.' And you have something which isn't as good or doesn't allow as much functionality or flexibility perhaps as something else."—Research and development business manager, Trust 2

"As a tax payer, I'm furious, as a clinician who's dedicated time speaking on behalf of other professionals who've spent hours of unpaid time trying to make this work, they feel devalued, marginalised, and ignored. So there's enormous anger in this organisation, particularly at [name], with the way in which we've been dismissively treated."—Medical director, Trust 1

5.1.6. Timetable for replacement of patient administration systems

To implement the care records service software, most Trusts will need to replace their existing patient administration systems. The new administration system will act as a foundation on which additional "bundles" of clinical functions can be added. However, patient administration systems cannot be replaced immediately in all Trusts. For example, in London this activity alone is projected to take up to five years. The timing of this replacement is causing concern, and participants reported that their Trusts have been jostling for a slot that meets their particular needs (box 6).

Three Trusts have reported an urgent need to replace existing administration systems for radiology or pathology. According to participants, the previously scheduled implementation of such replacement systems has been put on hold

until details of the NPfIT have been made public (box 6). Such delay may mean a risk of system failure, but buying a temporary solution is seen as costly. Being first in the queue for implementing the care records service may increase the risk of delays and teething problems, with details of forthcoming support from the local service provider for change management still unclear. However, being at the end of the queue may lead to "planning blight," with no new local IT development until the new administration system is provided (box 6).[88]

Box 6: Jostling for a new patient administration system (PAS), concern over delays, and "planning blight"

"And so, obviously everybody wants the [new] PAS straight away, and you're obviously in the queue for that with everybody else."—Divisional manager, Trust 4

"It's going to be an absolute scrabble, you know, and I'm a bit annoyed. We went to a launch day for the, for the [local service provider] and one of questions I said, 'You know, there's 77 Trusts, a limited number of slots [for PAS replacement], you know, it is going to be a big bun fight.'"—IT director, Trust 4

"If we aren't one of the first PAS's, which I don't think we are, it could be 2010 or something before we even get a PAS, and then, you know, we've got to implement all the various compliant systems. So it could be a, over a decade before anybody, you know, and it will be over a decade in some places before anybody at some Trusts see any difference.—Chief executive, Trust 4

"Our biggest sort of stopping block for taking anything from NPfIT is the fact that nine times out of 10 we've got to have the [new] PAS in, so, as much as we would like to take some of the modules, we can't—Electronic patient records and NPfIT programme manager, Trust 2

"It's, well, it's been delayed basically. I mean in implementation, purchase and implementation of the system by a year and a half, I think, while we're inevitably waiting for the [local service provider] to be sorted, and now we're waiting for the process to go though … It's a bit of a mish-mash going on there, I must say. Um, I think, you know, you've got to kind of look at your local priorities in this case and say, 'We need a new system in for risk factors and for managing demand and recording data better, um, and we need to go ahead and purchase as soon as we can.'"—Divisional manager, Trust 4

"NPfIT for London said, 'No, you have to do it this way.' And it's not, it's just not up for negotiation, it is a very centrally driven mandate. 'You will take PAS, you will take some minimum orders that include maternity and theatres, and then you can take some prescribing and some pathways.' So, we were definitely aiming to do the clinical end of things first … it is frustrating because that's—you're right, in terms of strategy we did not want to do our PAS next and we did not want to do theatres and maternity."—IT director, Trust 4

5.2. Stage b.: results

Six main themes emerged from our phase a of this part of the study[86]:

1. The impact of multiple sites resulting from recent mergers
2. Poor communication between Connecting for Health (CfH) and local managers
3. The impact of financial deficits
4. The need to prioritise performance targets
5. Supporting existing 'legacy' IT systems
6. The delayed timetable for replacement patient administration systems

Eighteen months later, three of the previous concerns were still apparent (themes 2, 4, 5 below) and five new issues were raised:

1. Increased support for the overall goals of the programme
2. *Continuing* impact of financial deficits
3. Managers distracted from implementing the programme by other priorities
4. *Continuing* poor communication between CfH and local managers
5. *Continuing* delay in replacing patient administration systems
6. Growing risk to patient safety associated with delays
7. Loss of integration of components of the programme
8. Discontent with Choose & Book

The issues raised in interviews were similar among staff who had taken part in the first round of interviews and among staff who not been interviewed previously.

5.2.1. Increased support for the goals of the programme

Since the first round of interviews, we found that support for the concept underlying the programme had grown. The overriding view was that the NHS urgently needs the benefits that can be gained from IT modernisation implemented in a standardised way. (Box 7) We found very little resistance to IT modernisation, with interviewees reporting that their staff are ready, and sometimes "desperate", for progress. However, alongside this growing support, we also found concern about the ability of programme managers to deliver the programme. To maintain momentum, interviewees said that CfH

needed to deliver products that work very soon. They also emphasised the need for independent evaluation to measure the benefits and costs (Box 8).

Box 7: Increased support for the overall goals of the NHS IT programme

"I still maintain it's the right thing to do. I think the principle, the principles, the philosophy and the vision I think are absolutely sound. The challenge has been deliverability …" [Chief executive, Trust 4]

"two years on I still believe in the concept, um, because I think the biggest single problem we have is sharing information between organisations and actually even within organisations, so the idea of having a single system or common systems as an IT concept only makes sense" [Director of IM & T, Trust 4]

"The consequences are, um, a complete re-think about the way that, um, IT is introduced and it's needed it desperately…NHS IT programme is visionary, brilliant" [Director of IM & T, Trust 2]

Box 8: More product placement and benefits realisation

"We have to get some confidence back into the programme and that has to be about delivery because they can talk until the cows come home, but unless we see something happening on our own patch with a real clinical win to keep people onboard…" [Director of IM & T, Trust 4]

"I think one of the things that they haven't done very well is clarify some of the benefits they think that you're going to get out of it. …I haven't seen, you know, a good list of benefits… I mean, you know, about between GPs and consultants, I mean actually things like managing a waiting list" [Director of performance and improvement of information, Trust 1]

"I think the…two big difficulties, the two big issues will be affordability, is it really going to deliver the benefits, um, for the cost and is it, is it a cost pressure rather than an enabler of better efficiency across the organisation as a whole? …we are dependent on getting benefits out of it. …and I'm not confident at this stage this stage that the system in operation will be so beneficial that it will really drive loads of things forward" [Chief executive, Trust 3]

5.2.2. Continuing impact of financial deficits

In our earlier interviews, senior staff in Trusts facing financial difficulties were concerned about how to pay for the implementation costs associated with IT modernisation. Currently, financial difficulties within the NHS are even more widespread and this issue has become more important. Respondents reported that making savings is now more critical and that applications which are part of the programme are not the bargain they were expected to be. Implementation of picture archive and communication systems (PACS) is also

causing disquiet. Some respondents reported that PACS applications supplied through the programme appear to be more expensive than market alternatives (Box 3) but a central CfH mandate has left them with no choice but to implement the more expensive programme option. (Box 9)

Box 10: Expensive solutions especially PACS implementation

"a lot of the things are being sold to us at a much higher price than we would have been able to get if we'd been in a real market situation, so the total costs to the NHS have been very high indeed." [Medical director, Trust 4]

"You know, we went out to procure a PACS system that was not part of the national programme, and, you know, got told we couldn't do it. That's resulted in more, a lot more expenditure for the Trust than the local solution, so I think that then heaps another layer of problems on… where we have a deficit, um, to be forced down a route that's more expensive without…financial support that really we should be getting about that, you know, it's just another disincentive really." [Chief executive, Trust 2]

"it's certainly extensive costs, um, and it's compulsory acquisition, we have to have it in by March, that's it. So, it's, it's just a cost pressure, it's another, another one of many cost pressures at the Trust." [Head of system delivery, Trust 1]

5.2.3. Managers distracted from implementing the NPfIT by other priorities

Financial deficits not only cause concern about how to pay for implementation of the programme but also act as significant distractions for managers. In the earlier interviews, some Trust staff reported that recent mergers and the need to prioritise attainment of performance ratings made it difficult to prepare for the programme. Eighteen months later, the priority of Trust finances dominated. Two of our four Trusts have had 'turnaround teams' in place (external consultants brought in to help Trusts resolve financial crises). One Trust also had the Department of Health's performance support team working with it. The dominant and immediate need to eliminate any overspend, whilst maintaining performance, appears to leave managers little time to commit to implementing the programme or any other new services or products. (Box 11) The programme was only reported to be a pressing priority in Trusts where managers perceived a significant risk to patient safety from having to maintain existing legacy systems while waiting for new systems to arrive. (Box 15)

5.2.4. Poor communication between Connecting for Health and local managers

Previously, interviewees in all four Trusts were concerned with a lack of clarity from CfH about the timetable for implementation. Eighteen months later, although respondents were enthusiastic about the goals of the programme, the perception of poor communication was unchanged. There is still uncertainty about the timetable for delivery of key components of the programme (e.g. core hospital administration systems compliant with the hardware and software applications that will make up the programme) and about the extent of financial assistance for 'required' components. Respondents reported that much of the decision making has been between CfH and the local IT service provider. This lack of local involvement appears to have increased feelings of disempowerment and frustration. (Box 12) The uncertainty has also resulted in some Trusts adopting policies that actively discourage staff from engaging with the programme (Box 13).

Box 11: Managers distracted from implementing the NHS IT programme by other priorities

"Actually motivating people in this particular Trust at this particular time to have the vision to get involved in a nation-wide project, which isn't delivery, is virtually impossible. The majority of my colleagues are surviving day to day with no beds, cuts… There are real immediate issues, there isn't the, um, the luxury, I suppose, of people having the time and the intellectual capacity to pursue a ten year vision. We try to, we're trying to survive." [Medical director, Trust 2]

"I would like to see good IT systems within the NHS…where I'm coming from in a Trust that's got the Performance Support Team in and we've got the Turnaround Team in, um, we are trying to pull out a great deal of expenditure about ten percent of our budget…it does feel a little unreal trying to implement a large IT system on top of that… there's no real plans yet because we haven't got that far. And, to be honest, the whole other agenda [making savings] is just taking my time up." [Director of nursing, Trust 1]

Box 12: Continued uncertainty and feeling of disempowerment

"The frustration is we're not the customers, as far as the suppliers are concerned…. CfH pull the strings, it's their contract, we're just the entity that takes the solution" [Director of IM & T, Trust 2]

"The communication has been bloody awful really…we've kind of been the recipients of those relationships as opposed to being directly as influential as we would like to be in those relationships. I'm saying is every two months we say "Where's my pathology system?" "Oh, well, we've got to finish this …" so you kind of tune out, that's how it has felt, you've felt a little bit I guess disempowered really, um, because, you don't have the internal levers to actually, most problems I've got I can sort out a lot, but I feel it's not within my power to sort them out." [Chief executive Trust 4]

"so ourselves kind of at the bottom of the food chain we just, we don't get involved in any of this and it has been two-and-a-half years, it seems to be solid negotiation and re-negotiation between NHS IT programme and BT." [Director of IM & T, Trust 4]

Box 13: Lack of clinician engagement

"I'm not driving the national programme forward at all…. We're not doing any enabling at all as far as that process is concerned. I'm definitely not going to do what some of my colleagues have and that's work on the basis that they were getting their slots and have ended up with staff employed, ready to go and nothing to go with." [Director of IM & T, Trust 2]

"we've actively discouraged it here [engagement], which is a strange thing to do, in a way, but because we didn't want to raise expectations…there is no software backing that up at the moment, or not that we've seen…I don't encourage our clinicians to get involved on the demonstration days." [Director of IM & T, Trust 4]

"I wouldn't go out and sell it to people because I don't know when it's going to arrive. …getting people too enthusiastic on specific timescales would have been very dangerous." [Chief executive, Trust 4]

"I think the biggest problem we've had, as an organisation, is, um, you have to have a product to sell to the clinical staff to get them enthused, to get them to use it, and the biggest problem we've had is that the product has not revealed itself to us yet." [Medical director, Trust 3]

5.2.5. Continuing delay in replacing PAS

In the first interviews, respondents were concerned about when their PAS would be replaced. Originally, the national programme planned for PAS to be installed before any clinical applications. Due to delays in developing a PAS that can achieve connectivity with the 'spine' (a nationally accessible summary patient record)[89], this plan has had to be revised and interim off-the-shelf applications are now being offered. The revised plan has slowed progress

and Trusts are still unsure when their replacement PAS will be implemented. Interim applications will allow Trusts to move forward to some extent, but will not achieve the promised wider connectivity with other NHS hospital Trusts and primary care teams. (Box 14)

5.2.6. Growing risk to patient safety associated with delays

Before the NPfIT was conceived, NHS hospitals bought their own IT systems. When first interviewed, senior clinicians were worried that the replacement of these systems (often carefully customised to meet local needs) might result in a loss of functionality. This concern, though still evident in stage b. interviews, has been largely superseded by the urgent need to replace legacy systems. When details of the NPfIT were announced in late 2002, many Trusts stopped investing in their existing IT systems, choosing instead to spend money on other priorities while waiting for applications compliant with the programme systems to be supplied. Delays mean that Trusts in our study are still waiting for new systems. Where replacement systems were needed in 2002, the delay is now perceived to represent an unacceptable risk to patient safety, with Trusts considering buying interim systems outside the NPfIT. (Box 15)

Box 14 Continued delays and re-planning

"the dates keep getting re-planned because we're not allowed to say delayed anymore we joke in this Trust that NHS IT programme is never closer than two years away and just when you think it's actually going to be closer it suddenly goes…. again and it's two years away again." [Systems training manager, Trust 3]

"I see all the sort of stuff, the propaganda that comes out from CfH and they're always saying how a lot of these things are actually on time, despite what the press says, um, hundreds of people are using the new systems and all that sort of, and I must say, you know, there's not an awful lot of evidence of that across the country, I don't think." [Clinician lead for CfH, Trust 2]

"They obviously, they know that the CRS isn't going to deliver in a sort timely manner, so they're kind of looking at this other product to work with existing PASs." [Assist. director of IM & T, Trust 4]

"so we've got these tactical solutions coming in and that helps because we're seen to be moving forward. My only problem with tactical solutions is that in a few year's time one expects that tactical solutions to be replaced with whatever IDX is going to demand and I don't know that I really want to put my Trust through implementing a tactical PAS and then doing it again." [Director of IM & T, Trust 2]

Box 15: Concern over growing risk to patient safety, some Trust may go it alone.

"…our path system is extremely out of date, it's not just obsolescent, it's obsolete. When we had to buy some new bits for it recently we had to buy them through Ebay from someone in America because there's just no bits in this country, so it's a huge risk to the Trust that we're still carrying this path system…" [Medical director, Trust 4]

"It's been urgent that it's replaced all the time I've been here, which is about three-and-a-half years, so I mean the first thing I heard about when I arrived was the fact that the PAS system needed to be replaced. It is a clinical risk" [Director of nursing, Trust 1]

"And there are a number of risks that are associated with our old system, some very serious risks and risks in development and progress within the organisation and between the organisations due to this lack of putting a good idea into practice. [Divisional manager for diagnostic therapies and outpatients, Trust 4]

"that's a risk we, that is a risk. I mean it could, you know, die tomorrow, it's such an old system and then we are really stuffed, basically." [Director of nursing, Trust 2]

"People are saying 'Thank god we're going to get a new system that will replace this load of old, you know, cobblers.'…Americans use the expression "You need a burning platform to get change." Well, I think from an IT perspective we've probably got one." [Director of IM & T, Trust 2]

"One of the options I have is to say 'To hell with it, I'll just go and buy one.' Well, that's a kind of tricky decision and that's the decision some of my peers are making elsewhere, they're saying 'Well, sod that, I'll go elsewhere.'" [Divisional manager for diagnostic therapies and outpatients, Trust 4]

5.2.7. Loss of integration of components of the programme

The original goal of access to information across the NHS, that underpinned the NHS IT programme appears to have been lost.[90] The lack of integration offered by interim applications has left senior Trust staff questioning whether NHS-wide connectivity will ever be achieved and, if not, why Trusts have had to wait several years for the new systems. The purchase of interim applications does not seem very far removed from how the NHS acquired IT before the programme, with the problems of this approach seemingly perpetuated, such as databases that cannot be accessed from outside the Trust. (Box 16) Managers also questioned how the Government vision of decentralising clinical services, by increasing private sector provision, aligns with a centralised approach to information sharing. (Box 16)

Box 16: Loss of integration of components of the NHS IT programme

"I think it is back-peddling big time because I don't think the, right now they're in a position to deliver that original vision and so even things like the PACS was going to be an NHS-wide archive and then it was going to be a cluster archive and now they're just talking about having a Trust archive" [Director of IM & T, Trust 4]

I'm just worried that the ideas are actually drifting away from the way that initial strategy, from the way the Trust is working, whereas at one time you kind of offered a nice way forward I'm worried it's kind of diverging" [Divisional manager for diagnostic therapies and outpatients, Trust 4]

"One of the things that's become apparent is that the original vision of a shared record between primary and secondary care is not at the moment on the, on the design, aim and design….what they're looking to do is to use messaging systems between primary and secondary care, so effectively you'll have electronic letters and discharge summaries and those sorts of reports …and the spine won't, the spine is currently going to be quite thin, so it's not going to be data rich." [Clinician lead for CfH, Trust 2]

"we've got foundation Trusts, we've got perhaps more importantly the mixed economy so, um, are we saying that a condition of a private provider receiving NHS work is that they have to be signed up to the national programme? …we're not going to have a national solution that actually is fit for purpose in a mixed economy and providers." [Chief executive, Trust 2]

"I genuinely am not sure whether the solutions are solutions to yesterday's analysis rather than today's analysis…. I think what's happened over the last few years is we have moved from NHS PLC to health care, as an industry, which has lots of different players in it" [Chief executive, Trust 3]

5.2.8. Discontent with Choose & Book

Following the stage A interviews, acute Trusts and local primary care teams have proceeded with implementation of Choose & Book, a system which allows GPs to make patient appointments and referrals into acute Trusts electronically. We found little support for the patient choice element of Choose & Book (patients being able to choose to be referred to one of a range of hospitals) among the staff we interviewed. (Box 10) The technical problems affecting electronic booking have also undermined confidence in other planned applications. None of the managers or clinicians we interviewed were optimistic about the ability of CfH to deliver the systems. The doubts expressed were twofold; whether it was technically possible, and whether the products would be delivered in a reasonable time frame. Feelings of frustration were expressed at the slow progress. (Box 17)

Box 17: Discontent with Choose & Book & loss of confidence in the programme

"I've not really talked to the clinicians about, about whether they think it's a good idea or not [Care Records Service]. They certainly think choose, choose and book is a crap idea, they hate it" [Director of performance and improvement of information, Trust 1]

"we'll call it choose and book because it helps with politics. The software is not fit for purpose…. We have an unstable middle-ware server because the spine keeps vanishing…what happens is the synchronisation messages from them to the other doesn't happen, things get lost, so you end up with patients booked, but we don't know about them…We're getting a fifty-three, sorry fifty-seven percent error rate at the moment" [Director of IM & T, Trust 2]

"technically I'm not sure that they can deliver it at the moment. I don't think they're, I don't think they have the architecture in place to actually deliver it on a national scale, let alone, actually even a cluster scale, to be honest, so I think they are struggling with it." [Director of IM & T, Trust 4]

"somebody, not here, but at the PCT level is trying to increase that all the time [usage by GPs]…I know that some GPs absolutely hate it and I get the impression that they're using it under duress and that the slightest fault is a case of 'Well, what a rubbish system, would never work anyway.'" [Chief executive Trust 4]

if it doesn't start delivering soon people will begin to say it can't deliver …they, um, they just feel resentment or that it's irrelevant or, worse still, it looks like money poured down the drain while they're having to make staff redundant ……then there will gradually be a sort of almost a "We're going to make sure it doesn't work" mentality coming. [Chief executive, Trust 4]

5.3. Summary of findings

The first round of interviews with senior managers and clinicians highlighted four key issues:

(a) Trusts vary in their circumstances, which affect their ability to implement the NPfIT.

(b) The process of implementing the NPfIT was suboptimal, leading to low morale among NHS staff responsible for implementation.

(c) The overall timetable for implementation was unrealistic, with Trusts facing major uncertainties. The need to renew the PAS represented a bottleneck and the schedule for this activity could not be reconciled with targets for implementation of substantive IT applications.

(d) Short term benefits of IT modernisation are unlikely to be sufficient to persuade NHS staff to support the NPfIT unreservedly, particularly if new applications deliver lower levels of functionality.

Although it was far too early at the time of these interviews to assess the success of the NPfIT, the process of implementation was already clearly causing concern. Unrealistic and shifting timetables, lack of consultation and communication with CfH managers, and unperceived short-term benefits was affecting staff morale.

In the second round of interviews, it was clear that the NPfIT is a highly desirable objective; in line with the National Audit Office report (which was published during the intervening period),[44] interviewees were enthusiastic about, and overwhelmingly supportive of, the goals of the programme.

However, senior Trust staff still raised serious concerns, several of which were the same as during the first interviews. Continuing uncertainty about the programme was making key managerial decisions more difficult, given the current need to make financial savings and achieve efficiencies.

Although IT modernisation should facilitate these goals in the longer-term, at the time of the second interviews senior managers still did not know:

(a) what the local costs of implementation will be;
(b) when a replacement patient administration system compliant with the programme will be available;
(c) the timetable for delivery of interim applications;
(d) the features of these applications;
(e) the likely benefits and efficiencies from new systems.

In the face of these uncertainties, managers found it difficult to prioritise implementation of the programme. Concern was expressed about threats to patient safety from a 'patch and mend' approach to maintain existing systems. Trust managers need to be given concrete information, about implementation timetables, system compatibility with the long term goals of the programme, and value-for-money. Communication generally between CfH and Trusts needs to improve. Finally, Trusts need assistance to prioritise IT modernisation against other competing financial pressures, for example by inclusion in performance management frameworks.

6. Qualitative findings from Level 2: implementation of specific e-functions

6.1. Introduction

As set out in chapter 1, we planned to study the implementation of three specific functions: PACS; CPOE; e-booking. We report here on findings from our studies of PACS (implemented wholly or partially in three Trusts) and CPOE (implemented in two Trusts, although can be classed only as attempted implementation in one), as e-booking had not been implemented widely enough (implemented only partially in one Trust).

As described in chapter 4, these functions were studied using the analytical framework of diffusion of innovations theory[78] and further work by Greenhalgh et al[79], developing a conceptual framework for the factors influencing the diffusion and implementation of innovations. In this framework, Greenhalgh et al[79] identify nine interacting elements relating to, for example, attributes of the innovation; characteristics of the adopter; system readiness for innovation; implementation process, and so on.

In this chapter, we outline the background to the IT applications (innovations) and then report on our findings in terms of key factors influencing their adoption: attributes of the application; characteristics of the adopters; implementation processes; and organisational factors. We also report on the impact of the implementation of these IT applications. As Greenhalgh et al[79] and others have noted, these factors interact with each other in complex ways, for example, the attributions of the innovations may affect the implementation process which in turn affects adoption.

6.2. Background to IT applications

6.2.1. Picture archiving and communication system (PACS)

Broadly, there are two types of PACS: computerised radiography which changes the film cassette into a digital image, and digital radiography ('true' PACS) which has no film, the image being digital from the outset. Digital radiography is more expensive but more efficient than computerised radiography. We interviewed 17 end users in the three Trusts using PACS (the fourth Trust had not implemented it) during the period January –October 2005.

These end users were using digital radiography systems. Only one Trust (no.4) had a true PACS system, digital radiography throughout the Trust, with no hard film available to staff or used. Staff interviewed from another two Trusts had partial systems in place. Trust 2 had PACS throughout one part of a new building on one part of spilt site, so digital films were moved around clinics, between staff that worked in this new building, and adjacent buildings, but were not available for viewing across other parts of the Trust. Trust 3 had two pockets of PACS, with just one machine for digital radiography situated in each. This meant staff using these machines could take small numbers of digital films but these made up a small proportion of the total x-rays taken. Viewing could be done from most parts of the Trust but was limited to the small number of digital films. All these PACS systems were implemented prior to NPfIT. The NPfIT is providing a computerised radiography version of PACS.[56,91,92] We asked interviewees about their experiences of using the PACS system they had implemented and their views on implementing the NPfIT version of PACS. PACS was widely used, and extremely popular with the end users we interviewed.

6.2.2. e-test ordering and browsing (CPOE)

The systems are different between the two Trusts using this application. In Trust 1, the system which went live in 2001 is both for ordering tests and browsing. It is very quick and easy to use – takes about 15 seconds to a minute and has clearly laid out instructions. In Trust 2, on one hospital site, there are separate systems for e-test ordering and browsing, both implemented in 2002, which replaced a previous DOS-based e-test ordering/browsing system. While the DOS-based system had been used by the majority of staff, the current e-test ordering system is used only by a minority of staff. Most staff use the browsing system.

We interviewed 21 staff in these two Trusts during the period January to October 2005.

6.3. Findings

We present our findings in terms of four main factors which influence the adoption of these IT applications: attributes of the application; characteristics of the adopter; implementation processes; organisational factors. Finally, we present the impact of the different IT applications, although these also, in turn, affect how widely the application is adopted.

6.3.1. Attributes of the IT application

As others have found, the attributes of the IT application are very important in influencing its rate of adoption. These include ease and speed of use, reliability, ability to customise, and compatibility with existing practices.

i) Speed/ease of use/reliability

PACS was perceived by many users as fast, easy to use, and reliable – as the following quotes from Trust 4, which had 'full' PACS, illustrate:

"the systems were so user-friendly, so easy to work, people enjoyed using it, so we didn't have any major problems" [PACS trainer, Trust 4].

"It was remarkably quick (to learn) and people felt pleased with themselves having been able to, to master it" [Radiologist and PACS lead, Trust 4].

"If there's a doctor who hasn't worked here before I can show them how to use it very quickly" [Administrator, Trust 4].

This experience at Trust 4 contrasted with that of Trust 2 where users found PACS more time-consuming than analogue film. This was because only a partial PACS system had been implemented so that viewing could only take place across part of the site and staff moving around the site had to use more than one system.

The experience between the two Trusts using different systems of e-test ordering and browsing illustrates the importance of the usability of the IT application. In Trust 1 where the systems were perceived as easy to use and time-saving, there has been much greater adoption than at Trust 2 where ordering in particular has had a slow rate of adoption because it is very hard to use:

"for new members of staff, um, even with the best will in the world, for the first couple of weeks they are functioning at about fifty percent of what somebody else is" [Senior clinician, Trust 2].

ii) Ability to customize/compatibility with existing practices

One important attribute for e-test ordering was the ability to customize. In Trust 1, they have been able to customise their orders:

"we introduced rules…. these tests would be ordered and with a bit of jiggery pokery it works and it continues to work and that makes a real difference so that I know that all the tests will be done on our patients when they come to intensive care. There were one or two funny glitches, but essentially it worked" [Clinician, Trust 1].

In Trust 2, however, the system of e-test ordering was not perceived as compatible with existing practices and therefore rate of adoption has been slow:

"it's not intuitive as to who does the test, so you may have to go into extensive laboratory menus to try and identify what the test is… and I could spend ages trying to look through to find out where…more often what I may end up doing is I'll either have to phone somebody to find out… Or else I just default using a piece of paper. So for unusual tests or for even things that are slightly unusual, the things that I don't know where they are it can take too long to go. There's a second problem, um, in naming of tests there's no standardised mechanism of naming of tests. …could be that they're listed alphabetically, um, if I wanted to do fasting lipids, um, I don't, it may be in under 'f' for fasting lipid or it could be in for lipid, bracket, fasting or it could be in under cholec 'c' for cholesterol, plus ……brackets, fasting" [Senior Clinician, Trust 2].

6.3.2. Characteristics of the Adopters

Whether or not there were positive attributes of the IT application, there were difficulties in the initial implementation stage. These included potential adopters' concerns prior to implementation of each of the applications, particularly from those not used to using computers. One interviewee summarised others' views on resistance from, for example,

"consultants who are living in the dark ages.. I call the quill and inkwell brigade, who don't know what a PC looks like and they're frightened" [PACS manager, Trust 3].

There was initially a lack of belief in the IT application from some pre-implementation, and subsequently difficulties in making the transition from one system to another:

"orthopaedic consultants have indicated already that they don't believe that images will be as good…you need that really high resolution of plain film for bone….so traditionally orthopaedics departments can be awkward…they like to draw pictures on pre and post…"[PACS project manager, Trust 2].

"the clerical staff were a different issue, it took them longer to accept, accept they had to use it and they were a bit wary of it and they didn't really like it because it was a lot different to what they used to been doing" [PACS trainer, Trust 2].

"Transition period was a bit difficult…we still wanted to look at the old x-rays as the well as the ones that were on the computer" [Administrator, Trust 4].

"We're had our problems with PACS…we had loads and loads of problems with the archive, with the workflow and everything, um, until we got it right…I think for about a year it was difficult" [PACS trainer, Trust 4]

The characteristics of the adopters did not remain fixed, however, and there were changes over time as IT applications innovations were implemented. The attributes of the application influenced how the adopters viewed it, and similarly the processes of implementation affected how potential users adopted the application, or not.

6.3.3. Implementation processes

Important factors here were the levels of user consultation and involvement, quality of training and IT support, and a 'critical mass' of implementation.

The level of user consultation and involvement varied between IT applications and Trusts. There were criticisms of the lack of involvement in CPOE systems in Trust 2 with key staff groups:

"it comes back to the importance of bringing on clinicians right at the beginning of designing the system in that they're the people that have to use it and they're the more, the most important people. You know, their ideas are not going to be the same as some IT bod sat in a room designing it" [IT trainer, Trust 2].

Whereas in Trust 1, they had carried out some user consultation on adapting the e-test ordering system to their needs:

"they wanted our final input as to were we happy with everything, all the tests that were on there, um, aspects of how they order? Did we want any rules in? For example, so there's some tests that have got certain rules attached to them that prevent you from ordering them or if it's inappropriate or that come up with warnings saying that, you know 'This needs to be discussed with, you know, a haematology consultant before it actually can be analysed' or something like that. So we were, we were involved in that side of things" [Senior Clinician, Trust 1].

The quality and amount of training, as well as IT support, also differed between Trusts. The PACS systems seem to require less intensive training, as they are easier to use, however, on-going training with new staff, particularly junior doctors is important. Training, both initial and on-going, is criticised in both Trusts with e-test ordering and browsing:

"we have a reasonable turnover of staff and a new staff member may appear, um, they have to go for training, um, the nearest next date for their training may be ten days away… and for ten days they're working at a major disadvantage in that they have to use paper, um, so they get to sort of learn how the clinic runs, but using what, using a strategy that they then have to unlearn" [Senior clinician, Trust 2].

"one of our significant issues is that we, new medical staff, for instance, there's only a two hour slot for training them on EPR…I mean we have certainly got some ……training and the sort of local support, but I mean it isn't, it isn't as great as it might, as it might be" [Project manager, test ordering, Trust 1].

IT support in the form of responsive helpdesks accessible 24 hours a day is an important element of the implementation process:

"You ring the helpdesk, you're on hold for ten minutes, um, they will say "Don't know, I'll have a look at it, call you back later" which they never do" [Clinician, Trust 2].

"I said 'Well look, we have locums who turn up at five o'clock in the evening to work on intensive care, to work on the wards, they've got to be able to access the system.' Then they said 'Oh, well we'll have somebody on site to train them.' Well they don't have people on site to train them. And then they said 'Well, we'll give them a temporary password.' And so what actually happens is that people give them out, somebody, the person they're taking over from gives them their password. Well, you know, that the IT people say 'Well that must never ever happen.' But there is, there is a lack of understanding by the IT people of how hospitals work" [Clinician, Trust 1].

Finally, achieving a critical mass of implementation i.e. implementing the IT application widely enough so that it is worthwhile for staff to use it is important. For example, in Trust 4, the PACS lead, a radiologist, stated:

"in order to complete that functional loop we have to also put the, um, PACS into the orthopaedic clinics and into theatre" [Radiologist and PACS lead, Trust 4].

Related to this issue of critical mass is also reducing access to alternatives so that users have to switch to the IT application:

"hardest part also is to make sure that you're not printing films… have to be very, very strong to say 'I'm not printing films, you've got to look at things on PACS.'" [PACS trainer, Trust 4]

6.3.4. Organisational factors

In addition to the implementation processes outlined above, there are a number of organisational factors which had either a positive or negative impact on the adoption of these particular IT applications. These included awareness of the 'business process' in the design of the application; the presence of a strong project management team; and the level of the ability of the organization to work as a whole and in teams, rather than disparate units.

i) Awareness of the business processes

An important factor in the adoption of these IT applications was how far those designing and implementing them understood the nature of 'the business' they were designing for. There were contrasting experiences of this in terms of e-test ordering in Trust 1 and 2.

"I think this company was totally unaware of how, what the clinicians wanted, either that or they couldn't produce what we wanted. We got quite a lot of noise around here in the sense that they couldn't produce what we wanted… I don't think they had the technical know-how... was the impression we had, they couldn't actually do what was required to produce a user-friendly ordering system" [Senior clinician, Trust 2].

"The test ordering is one of the systems that works well here, it's been around or quite a while. Um, the guy that runs it is integrated into the business as well, he's, he's not just a technologist, he follows the business process as well. So that works well for us" [Junior doctor, Trust 1].

However, not everyone at Trust 1 shared this view:

"one of the other things which I think could be done slicker by a Trust organisation because you have people working to a test script that they don't necessarily understand the business logic behind. …to give you, give you an

example, um, I had one of their business analysts say "We've been running this test script on a particular test and we're getting a funny answer." When I looked through the test script and I said "Well the reason why you're having an issue is that we would never report that particular value in that way" [Project manager, test ordering, Trust 1].

"what happens a lot of the time too is you get a technology solution and all these technology people say 'This is the way you've got to do it.' What they don't do is consult the business and say "This is the way the business has to work now for NHS clinical practice." This is the way they have to work now to fit in with the system" [House officer, Trust 1].

ii) Strong project management team with high level management support

It was widely recognized that implementation of these IT applications requires very strong project management which is supported at a high level of management within the organisation.

"my experience has been the top down directives, if it's not supported by someone from the top there's no point in doing it. If it's handed to, if it's a task handed to a junior project manager or somebody like that it's got no authority to make people use the system and it just becomes another system that makes the IT environment more complex and wastes everybody's time and effort" [EPR implementation manager, Trust 1]

"A lot of credit should go to [name of person] because he was at clinical directorship level and he's a very forward thinking guy, which made him, or forced him or gave him the possibilities to work very closely with other high up people…he already had that working relationship with the directorate and I think that helped a lot….whole team was behind him and trusted him" [Radiographer, Trust 4].

"the management chain is very short and very close…within this directorate it, it's excellent…extremely close working relationships" [Radiologist, Trust 3].

"I don't think there's anybody in [the IT company] now here who was, who was here at the beginning of the project…there is nobody left who had anything to do with this implementation" [PACS project manager, Trust 2].

"they had people that were going to put in this NPfIT stuff that had absolutely no experience in project management whatsoever and no change management experience …… they really couldn't grasp the impact that these things were going to have on the, on the organisation and that seems to be fairly ……the NHS. …Um, a lot of the Trusts need to rethink have they the resource for these sort of projects. I think having inexperienced people is just destined to failure" [EPR implementation manager, Trust 1].

iii) Level of organisational unity and teamwork

This point relates to the importance of team working both within and between departments, and the ability of the organisation to work as a whole to implement these IT applications. There seemed to be more examples of this in Trust 4 than the other three Trusts, which may be at least in part because as a single-site hospital this process is easier.

"This whole journey is what needs to be looked at and it's a mistake to just look purely from a rather selfish viewpoint"[Radiologist and PACS lead, Trust 4]

"they [staff] were not an audience, they were actually part of the decision-making process" [Radiographer, Trust 4]

"everybody we worked as a team together, attending meeting together and they were minuted…..if we are not part of the team all the work that you do is not going to be, you don't achieve anything…You have to work, um, as a group and communicate" [PACS Trainer, Trust 4]

"It's important to have a multi-team approach, holistic approach when consulting staff" [Radiologist, Trust 3].

"there's quiet a lot of examples of where one party's interest actually conflicted with another's and it depends on who's got more political weight as to who gets what, who moves forward and who doesn't and quite often the ones that don't have, um, a big voice so to speak, end up with the burden… there's probably no-one in this Trust at the moment that has a good holistic view of the requirements and things of all the different departments and that's something that's been addressed at the moment as well" [EPR implementation manager, Trust 1]

"Well, it's not been an easy situation all told because obviously as well there's been a certain element of feeling between the sites in so much as one site has got a brand new hospital, the other one has got one that needs completely redeveloping….the sort of the staff of the Trust generally haven't really particularly knitted together as one organization" [EPR trainer, Trust 1].

6.3.5. Impact of implementing IT applications

As shown in the quantitative analysis (see chapter 7), the impact of these IT applications was relatively limited because the implementation was limited. The impact of implementing these applications related to the following areas: patient experience; working practices; and safety/governance. In all cases, there were positive and negative examples of these reported, but overall, for PACS in all three Trusts and e-test ordering in Trust 1, the positives appear to outweigh the negatives. Having said that, very little formal measurement of

these consequences was carried out by the Trusts, for example, the reported increase in the numbers of tests following implementation of e-test ordering was not quantified by Trust 1.

These consequences are important, not least because the perceived positive and negative impact of implementing the IT application influenced continued use of the application and wider adoption.

i) Impact on patient experience

In terms of patient experience, improvements from PACS cited included lower radiation doses resulting from fewer repeat x-rays because fewer lost images, reduced waiting times during the period of the patient's appointment, increased information for patients as they can see their x-ray image on the computer screen, and innovation now perceived as 'essential' to the diagnostic part of the patient pathway by respondents at all three Trusts.

"PACS is something that has moved from being an innovation toy to critical to the pathway of evaluation of a patient" [Radiologist and PACS lead, Trust 4].

"in the past there was that kind of waiting, either for the films or the film packets…the patient just goes straight back now, get registered, has the x-ray and then off they go back to the clinic" [PACS trainer, Trust 4].

"many patients actually like the concept of seeing what's wrong with them and they can understand" [Radiologist and PACS lead, Trust 4].

"it's much less remote… [patients can] sit there side by side with their clinician and discuss various things" [Radiologist and PACS lead, Trust 4]

Positive impacts on patient experience were reported where e-test ordering is working well at Trust 1, but where the e-test ordering system is not working well at Trust 2, negative effects on patient experience were reported. For example, doctors reported that because of the complexity of the system, they have to interact with a computer screen for long periods of time during a consultation, resulting in less eye-contact with the patient.

ii) Impact on working practices

We had anticipated that we would have more significant findings relating to changes in working practices had there been more widespread

implementation of IT applications. However, there were reported improvements to working practices for both PACS and where e-test ordering and browsing has worked well, these included improved workflow and improved communication between professionals:

"you can have multiple teams looking at their images at the same time" [PACS project manager, Trust 2]

CPOE significantly reduced reporting time as reported by Trust 1:

"things that used to have a three day turnaround time are now coming out in, they're getting back in forty minutes" [Project manager, test ordering, Trust 1].

And it

"will save clinicians' time as well as nurses' time because the nurses aren't waiting for the doctors to come, the doctors aren't waiting, they're not having to juggle their work and prioritise, you know, and having to do, come and take, take the blood and order it immediately" [Trainer, e test ordering, Trust 1].

"but another advantage it has now got is, um, specialist nurses have now got some ordering privileges, which means that it does make it more convenient for the patient because it's often the nurse that's drawing the blood, um, so patients can actually have tests when they're needed. Rather than having to wait for a doctor to come and take it the nurse can actually initiate patient care quicker" [Ward sister, Trust 1].

Trust 1 also reported that this IT application reduced the number of duplicate tests ordered, although they were not able to quantify this.

Many PACS users reported that decision-making had improved, for example,

"we can now screen those letters, pull up the x-ray at the same time…make a decision as to how urgent we need to see the patient based on that picture…now we have old films on the system …you can pull up two films and compare" [Senior clinician, Trust 4].

And fewer lost films resulted in fewer repeat x-rays as noted above which has benefits for both patients and the hospital.

In Trust 1 some improvements to the working environment were reported:

"it makes the job more enjoyable from that point of view because it takes nursing on that bit further rather than just, just the actual nursing side of it. It's, it's all part of being a team, a team approach to looking after, after the patient" [Ward sister, Trust 1].

However, some disadvantages to the IT applications were reported. Trust 1 reported that CPOE had resulted in an increase in the number of orders:

"we are finding that because it's so easy to place orders for some, to be collected when you're not there, that we're seeing quite a high increase, well, we've seen a high increase which we've not really been able to control" [Project manager, test ordering, Trust 1].

In Trust 2, however, the CPOE system was reported as being slower than the previous system resulting in increasing inefficiencies and a decline in relationships between clinical staff and laboratory staff.

iii) Safety/clinical governance

Both IT applications were perceived to improve safety in various ways, however some examples of decreases in safety were also cited.

In Trust 1, there was widespread reporting of e-test ordering and browsing resulting in a reduction in errors. These included fewer patient identification errors and staff having to take more responsibility for their work because it is recorded electronically:

"people are more responsible for their own work. You know, that they know that if it's done electronically there is a record, you know, and that can't be denied" [EPR trainer, Trust 1].

"they can't cover up their mistakes, they can't cover them up, is the answer to that, they can't cover up a mistake, but they are, they have to be more responsible" [EPR trainer, Trust 1].

Most interviewees viewed PACS as contributing to improved patient safety, for example, in terms of improving quality control and providing better security:

"you have better evidence, so you are policing the quality control better than you could" [Radiographer, Trust 4].

"Now they have a situation where they cannot get rid of an image so they have to decide whether they send it to PACS so it will be see by a clinician during reporting so he will know that they passed through a bad image…they have evidence, you have evidence that a particular person is sending more to the bin than anybody else" [Radiographer, Trust 4]

"data-wise it's been fantastic for security…there was always the ability of people to walk in and maybe pick up a film and look at it, but with PACS you simply can't do that" [EPR trainer, Trust 2].

There were concerns, expressed, however, about potential threats to patient safety which these IT applications may engender. Some of these could be interpreted as professional anxieties about their roles. For example, concerns

were expressed about the openness of PACS and a range of clinicians being able to view images. We have already mentioned the reduction in exposure to radiation because of fewer x-rays required using PACS. However, others mentioned that there might be less diligence in monitoring exposure to radiation.

"radiation incidents can go up because you've got a lot of patients, a whole load of John Smiths and the clinician wants John Smith number one to select, but inadvertently selected number two" [Radiographer, Trust 3].

There were also concerns that these IT applications might lead to less security for patients in terms of access to their records or an increase in errors.

"one of the big nightmares is, um patients being double-recorded…the computer is not as savvy as a human in the sense of, you know, if there's a space there but the rest of it is the same that's go to be a new person" [Senior clinician, Trust 4].

"just the fact of many automated processes…it will automatically go on and do that for you, which sounds great, but if you get a bit carried away it might sort of do that to a patient that you didn't intend to do" [Radiographer, Trust 3].

"There was I mean a real, what was a real, you know, SUI, serious untoward incident, whereby it was discovered after about a year of we were doing….somebody was fiddling around and they, they realised that they could change this two weeks to show me all the unsigned letters and they suddenly found that they had five hundred unsigned letters because they just disappeared off the end…a thousand letters never got sent" [Senior clinician, Trust 1].

In Trust 2 where an inadequate e-test ordering system was implemented, there was a widely held perception that the system led to increases in errors and increased clinical risk, as this example illustrates:

"the biggest impact it's had on patient care that was that for quite a significant period of time our clinic had to continually audit whether we were receiving results because we, it pointed out, identified and pointed out for the hospital that large numbers of results, whether positive or negative, were disappearing into the computer and no-one was being made aware of positive results, which had, which clearly had with it there are definite instances where it had clinical consequences…. we became aware that patients were having, um, had chlamydia but no results had ever been received by anyone" [Senior clinician, Trust 2].

6.4. Summary of main findings

Three out of four Trusts had implemented some sort of PACS system, but only Trust 4 had implemented a 'true' PACS. Two Trusts had implemented e test ordering and browsing, but in one of these (Trust 2) the system was so poor it was hardly used so, in effect, had not been implemented.

Drawing on the literature on diffusion of innovations, we found that there were four, inter-related factors which influenced the adoption of these IT applications: the attributes of the application; the characteristics of the adopter; implementation processes; and organisational factors. In terms of the attributes of the application, the speed, ease of use, reliability and the ability to customise were key issues. Thus PACS in Trust 4 was adopted much more widely than in Trust 2; and e test ordering and browsing was adopted much more quickly and effectively in Trust 1 than in Trust 2. Characteristics of adopters seemed to be most important in the early stages of implementation and so in all Trusts, the challenge of persuading potential users who were not familiar with using IT was raised. The way these IT applications were implemented was crucial to their use, in particular, the level of user consultation in the implementation; the quality of training and IT support; and whether the applications were implemented in terms of creating a 'critical mass' of benefit. Finally, there were some key organisational factors which influenced the adoption of these IT applications, the most important of which were: that the designers and implementers of the application understood the business process the IT application was going to be used in; a strong project management team to implement with high level management support; and the level of team working within and between departments and the ability of the organisation to work as a whole (for example, to implement a 'critical mass' of the application).

The perceived impact of these IT applications varied according to the application, how they had been implemented, and relate to the following areas: patient experience; working practices; and safety/governance. In all cases, there were positive and negative examples of these reported, but overall, for PACS in all three Trusts and e-test ordering in Trust 1, the positives appear to outweigh the negatives. Although, very little formal measurement of these consequences was carried out by the Trusts, for example, the reported increase in the numbers of tests following implementation of e-test ordering was not quantified by Trust 1.

These consequences are important, not least because the perceived positive and negative impact of implementing the IT application influenced continued use of the application and wider adoption.

7. Quantitative results

7.1. Information about participating Trusts

Table 18 gives background quantitative information about each Trust in the study, and shows which of the Trusts implemented the IT systems on which the study is based, and when. As with any comparison, the characteristics of the control are as important as the characteristics of the intervention, when interpreting differences between the two. In the three Trusts without CPOE, some form of computer-based access to pathology test results tended to be available, but this fell far short of the rapid and easy access which should be provided by a full CPOE system, and computer-based access to results was not widely or consistently used by clinicians. Trust 3 had limited PACS functionality in its children's hospital (X-ray only, mainly within ITU). Trust 2 was unable to provide pathology data for the period before October 2002, and no Urea & Electrolyte (UE) test data were available for this Trust. Data for the first three months of year 2000 were missing for Trust 2 inpatient and outpatient, Trust 3 pathology, and Trust 4 pathology and radiology.

7.2. CPOE association with primary outcomes

The results of the between-Trust and within-Trust comparisons for implementation of CPOE are summarized in **Tables 19a and 19b** respectively. These tables show the coefficient or odds ratio for the regression model interaction term which estimates the effect of the CPOE implemented in Trust 1 system on the primary outcomes (see **Table 15**). The between- and within-Trust data on which these analyses were based are summarized in **Appendices 11.1** and **11.2** respectively.

The between-Trust results show trends in several outcomes, comparing the post- and pre-intervention periods; these can be seen in the data (**Appendix 11.1**). In particular, use of full blood count (FBC) and urine culture (UC) tests increased for inpatients, and use of all test types increased for outpatients. 'Repeat' tests at outpatient appointments also increased for each type of test. Trends revealed by the between-Trust analyses were generally consistent with the results of the within-Trust analyses, with the exception of UC testing among inpatients (**Appendix 11.2**). Evidence for a possible beneficial impact of an CPOE system

is seen most strikingly in the reduction in outpatient tests. This effect is seen in the between- and within-Trust comparisons for FBC and UE tests; for UC tests the effect is seen only in the between-Trust comparison. The effect of CPOE in reducing 'repeat' FBC tests at outpatient appointments is also seen in the between- and within-Trust comparisons.

Conversely, CPOE appears to increase the use of UE tests among day case patients. The between-Trust comparison reveals an almost fourfold increase associated with CPOE; the within-Trust comparison shows that this indicator was more than doubled.

The other possibly beneficial effects attributable to CPOE, although seen only in the within-Trust comparison, are reduction in FBC and UE tests repeated within 48 hours during an inpatient stay, and a reduction in FBC testing among inpatients. Conversely, CPOE is associated with an increase in UC testing among inpatients and day case patients.

7.3. PACS association with primary outcomes

The results of the between-Trust comparison for implementation of PACS are summarized in **Table 20a**; results of the first and second within-Trust comparisons are summarized in **Tables 20b** and **20c** respectively. As for CPOE, each table shows the coefficient or odds ratio for the regression model interaction term which estimates the effect of PACS on the outcome. The corresponding between-Trust and within-Trust data on which these analyses were based are summarized in **Appendices 12.1** and **12.2** respectively.

There was a consistent upward trend in 'repeat' plain-film X-ray exams at outpatient appointments, seen in the between-Trust (**Appendix 12.1**) and both within-Trust comparisons (**Appendix 12.2**). An upward trend in Computed Tomography (CT) scans per inpatient day and a downward trend in plain-film X-ray exams 'repeated' within 48 hours during an inpatient stay were seen in the between-Trust comparisons and in one of the within-Trust comparisons. A downward trend in use of plain-film X-ray exams among inpatients was seen in both within-Trust comparisons. Other trends were apparent only in one type of comparison.

Table 18: Characteristics of the participating Trusts

		Trust 1	Trust 2	Trust 3	Trust 4
Beds		954 (2 sites)	821 (2 sites)	1110 (1 site)	470 (1 site)
Forecast cumulative deficit, 1997-2007 (% of 2006/2007 turnover)		£38M (14.5%)	£67M (26.0%)	£14M (3.7%)	£1.5M (1.1%)
Annual inpatient admissions	2000	73,328	78,647[3]	94,135	36,044
	2001	75,573	78,824	91,744	32,548
	2002	75,400	83,716	94,933	32,824
	2003	77,079	88,377	103,119	33,186
	2004	82,686	99,479	112,599	33,889
	2005	87,971	105,114	116,771	37,902
Annual outpatient appointments	2000	369,606	367,460[3]	397,928	203,179
	2001	369,070	418,547	399,863	202,171
	2002	385,132	426,255	411,195	197,269
	2003	398,120	410,493	407,296	200,634
	2004	418,590	399,325	422,043	192,942
	2005	429,354	356,569	432,251	197,616
Annual pathology tests (Full Blood Count, Urea and Electrolytes, and Urine Culture) for inpatients, outpatients and A&E.[1]	2000	166,824	data unavailable	291,623[3]	231,201[3]
	2001	168,034		311,974	315,188
	2002	183,658		339,997	315,530
	2003	200,639	452,752	370,298	335,374
	2004	200,716	494,192	397,392	333,464
	2005	205,376	505,235	404,766	330,697
Annual radiological examinations (Plain Film, Computed Tomography and Ultrasound) for inpatients, outpatients and A&E.	2000	69,956	187,365	191,652	71,376
	2001	70,560	186,219	161,285	71,518
	2002	77,221	188,012	162,319	72,740
	2003	80,346	193,820	167,449	75,142
	2004	83,645	197,991	173,973	73,160
	2005	85,877	203,731	179,865	72,899
CPOE		New system implemented 2001-2002[2]	None	None	None
PACS		None	None	None	New system implemented 2001-2002[4]

[1] Urea & Electrolytes test data unavailable for Trust 2.

[2] Except in maternity.

[3] Estimated from data for 9 months (April - December)

[4] First in A&E and trauma & orthopaedics, then in all other specialties (see Table 2).

Table 19a: Implementation of CPOE, between-Trust comparison (Trust 1 vs. Trust 2, 3, and 4). Regression coefficient (Co) or odds ratio (OR) = interaction between intervention (Trust 1) and post-intervention period (2003-2005).

	Pathology test type	Full Blood Count	Urea & electrolytes[1]	Urine culture
Primary outcomes		**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**
Inpatient	Tests per inpatient (non-zero vs zero response)	OR=0.74 (0.48, 1.16)	OR=0.66 (0.43, 1.02)	OR=1.14 (0.80, 1.63)
	Tests per inpatient day (continuous non-zero response)	Co=1.00 (0.90, 1.10)	Co=1.03 (0.89, 1.18)	Co=0.93 (0.82, 1.06)
	Tests per day case (non-zero vs zero response)	OR=1.76 (0.78, 3.99)	**OR=3.63 (1.66, 7.94)[2]**	OR=1.29 (0.54, 3.13)
	Test within 48hrs of prior test of same type	OR=0.93 (0.79, 1.10)	OR=1.07 (0.89, 1.29)	OR=0.89 (0.70, 1.12)
Outpatient	Tests at outpatient appointment (non-zero vs zero response)	**OR=0.25 (0.16, 0.40)[2]**	**OR=0.55 (0.39, 0.77)[2]**	**OR=0.30 (0.17, 0.51)[2]**
	Same test at next outpatient appointment	**OR=0.73 (0.53, 1.00)[2]**	OR=0.84 (0.64, 1.11)	OR=0.73 (0.52, 1.02)

[1] No data were contributed by Trust 2.

[2] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

Table 19b: Implementation of CPOE, within-Trust 1 comparison (Obstetrics vs. all other specialties), regression coefficient (Co) or odds ratio (OR) = interaction between intervention specialty (obstetrics) and post-intervention period (2003-2005).

	Pathology test type	Full Blood Count	Urea & electrolytes	Urine culture
Primary outcomes		**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**
Inpatient	Tests per inpatient (non-zero vs zero response)	**OR=0.68 (0.55, 0.84)[1]**	OR=1.24 (0.94, 1.64)	**OR=2.03 (1.68, 2.46)[1]**
	Tests per inpatient day (continuous non-zero response)	Co=0.95 (0.88, 1.03)	Co=0.98 (0.90, 1.06)	Co=0.90 (0.81, 1.00)
	Tests per day case (non-zero vs zero response)	OR=1.35 (0.81, 2.24)	**OR=2.41 (1.54, 3.78)[1]**	**OR=3.49 (1.83, 6.67)[1]**
	Test within 48hrs of prior test of same type	**OR=0.88 (0.79, 0.98)[1]**	**OR=0.77 (0.69, 0.87)[1]**	OR=0.90 (0.64, 1.27)
Outpatient	Tests at outpatient appointment (non-zero vs zero response)	**OR=0.70 (0.55, 0.88)[1]**	**OR=0.51 (0.39, 0.65)[1]**	OR=0.86 (0.67, 1.10)
	Same test at next outpatient appointment	**OR=0.84 (0.71, 0.99)[1]**	OR=0.80 (0.63, 1.02)	OR=0.81 (0.64, 1.04)

[1] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

Evidence for a possible beneficial impact of PACS is seen in the reduction in 'repeat' plain-film X-ray exams at outpatient appointments (as seen in the between-Trust comparison, **Table 19b**, and the second within-Trust comparison, **Table 19c**), and in the reduction in inpatient CT scans (between-Trust comparison). Other evidence for a possibly beneficial effect of PACS was the reduction in plain-film X-ray exams requested at outpatient appointments (second within-Trust comparison only). Conversely, in the between-Trust comparison, PACS was associated with increases in CT scans requested at outpatient appointments, and with CT scans 'repeated' within 48 hours during an inpatient stay; and in the second within-Trust comparison, with an increase in plain-film X-ray exams per inpatient.

The reduction in ultrasound (US) scans 'repeated' within 48hrs during an inpatient stay, which is seen in both within-Trust comparisons, is very unlikely to be attributable to PACS because ultrasound was not part of the PACS implementation. Also, the numbers of patients from which these results were derived are relatively small (**Appendix 12.2**). The only way in which the reduction in repeat US scans might be attributed to PACS would be if, for example, general reorganisation of work flows in radiology as a result of implementing PACS for other imaging modes also brought about similar changes. Interviews with staff in Trust 4 confirmed that work flows in radiology were indeed radically changed when PACS was implemented, but the interviews did not address directly whether these changes could have affected ordering and reporting of US scans because they were conducted prior to this quantitative analysis being carried out..

7.4. Secondary outcomes

The results of our analyses of the impact of CPOE and PACS on secondary outcomes, comparing intervention Trusts with control Trusts, are summarized in **Table 21a**. The results of within-Trust comparisons are summarized in **Table 21b** for CPOE and **Table 21c** for PACS. The data on which the between-Trust analyses were based are summarized in **Appendix 13.1**; the data on which the within-Trust analyses were based are summarized in **Appendix 13.2** for CPOE and **Appendix 13.3** for PACS.

Table 20a: Implementation of PACS, between-Trust comparison (Trust 4 vs Trusts 1, 2, and 3). Regression coefficient (Co) or odds ratio (OR) = interaction between intervention (Trust 4) and post-intervention period (2003-2005).

	Radiology examination type	Plain film	Computed Tomography	Ultrasound (not part of PACS in Trust 4)
Primary outcomes		**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**
Inpatient	Tests per inpatient (non-zero vs zero response)	OR1=0.90 (0.71, 1.14)	**OR1=0.83 (0.70, 0.98)**[1]	OR1=0.89 (0.69, 1.14)
	Tests per inpatient day (continuous non-zero response)	Co1=0.97 (0.90, 1.05)	Co1=1.02 (0.91, 1.14)	Co1=0.96 (0.85, 1.09)
	Tests per day case (non-zero vs zero response)	OR1=1.01 (0.55, 1.86)	OR1=0.73 (0.31, 1.73)	OR1=1.55 (0.83, 2.89)
	Test within 48hrs of prior test of same type	OR1=1.02 (0.91, 1.14)	**OR1=2.18 (1.52, 3.14)**[1]	OR1=1.08 (0.81, 1.44)
Outpatient	Tests at outpatient appointment (non-zero vs zero response)	OR1=0.90 (0.76, 1.07)	**OR1=1.89 (1.26, 2.84)**[1]	OR1=1.48 (0.60, 3.66)
	Same test at next outpatient appointment	**OR1=0.62 (0.44, 0.88)**[1]	n/a[2]	OR1=0.58 (0.19, 1.82)

[1] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

[2] Not analysed due to small numbers.

Table 20b: Implementation of PACS, first within-Trust 4 comparison, before and after implementation in A&E and orthopaedics. Regression coefficient (Co) or odds ratio (OR) = interaction between intervention and post-intervention period.

	Radiology examination type	Plain film	Computed Tomography	Ultrasound (not part of PACS in Trust 4)
Primary outcomes		**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**
Inpatient	Tests per inpatient (non-zero vs zero response)	OR=1.10 (0.97, 1.25)	OR=1.05 (0.85, 1.31)	OR=1.03 (0.74, 1.43)
	Tests per inpatient day (continuous non-zero response)	Co=1.01 (0.88, 1.14)	Co=0.95 (0.73, 1.23)	Co=1.18 (0.88, 1.58)
	Tests per day case (non-zero vs zero response)	OR=0.81 (0.65, 1.02)	OR=0.98 (0.36, 2.65)	OR=0.71 (0.16, 3.17)
	Test within 48hrs of prior test of same type	OR=0.96 (0.89, 1.02)	OR=0.70 (0.26, 1.88)	**OR=0.24 (0.10, 0.55)**[1]
Outpatient	Tests at outpatient appointment (non-zero vs zero response)	OR=0.90 (0.81, 1.01)	n/a[2]	n/a[2]
	Same test at next outpatient appointment	OR=0.85 (0.62, 1.17)	n/a[2]	n/a[2]

[1] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

[2] Not analysed due to small numbers.

Table 20c: Implementation of PACS, second within-Trust 4 comparison, before and after implementation in all specialties except A&E and orthopaedics. Regression coefficient (Co) or odds ratio (OR) = interaction between intervention and post-intervention period.

	Radiology examination type	Plain film	Computed Tomography	Ultrasound (not part of PACS in Trust 4)
Primary outcomes		**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**	**Regression coefficient or odds ratio (95% CI)**
Inpatient	Tests per inpatient (non-zero vs zero response)	**OR1=1.33 (1.09, 1.62)[1]**	OR1=1.05 (0.94, 1.17)	OR1=0.81 (0.65, 1.01)
	Tests per inpatient day (continuous non-zero response)	Co1=0.95 (0.81, 1.12)	Co1=0.75 (0.54, 1.04)	Co1=0.89 (0.53, 1.50)
	Tests per day case (non-zero vs zero response)	OR1=1.05 (0.84, 1.30)	OR1=0.99 (0.50, 1.98)	OR1=0.45 (0.08, 2.63)
	Test within 48hrs of prior test of same type	OR1=1.05 (0.92, 1.21)	OR1=0.51 (0.26, 1.03)	**OR1=0.35 (0.16, 0.75)[1,2]**
Outpatient	Tests at outpatient appointment (non-zero vs zero response)	**OR1=0.75 (0.69, 0.82)[1]**	n/a[3]	n/a[3]
	Same test at next outpatient appointment	**OR1=0.75 (0.61, 0.92)[1]**	n/a[3]	n/a[3]

[1] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

[2] This estimate is based on small numbers in the intervention group (see **Appendix 12.2**).

[3] Estimate could not be calculated because of the small number of patients who had a CT repeated at the next outpatient appointment.

There were clear trends over time in seven of the eight secondary outcomes in the between-Trust analysis. Of these seven trends, three were consistent between both types of analysis (between- and within-Trust); greater likelihood of being discharged following admission (i.e. shorter length of stay), the lower likelihood of intended day case patients being admitted overnight, and the increased likelihood of being discharged from further follow-up at an outpatient appointment. There were upward trends in day case admission and outpatient attendance in the between-Trust comparison, but a downward trend in these outcomes in the comparison within Trust 1. One of the two comparisons within Trust 4 showed an upward trend in outpatient attendance. Comparisons within Trusts 1 and 4 showed opposite trends in outpatient attendance. None of the trends in secondary outcomes within Trust 4 were seen in either the first or second PACS comparison.

The between-Trust and within-Trust analyses showed potentially detrimental associations of CPOE and PACS with a reduced likelihood of outpatients being discharged. This association in the between-Trust analysis was contradicted by the analysis within the Trust that implemented CPOE, which showed the opposite effect. The between-Trust analysis showed a beneficial effect of CPOE in reducing inpatient deaths; this result could not be investigated in the within-Trust analysis because there were an insufficient number of deaths in the control specialty (obstetrics). Conversely, analysis within the Trust which implemented CPOE showed potentially detrimental associations of CPOE with longer length of stay, and an increased likelihood of a day case patient being admitted overnight; these associations were not seen in the between-Trust analysis. An association of PACS with longer length-of-stay was seen in the second, but not in the first, within-Trust PACS comparison; as was an association of PACS with a reduction in the proportion of outpatients discharged. A shorter time-to-death was seen in the first, but not in the second, within-Trust PACS comparison.

Table 21a: Implementation of CPOE (Trust 1) and PACS (Trust 4), between-Trust comparison. Hazard (HR) or odds ratio (OR) = interaction between intervention Trust (Trust 1, CPOE; Trust 4, PACS) and post-intervention period (2003-2005).

		Trust 1 (CPOE)	Trust 4 (PACS)
Secondary outcomes		**Hazard or odds ratio (95% CI)**	**Hazard or odds ratio (95% CI)**
Inpatient	Length-of-stay (excluding day cases)	HR=1.02 (0.96, 1.08)	HR=0.95 (0.89, 1.02)
	Inpatient treated as a day case (i.e. zero length of stay)	OR=0.97 (0.77, 1.22)	OR=0.92 (0.74, 1.15)
	Intended day case patient admitted overnight	no data available	OR=0.85 (0.53, 1.39)
	Emergency re-admission (within 28 days)	OR=1.05 (0.84, 1.32)	OR=0.95 (0.79, 1.14)
	Deaths	**OR=0.82 (0.71, 0.95)**[1]	OR=0.91 (0.75, 1.09)
	Time-to-death	HR=0.98 (0.92, 1.04)	HR=1.05 (0.99, 1.11)
Outpatient	Attendance (Attended vs Did Not Attend)	**OR=0.87 (0.78, 0.98)**[1]	OR=0.94 (0.86, 1.04)
	Outcome (discharged vs follow-up)	**OR=0.73 (0.55, 0.98)**[1]	**OR=0.58 (0.43, 0.78)**[1]

[1] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

Table 21b: Implementation of CPOE (Trust 1), within-Trust comparison. Hazard (HR) or odds ratio (OR) = interaction between all specialties except obstetrics and post-intervention period (2003-2005).

		Trust 1 (CPOE)
Secondary outcomes		**Hazard or odds ratio (95% CI)**
Inpatient	Length-of-stay (excluding day cases)	**HR=0.95 (0.92, 0.97)[1]**
	Inpatient treated as a day case (i.e. zero length of stay)	**OR=1.61 (1.36, 1.92)[1]**
	Intended day case patient admitted overnight	n/a[2]
	Emergency re-admission (within 28 days)	n/a[2]
	Deaths	n/a[2]
	Time-to-death	HR=0.96 (0.92, 1.00)
Outpatient	Attendance (Attended vs Did Not Attend)	**OR=1.42 (1.22, 1.66)[1]**
	Outcome (discharged vs follow-up)	**OR=0.74 (0.70, 0.77)[1]**

[1] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

[2] Not analysed due to small numbers.

Table 21c: Implementation of PACS (Trust 4), within-Trust comparison. Hazard (HR) or odds ratio (OR) = interaction between intervention specialties and post-intervention period (2003-2005). 1st PACS comparison , before and after implementation in A&E and orthopaedics (post-intervention period, 12/2001-10/2002; pre-intervention period, 01/2000-11/2001). 2nd PACS comparison, before and after implementation in all specialties except A&E and orthopaedics (post-intervention period, 11/2002-12/2005; pre-intervention period, 12/2001-10/2002).

		1st PACS comparison	2nd PACS comparison
Secondary outcomes		**Hazard or odds ratio (95% CI)**	**Hazard or odds ratio (95% CI)**
Inpatient	Length-of-stay (excluding day cases)	HR1=0.97 (0.90, 1.04)	**HR1=0.91 (0.83, 0.99)[1]**
	Inpatient treated as a day case (i.e. zero length of stay)	OR1=0.94 (0.82, 1.09)	OR1=0.81 (0.46, 1.04)
	Intended day case patient admitted overnight	OR1=1.54 (0.85, 2.79)	OR1=1.72 (0.89, 3.30)
	Emergency re-admission (within 28 days)	OR1=1.04 (0.89, 1.21)	OR1=1.04 (0.89, 1.23)
	Deaths	OR1=1.38 (0.91, 2.09)	OR1=1.50 (0.87, 2.58)
	Time-to-death	**HR1=1.12 (1.01, 1.25)[1]**	HR1=1.00 (0.80, 1.25)
Outpatient	Attendance (Attended vs Did Not Attend)	OR1=0.99 (0.93, 1.04)	OR1=0.94 (0.84, 1.05)
	Outcome (discharged vs follow-up)	OR1=0.95 (0.87, 1.04)	**OR1=0.82 (0.75, 0.90)[1]**

[1] Estimates with confidence intervals excluding 1 are shown in underlined bold text.

7.5. Summary of findings

Our study was the largest of its kind within the UK, if not internationally, and it was made possible by the uniformity of data reporting across NHS Trusts. We discuss our results in detail below; these were interpreted in the context of temporal trends in the outcomes (as indicated by the regression model parameter for the post-intervention period vs the pre-intervention period), and by inspection of the data on from which the regression model estimates were obtained (as summarized in **Appendices 11** to **13**).

Implementation of the CPOE system or PACS was incorporated in each of the regression models as an interaction term; hence the quantifiable impact of the IT system manifests as a modification of the underlying temporal effect (trend). Such underlying trends were seen for two-thirds (25/39) of all outcomes in between-Trust comparisons, and in half (34/67) of all outcomes in within-Trust comparisons. In between-Trust analyses, we found evidence for an effect of CPOE on 5 out of 18 primary outcomes, and on 3 out of 7 secondary outcomes; and for PACS, on 4 of 17 primary outcomes, and 1 of 8 secondary outcomes. Only three of these thirteen effects occurred in the absence of an underlying trend in the outcome.

7.5.1. Impact of CPOE on primary outcomes

The effect of CPOE in reducing the upward trend in outpatient pathology tests derives from the decrease in FBC, UE and UR tests ordered at outpatient appointments in the intervention Trust, compared with increases in this indicator in the two control Trusts for which data were available (**Appendix 11.1**). Within the intervention Trust, this same effect is seen for FBC and UE tests in the intervention specialties compared with the control specialty (**Appendix 11.2**). Attribution of this effect to implementation of CPOE is plausible if the CPOE system enables the clinician to access the patient's pathology test history during the outpatient appointment, thus reducing the number of unnecessary repeat tests. This argument is strengthened by the

reduction in 'repeat' FBC tests ordered at consecutive outpatient appointments, as seen in both between- and within-Trust results. These findings are consistent with the views of users expressed in interviews (see chapter 6).

The effect of CPOE in further increasing the upward trend in UE tests ordered for day case patients, as seen in both between- and within-Trust results, derives from a large increase in this indicator in Trust 1 (from 2.2% to 10.2%) compared with the two control Trusts, one of which also saw a large increase (from 9.9% to 18.7%), and from a relatively small increase in this indicator in the control specialty (from 4.8% to 7.1%) compared with all other specialties within Trust 1 (from 2.3% to 10.7%). There has been a large increase in UE test ordering across all Trusts, but the reason for the greater relative increase in the intervention Trust is unclear, hence attribution of causality to the implementation of CPOE is not possible. It should also be noted that the proportion of day case patients for whom a UE test was ordered in Trust 1 remained much lower than in Trust 4, suggesting that our measure of effect may be susceptible to residual confounding due to differences in case mix between the Trusts.

Five other possible effects of CPOE were suggested by the within-Trust analysis: no change in FBC inpatient tests (compared with an increase in obstetrics), a relatively smaller increase in FBC and UE inpatient tests repeated within 48hrs (compared with larger increases in obstetrics), a big increase in UC tests per day case (compared with a reduction in obstetrics), and a relatively small decrease in UC tests per inpatient (compared with a larger decrease in obstetrics). Again, interpretation of these results, and attribution of causality to implementation of CPOE, is not possible without an in-depth understanding of clinical practice within specialties. However, given that all of these effects derived mainly from trends within the control specialty, the role of CPOE can probably be discounted.

7.5.2. Impact of PACS on primary outcomes

Implementation of PACS attenuated an upward trend in CT scans requested for inpatients, but amplified an upward trend in CT scans requested at outpatient appointments. PACS was also associated with an increase in CT scans repeated within 48hrs during inpatient stay. These effects were seen only in the between-Trust analyses. The first of these effects derives from a relatively small increase in inpatient CT scans in the intervention Trust (from 8.1% to 10.2%) compared with the control Trusts. The second effect derives from a big increase in outpatient CT scans in the intervention Trust (from 0.02% to 0.21%), compared with no change in Trusts 2 and 3, although there is a similarly big increase in Trust 1 (from 0.03% to 0.25%). The third effect derives from a doubling of repeat inpatient CT scans in Trust 4 (from 1.2% to 2.5%) compared with small reductions in Trusts 2 and 3, and a slight increase in Trust 1.

Explanations for the relatively large increases in outpatient CT scans and repeat inpatient CT scans in the intervention Trust, and the large increase in outpatient CT scans in Trust 1, were not forthcoming from the Trusts. New CT machines were installed in the intervention Trust in 2000 and 2006. A new CT machine was installed in Trust 1 in 2003, but this was to replace an existing machine. These results suggest that implementation of PACS in Trust 4 may have enabled an increasing demand for CT scans to be met through outpatient appointments, rather than through inpatient admissions. It is then plausible that those patients who still required hospital admission would be those patients who needed repeat scans. However, a large increase in outpatient CT scans was also seen in one of the control Trusts, hence attribution of these effects to implementation of PACS is questionable.

PACS also appeared to attenuate an upward trend in repeat PF exams at consecutive outpatient appointments. As with repeat FBC tests at consecutive outpatient appointments, attribution of this effect to implementation of the new system is plausible if PACS enables the clinician to access the patient's radiological examination history during the outpatient appointment. However, an inspection of the data (**Appendix 12.1**) reveals that this apparent effect is due to increases in repeat outpatient PF exams within two of the control

Trusts; in the third control Trust and in the intervention Trust there is little change in this outcome. Also, while this effect was also seen within Trust 4 when all specialties except trauma and orthopaedics were compared with trauma and orthopaedics in the second PACS comparison, this result contradicts the data behind the first comparison, which show an increase in repeat PF exams after implementation of PACS (**Appendix 12.2**).

7.5.3. Impact of CPOE and PACS on secondary outcomes

Attribution of changes in secondary outcomes to implementation of either CPOE or PACS is even more problematic than the attribution of changes in primary outcomes to implementation of these systems. Secondary outcomes are likely to be strongly influenced by concurrent process changes and events within the NHS in general (affecting between-Trust comparisons), and within participating Trusts in particular (affecting between- and within-Trust comparisons). Our results did not demonstrate any consistent or plausible effects of CPOE or PACS on secondary outcomes.

8. Discussion

8.1. Introduction

In chapter one, we described how the conception of this project changed with the changing policy context. We had originally set out to evaluate the implementation of EPRs at local level. With the establishment of the NPfIT, we aimed to evaluate the impact of the implementation of IT applications through the national programme at local level. However, as the NPfIT failed to deliver according to its original timetable, in Level 1 of our qualitative study, we tracked the impact of this failure at local level at two points in time. We have been unable to evaluate IT applications implemented through the national programme because, in the course of this study, none were implemented in our four case study Trusts. We were able to evaluate quantitatively and qualitatively, to a limited degree, the impact of two specific IT applications (PACS and CPOE) which had been implemented in some of our Trusts prior to the launch of the NPfIT. We also conducted a systematic review of economic evaluations of large-scale health care IT implementations to meet our fifth objective, to evaluate the economic evidence for the cost-effectiveness of IT systems in health care.

In this chapter, we first summarise the main findings from the empirical elements of our study; secondly, we identify the study's strengths and weaknesses; thirdly, we place our findings in the context of the existing literature; fourthly, we identify future areas for research; and finally, we set out the implications for management and policy from our research.

8.2. Summary of main findings

8.2.1. Qualitative interviews, Level 1

The first round of level 1 interviews, with senior managers and clinicians, highlighted four key issues:

(a) Trusts vary in their circumstances, which affect their ability to implement the National Programme.

(b) The process of implementing the National Programme was suboptimal, leading to low morale among NHS staff responsible for implementation.

(c) The overall timetable for implementation was unrealistic, with Trusts facing major uncertainties. The need to renew the PAS represented a bottleneck and the schedule for this activity could not be reconciled with targets for implementation of substantive IT applications.
(d) Short term benefits of IT modernisation are unlikely to be sufficient to persuade NHS staff to support the programme unreservedly, particularly if new applications deliver lower levels of functionality.

It was far too early at the time of these interviews to assess the success of the NPfIT, but the process of implementation was already clearly causing concern.

In the second round (Level 1, stage b.) of interviews with senior managers and clinicians, it was clear that the NPfIT is a highly desirable objective. Interviewees were enthusiastic about, and supportive of, the goals of the NPfIT. However, senior Trust staff still had serious concerns, several of which were the same as during the first round of interviews.

Continuing uncertainty about the programme was making key managerial decisions about IT implementation more difficult, given the current need to make financial savings and achieve efficiencies. Although IT modernisation should facilitate these goals in the longer-term, at the time of the second interviews senior managers still did not know:

(a) what the local costs of implementation will be;
(b) when a replacement patient administration system compliant with the programme will be available;
(c) the timetable for delivery of interim applications;
(d) the features of these applications;
(e) the likely benefits and efficiencies from new systems.

In the face of these uncertainties, managers found it difficult to prioritise local implementation of the NPfIT. Concern was expressed about threats to patient safety from a ‘patch and mend’ approach to maintain existing systems. Trust managers spoke clearly about their need for concrete information about implementation timetables, system compatibility with the long term goals of the programme, and value-for-money. More generally, they also wanted communication between CfH and Trusts to improve.

8.2.2. Qualitative interviews, Level 2

Three out of four Trusts had implemented some sort of PACS system, but only Trust 4 had implemented 'true' PACS. Two Trusts had implemented e test ordering and browsing, but in one of these (Trust 2) the system was so poor it was hardly used so, in effect, had not been implemented.

Drawing on the literature on diffusion of innovations, we found that there were four, inter-related factors which influenced the adoption of these innovations: the attributes of the innovation; the characteristics of the adopter; implementation processes; and organisational factors. In terms of the attributes of the innovation, the speed, ease of use, reliability and the ability to customise were key issues. Thus PACS in Trust 4 was adopted much more widely than in Trust 2; and e test ordering and browsing was adopted much more quickly and effectively in Trust 1 than in Trust 2. Characteristics of adopters seemed to be most important in the early stages of implementation and so in all Trusts, the challenge of persuading potential users who were not familiar with using IT was raised. The way these innovations were implemented was crucial to their use, in particular, the level of user consultation in the implementation; the quality of training and IT support; and whether the innovations were implemented in terms of creating a 'critical mass' of benefit. Finally, there were some key organisational factors which influenced the adoption of these innovations, the most important of which were: that the designers and implementers of the innovation understood the business process the IT innovation was going to be used in; a strong project management team to implement with high level management support; and the level of team working within and between departments and the ability of the organisation to work as a whole (for example, to implement a 'critical mass' of the innovation).

The perceived impact of these innovations varied according to the innovation, how they had been implemented, and relate to the following areas: patient experience; working practices; and safety/governance. In all cases, there were positive and negative examples of these reported, but overall, for PACS in all three Trusts and e-test ordering in Trust 1, the positives appear to outweigh

the negatives. Although, very little formal measurement of these consequences was carried out by the Trusts, for example, the reported increase in the numbers of tests following implementation of e-test ordering was not quantified by Trust 1. These consequences are important, not least because the perceived positive and negative impact of implementing the innovation influenced continued use of the innovation and wider adoption.

8.2.3. Quantitative effects of implementation of CPOE and PACS

The investigation of quantitative effects distinguished primary outcomes, calculated from the number of diagnostic tests carried out, and secondary outcomes which were based on more general performance indices. The size of the effects estimated was certainly potentially important, in the sense that changes in the volume of test ordering of 10 to 20% would have major implications if observed across the NHS during roll out of the National Programme. Our difficulties lay in distinguishing the effects from background variation in the performance indices and in attributing those effects that appeared to be ‘real’ to CPOE or PACS.

The main effects of CPOE were in reducing the proportion of patients who had any pathology test at outpatient appointments and the number of patients who had the same test at their next outpatient appointments. These effects were observed to a greater or lesser extent for all tests that were investigated. These effects are plausible since the CPOE system should allow a clinician to access a patient's pathology test history during the outpatient appointment. There was some evidence that CPOE reduced the proportion of inpatients having pathology tests but this effect was not consistent across tests and between and within-Trust comparisons.

A similar effect with respect to repeat plain X-ray films and US scans on subsequent visits was observed when PACS was implemented. (Too few patients had a CT repeated to investigate the effect of PACS on this indicator for this modality.) However, there was no consistent effect on the overall proportion of patients who had a plain X-ray film, CT or US scans at outpatient appointments. This may be because these tests are less likely to be ordered

in primary care, so patients would be unlikely to have previous test results. In this interpretation, outpatient appointments at which imaging tests were carried out were effectively for the purpose of having these tests. As with CPOE, there was possibly some evidence that PACS reduced the proportion of inpatients having imaging tests but this was not consistent for between and within-Trust comparisons.

A variety of changes in secondary outcomes were observed but attribution of the changes to implementation of CPOE and PACS was more problematic since the hypothesised chain of causality linking the application to the outcome was more tenuous. Secondary outcomes are likely to be strongly influenced by concurrent process changes and events in the participating Trusts. However, there did appear to be a consistent reduction in the proportion of patients discharged at outpatient appointments after both applications were implemented.

8.3. Strengths and weaknesses of the study

8.3.1. Qualitative study

Level 1 interviews

The themes that emerged were communicated to us by interviewees, with supporting information that showed their importance to the participating Trusts. In these circumstances the validity of our findings is not in question, but the small number of cases makes us cautious about generalising more widely. In support of the generalisability of the study, however, the circumstances of participating Trusts that were often the basis of managers' concerns are prevalent throughout the NHS: such as poor performance ratings (26% of acute Trusts have <2 stars),[93] having a financial deficit (18%),[94] or having recently merged.[68] These issues did not necessarily coincide in the participating Trusts, supporting the view that they are independent. Where the same issues occur in other Trusts, we would expect them to have a similar impact. The main limitation of our study is that we may have missed important factors because they were not present in our participating Trusts. Therefore,

we cannot conclude that the issues highlighted in this report are the only or most important ones.

The small number of participating Trusts makes us cautious about generalising our findings. The Trusts studied are located in only two of the five geographic implementation clusters. However, uncertainty over timetables and a lack of progress have been widely reported across all regions of England.[95] Moreover, mergers of IT companies also mean that the Trusts studied are being supplied by two of (now) four local service providers.[95] Concerns raised by respondents, about performance and finance, are prevalent issues in the NHS but may be more salient in our participating Trusts than nationally.

A further limitation of this longitudinal study, was the degree of staff turnover between the two stages. In the 18 months following stage A, there were several changes in personnel; of the 23 staff originally interviewed in 2004, only 11 were still in post in 2006 (2 out of 4 chief executives, all 4 directors of nursing, 2 medical directors and 3 directors of information technology). This is an important context to the study itself, but means that there are some discontinuities in terms of interview data.

Set against these limitations, ours is the only in-depth, longitudinal study of NHS IT modernisation. We interviewed a cross section of senior Trust staff responsible for implementing the programme in NHS hospitals over a period of two years. These interviews have provided us with a detailed account of their views about progress so far, the challenges they perceive in implementing the programme in NHS hospitals and their information needs, in addressing these challenges.

Level 2 interviews

We were able to study the factors which affected adoption and the impact of two specific IT applications (PACS and CPOE) in some of our case study Trusts. As implementation was limited (PACS was only fully implemented in one Trust, partially in two others; CPOE was only fully implemented in one Trust), this part of our study was not as large as we had hoped. As our focus

was on end-users' experiences of these IT applications, our use of the interview as method was appropriate, however we would have liked to have been able to interview a wider range of end users had implementation been more widespread. We were able, however, to study the impact of partial implementation of an IT application (PACS in two Trusts) compared to full implementation in another, and compare unsuccessful implementation of an IT application (CPOE) in one Trust with relatively successful implementation in another. This added to our understanding of the factors which influence adoption and diffusion.

Our intention had been to link the quantitative and qualitative data much more than we have been able to achieve. This is partly because of the limited amount of implementation and the focus of Level 1 of the qualitative study on the delayed implementation of NPfIT, and partly because of the length of time it took us to access the quantitative data from the Trusts. We are able to link some of the findings from the qualitative and quantitative studies on the impact of PACS and CPOE (see for example **7.5.1**).

8.3.2. Quantitative study

The main limitations of the quantitative study relate to our ability to attribute causality to observed associations. We observed associations of substantial magnitude, some beneficial and some adverse with respect to the efficiency of health care delivery, but few were 'significant' in a conventional statistical sense. Moreover, even where we did find significant associations, we cannot necessarily assume that these arise from implementation of CPOE or PACS.

In controlled before-and-after studies, one investigates how aggregate measures for a particular time period differ between 'intervention' and 'control' clusters, after adjusting for 'baseline' values of the aggregate measures for another time period when all clusters operated in a similar manner (either all control or all intervention). Within each time period and cluster, outcomes are aggregated over many individuals. When analysing such studies, it is vital to take into account the clustering of individuals within institutions (or other cluster unit); this can be done either by analysing the aggregate measures

themselves, or by analysing the individual observations with appropriate adjustment to the standard errors calculated. (When we analysed the data without taking account of clustering, all effects were statistically significant.) The latter method has more statistical power; however, the former method illustrates that our study was essentially a study with 'n'=28 for between-Trust comparisons (4 Trusts and 7 specialties, more for outpatients, although strictly only one intervention Trust), and n=7 for within Trust comparisons. Consideration of a controlled before and after study with only two institutions (which is often the case) also highlights the problem of inferring causality; such a study may well find a highly significant effect but there is no way of knowing whether the effect arises from implementation of the study intervention or from some particular characteristic of the institution. Attributing causality is strengthened by using multiple clusters because the difference in aggregate outcome between intervention and control clusters can be studied against the background context of variation in the outcome between all clusters.

Statistical power is greatest when the numbers of intervention and control observations are roughly equal. Obviously, we had no control over implementation of CPOE and PACS and simply note that the unequal allocation of observations to intervention and control groups meant that the study had less power than it might have had, if CPOE and PACS had been implemented more widely.

We carried out both between- and within-Trust comparisons as a check for consistency. In effect, the latter represent analyses that control for the possibility that between-Trust findings arise from external factors affecting only the intervention (or control) Trusts. Removing one source of variation would normally be expected to strengthen the analysis. However, in within-Trust analyses, the CPOE or PACS was only deployed (or withheld) in certain specialties. Thus, these analyses compared CPOE or PAC in some specialties with no CPOE or PACS in other specialties and we cannot be sure that the opportunity for CPOE or PACS to influence the outcomes we studied is the same for all specialties (a limitation which does not affect the between Trust comparisons).

If we had found many effects apparently associated with implementation of CPOE and PACS, we would have had to deal with the problem of attributing causality many times. In the event, we only found a consistent effect of CPOE on outpatient test ordering, for which there is a plausible explanation. Further investigation of this effect, at a finer level of detail or in a much larger sample of Trusts (with multiple Trusts implementing CPOE), would be required to be more confident that CPOE caused changes in test ordering. Conversely, that we did not find many effects associated with implementation of CPOE and PACS is both plausible and consistent with many other studies (see **8.4**).

We simply coded Trusts as implementing CPOE and PACS or not, although the situation was more complex as has already been described. There is a more general issue of what, precisely, should be considered to represent an innovative IT application, especially when many applications are implemented in a stepped fashion. For example, changes in radiological imaging often proceed from implementation of digital cameras, through digital storage, to effective electronic communication of images over a more or less extended period of time; similarly, electronic test ordering and browsing functions are not always implemented at the same time, and test ordering systems may differ substantially in their ability to implement restrictions on ordering on the basis of national or local guidelines. Nevertheless, the key point here is that the slight lack of 'purity' in our classification of Trusts as intervention and control could only mean that any associations we observed were underestimates of the effects of CPOE and PACS.

Although we restricted our between-Trust analyses to specialties common to all of the participating Trusts, our results remain susceptible to residual confounding within specialties due to differences in case-mix between Trusts. In within-Trust comparisons, the analyses assumed constant case-mix over time within specialties.

Our choice of outcomes was largely dictated by the data available from routine sources. Therefore, we had to develop 'proxy' outcomes for the outcome we wanted to investigate, for example [redundant] 'duplicate' tests. We did not have the level of detail necessary to determine whether tests repeated within this interval were actually redundant (e.g. redundant tests have typically been

identified by chart review). Our method of doing this, e.g. retest within 48 hours, may not be equally applicable across specialties but we found no evidence to the contrary by comparing the distributions of times to retest within specialties. Our choice of interval (48 hours) is also consistent with other studies.[97-99] If some retests within 48 hours are clinically necessary (as we expect), and hence uninfluenced by CPOE, and some retests after 48 hours are in truth duplicates, these misclassifications could only mean that the association observed was an underestimate.

It was not possible to verify data quality, although outpatient CDS data have been assessed as reliable.[96] Pathology test and radiology examination data were unlikely to contain significant omissions, since these were obtained directly from pathology laboratory information systems (land radiology information systems (RIS) into which all pathology tests and radiological exams were logged as standard operating procedure across all of the Trusts. More significant omissions may have arisen in using local patient identifiers to join these data with the CDS data. We had no means to verify the reliability of this process, but the consistency of our outcome measures, both within and between Trusts, gives us a reasonable degree of confidence.

One of our biggest difficulties was obtaining background information on the implementation of applications, particularly in the control Trusts. Front-line staff in pathology and radiology departments were too heavily burdened with work to respond to requests for information. Higher-level staff (managers and consultants) expressed more interested in the aims and ultimate success of our study, but lacked sufficiently detailed historical knowledge of systems in these departments. Hence we would be referred back to the same beleaguered front-line staff who had been unable or unwilling to respond to our original requests. These shortcomings were compounded by institutional amnesia as a result of high staff turnover, and by the demands of more immediate issues. (One consequence of the launch of NPfIT is that some of the best IT staff with inside knowledge of the NHS were head-hunted by local service providers, so there was quite high turnover in local Trust IT Departments.)

Despite these limitations, we believe our study provides more valid and applicable evidence of the effects of implementing CPOE and PACS applications than other studies have done. Our study was larger and broader in scope than previous ones and, despite small number of Trusts, broadly representative as we have argued above. The 'controlled before-and-after' design is recognised as one of the best ways to take confounding factors into account (at the level of both the institution and individual observations). Our limited ability to infer causality from the findings arose from the small number of Trusts we were able to include, not from the study design. In this first attempt to carry out an evaluation on this scale, we were unable to recruit more Trusts; it was difficult to obtain the data from Trusts and we only received the last batch of data required for the analyses in November 2006. What the study does demonstrate, however, are the opportunities for future research using the same principles, as the roll-out of NPfIT picks up speed (see **8.5**).

8.3.3. Limitations affecting the entire study

In both of the preceding sections, we acknowledge the limitations from having only four case study Trusts. Another limitation of our study is the lack of a primary care perspective. The NPfIT was conceived from the perspective of the entire NHS in England, combining the goals of the original episode-focused electronic patient record and the longitudinal, cradle-to-grave health record.[ENlib#1] Realisation of this vision requires equal commitment from all sectors of the NHS. We tried to address the primary secondary interface by studying the implementation of Choose and Book but were unable to do so in detail because this application was not introduced to a significant extent by any of the Trusts that we studied.

8.4. Findings in the context of existing literature

8.4.1. Qualitative study

Experiences of IT implementation in the UK[101] and other countries confirm the importance of sociocultural considerations. A case study from Australia

described a major failure of IT implementation, identifying organisational and cultural factors that led to the failure as well as technical ones, with the system failing to meet staff expectations.[12] In the United States introduction of the "computer physician order entry" led users to feel that their work was disrupted and not facilitated and that the organisation gained more than they did,[33] with reports of an adverse impact on team relationships.[34] This was mirrored in our study of the experience of the failure of implementation of CPOE in Trust 2.

There are also major technical and logistical challenges to implementation, but NPfIT project managers have shown commitment to dealing with these.[102] However, the sociocultural challenges are daunting,[25,26,28] and we found that senior NHS staff felt these to have been neglected. One concern is that staff will not experience tangible benefits in the near future,[7,20] but will have to cope with disruption, uncertainty, and change, and possibly a loss of IT functionality in the short term. In these circumstances, a more sophisticated approach is needed to gain the cooperation of front line staff, on whom success will depend.

The programme in wider context

GPs derive substantial benefits from using IT systems to support the day-to-day running of their practices. These systems have been designed to meet the small-business needs of GPs and to underpin relatively simple clinical functions,[104] allowing GPs to run their practices efficiently and autonomously. Therefore, GPs may perceive that they will not benefit substantially from the programme and, more importantly, may not want applications of the programme imposed on them.[105]

By contrast, acute hospital Trusts have to deal with more urgent and complex demands, requiring fast communication between hundreds of staff across many specialties and professional disciplines and, in emergency situations, between hospitals and health sectors. Although their IT systems have historically been poorly integrated, they stand to benefit hugely from modernisation, not least in achieving the efficiencies currently being demanded of them. For managers and clinicians in acute Trusts, the programme has to work. There is no alternative, independent procurement of

IT systems, in the absence of national standards, having already been tried with limited success.[106]

Implementation of Choose & Book illustrates these differing perspectives. Senior Trust staff reported that achieving "seamless connectivity" between primary and secondary care was a major obstacle, in addition to technical problems, and a lack of support for the concept of patient choice. There was no integration of Trust and GP IT systems and acute Trust staff were unable to reconcile implementation timetables and goals for Choose & Book with their primary care colleagues. Many GPs did not accept the concept and could choose not to.[107]

8.4.2. Quantitative study

It is clear from **8.2.3** that our strongest and most plausible finding is that implementation of an CPOE system was associated with a much slower upward trend in the proportion of outpatient appointments at which FBC, UE and UR pathology tests were ordered, and at which FBC tests were possibly re-ordered.

We conducted a literature search to identify comparable studies. For CPOE, this search was pre-empted by a fairly recent systematic review, to which we appended our own review of more recent publications. As might be expected, papers reporting issues around the implementation of health care IT systems are being published at a rapidly increasing rate. As might also be expected, there is little consistency in their findings, and studies vary widely in perspective, setting, size, and design.

In the systematic review, CPOE was associated with reduced pathology test volumes in 7 out of 11 studies, with no change in 3 studies, and with an increase in one study.[18] Only one of the studies (showing reduced volume), was performed in outpatients departments, and the intervention evaluated in this study was a module added to an existing CPOE system to display test charges.[85] We found one additional study (by the same author), in a US primary care setting, which reported a reduction in ordering of six types of pathology tests (including FBC, UE and UC), and requests for two types of

radiology examinations, if previous test or exam results were displayed. This result was for the study overall; the slight decrease in FBC and UE test orders was not analysed separately. UC test orders showed a slight increase.[108]

A recent study, involving the same CPOE system as was deployed in our intervention Trust (but looking at inpatient tests for liver function and plasma gentamicin and vancomycin levels), found no change in test order volumes[109]. Interestingly, this study did find other changes (in turnaround time, in information provided with specimens, and in ordering of tests removed from an order set), which suggest that changes may occur at a level of detail beneath our outcomes. That this level of detail may be requisite in designing studies to assess the impact of IT systems on health care provision, is best exemplified by a study of test utilization in a coronary care unit.[110] The intervention in this study comprised new clinical guidelines on test ordering, which were devised for the study and disseminated throughout, and modifications to an existing CPOE system. The study outcomes were specific to coronary intensive care, and the intervention and control care units were closely matched. The study did find that the intervention was associated with reduced test orders.

Our study did not demonstrate effects on radiological examination request behaviour which could be readily attributed to implementation of PACS. In the absence of a systematic review on this subject, we found one comparable study, which reported increases in inpatient and outpatient utilization of radiological services comparing one North American hospital with another hospital, and with the national average.[111] However, none of these comparisons were supported by statistical tests with which to measure the strength of evidence. We also found a study within a UK hospital, which reported some improvements in radiology department performance, including a slight reduction in the repeat imaging rate.[56] Other studies were either qualitative or examined other outcomes; those which examined length-of-stay found no impact of PACS.[56,112,113]

We should not be discouraged that our study joined almost all previous studies in failing to detect any consistent or plausible beneficial impact of CPOE or PACS on outcomes such as inpatient length-of-stay and mortality. In some sense, these outcomes served as negative controls, to ensure that our

intervention Trusts were not affected by major process changes which might confound any associations we found with our primary outcomes. For example, deployment of CPOE within Trust A coincided with construction of a new hospital under a government Private Finance Initiative (PFI). A more cogent argument is that, while CPOE systems and PACS may bring important qualitative improvements to the process of clinical care (particularly in making life easier for clinicians), these benefits are difficult to quantify and detect on a macroscopic (hospital-wide or Trust-wide) scale.

8.5. Research agenda

This study has shown that it is possible to use routinely collected patient-level data from disparate sources within very large health care institutions as a basis for assessing the impact of technological changes on indicators of clinical activity and operational efficiency. In the context of future research within the UK NHS, the transmission of local (Trust-level) patient identifiers in CDS data to NWCS, and the improving availability of datasets from specialist departments within Trusts, suggests that our technique of joining CDS data with these specialist datasets could form the basis for operational research on a nationwide scale. For example, the impact of new NPfIT functions could be assessed by comparing Trusts randomly selected from the group of early-adopters with a random selection of Trusts yet to implement the function. This method could be applied to changes other than the implementation of new technologies, and to much larger groups of Trusts.

This is an exciting prospect since the analyses are entirely feasible. The key requirement, in addition to a mandate to provide the necessary data, is extremely careful documentation of the implementation of IT applications over time, both with respect to timing and details of exactly what is being implemented. In principle, the NHS provides an appropriate setting to use an even stronger study design, e.g. a cluster randomised controlled trial or ‘stepped-wedge’ design (the same principles as the controlled before and after study but with randomisation of hospitals to implement earlier or later), but this would a require a level of national control of the implementation schedule across Trusts that is probably not achievable on both logistical and political grounds.

For this method to succeed, it is very important to study a large number of Trusts. Again, this is entirely feasible providing that routine data for Trusts can linked in similar ways, without the need to customise data management tasks. A large number of participating Trusts will improve statistical precision in the conventional manner. More importantly, however, it will also allow variation between implementing and non-implementing Trusts to be described in a more representative manner. Variation between Trusts is critical because variation at this level provides the basis for inference about the statistical significance of differences between implementing and non-implementing Trusts; having data from a large number of Trusts makes statistical inferences more applicable. Finally, having a large number of participating Trusts gives greater confidence in attribution of effects to IT modernisation (or other organisation wide innovation or technology); artefacts would have to be widespread, associated with the chosen indicators, and coincide with implementation in the majority of Trusts (not necessarily at the same point in calendar time), for their effects to be confused with those arising from implementing IT modernisation.

Large scale quantitative studies alone are, however, unlikely to provide all of the information required. The difficulty that we experienced in attributing effects to IT modernisation arose not simply because of the small number of participating Trusts but also because we had a poorly developed understanding of the way in which IT applications impact on health care. Qualitative studies, such as level 2 interviews, provide this understanding and can inform both the design and interpretation of quantitative studies.

Our study shows the usefulness of using qualitative methods to study processes of implementation at a local level. Multiple case studies, such as this one, provide useful analyses both within and across case studies, for example comparing where implementation has gone well and less well. Longitudinal studies are important in studying implementation processes, and in the case of implementing complex innovations within large systems, studies need to be conducted over significant time periods i.e. at least 5 years.

Development of appropriate outcome measures provides one example of the way in which qualitative and quantitative methods should be combined. One approach to the choice of outcomes (and, effectively, the one that we adopted) is simply to

study indices which are available, easily derived from routine sources or which policy makers aspire to influence for reasons of face validity.[54] A second approach is to base outcomes on feedback from users with experience of service delivery and IT applications, developing outcomes to reflect aspects of service delivery which the users themselves consider important to their ways of working and which they believe are influenced by IT modernisation.

One major evidence gap, of particular importance to senior managers in NHS organisations faced with implementing the NPfIT and the levels of uncertainty already described, is the absence of high quality evaluations of the economic implications of implementing organisation-wide IT applications. One reason for the lack of studies is the lack of high quality studies (using designs with good validity and which are well executed) of the resource consequences of implementation. However, the economic evaluations that we reviewed were also of poor quality from the point of view of the economic methods used.

We do not intend to criticise these studies unthinkingly. We acknowledge that there is a paradox. One the one hand, there is an urgent need for better evaluations of the economic and financial consequences of IT modernisation to help plan implementation, yet it is not clear that the methods conventionally used for economic evaluation are applicable to such large scale and complex interventions. We recommend that, in planning future economic evaluations, research should:

- Be clear about the precise question that needs to be addressed.
- Define precisely the nature of the intervention, for example with respect to its scale, the extent of integration between different components. It is important to remember that IT applications are not necessarily equally effective, as we observed.
- Wherever possible, aim to study and value the health consequences as well as resource consequences of IT implementation.
- Study carefully the transition from the existing method of providing health to the new method based on the intervention being studied, while at the same time studying the intervention longitudinally for a sufficient period of time to observe the kinds of effects that are hypothesised.

This study has taken place at the very beginning of the process of attempting to implement a national IT system at local level, and provides useful lessons for the future. Given the delays in implementation which we have described, we have not been able to study processes, such as changes in working practices, to the degree we would have liked. Whichever way IT policy develops in the future, it will be important to continue to study the processes of implementation and the impact they have on organisations, teams, and patient care.

With respect to specific research questions (see below), we strongly recommend continuity of research similar to this project as NPfIT is rolled out. Quantifying the effects of IT modernisation is very important in order to relieve the prevailing uncertainty, which in turn should promote uptake. Therefore, we offer no apologies for recommending new research questions using the same methods, which we believe have been successful. It should be noted that we were unable to study implementation of NPfIT because of delays and this, rather than local implementation of stand-alone applications, is the real innovation. Features of the NPfIT, such as the broad standardisation of applications and their integrated design, means that findings of our study cannot necessarily be generalised to NPfIT.

A. Develop a framework for recording the detailed implementation of NPfIT in all NHS Trusts, together with a system for logging business cases for local IT expenditure relating to implementation of NPfIT. This framework is vital for any comparative study of IT modernisation across the NHS.

B. Develop indicators which reflect important impacts of implementing IT applications and potentially important health consequences for patients. The research should use Delphi or consensus-like methods, bringing together people with knowledge of routine NHS datasets, local directorate databases, IT implementation, workforce training and planning, users (clinicians and others), patients, risk assessors, etc.

C. Quantify the effects of implementing new PAS systems which are compatible with NPfIT. The research should use quantitative methods as in this project, linked to PAS installation timetables from LSPs / cluster administrators. The time period studied should be long enough to allow description of: (a) a stable

baseline, (b) the period of implementation, (c) a short post-implementation period (1 year), (d) a long post-implementation period (2-3 years). The duration required means that the study will need to be partly retrospective, and partly prospective. We suggest that existing indicators would be satisfactory to address this research question. Qualitative methods could be used in parallel to study implementation processes in detail, for example: involvement of end users in the process, in formulating training requirements and in training itself; impact on patient access, e.g. facilitation of improvements in waiting times, in particular the 18 week target; impact on clinical work, e.g. benefits/disbenefits for patient safety; impact on professional relationships, e.g. team working, in both the short and long term.

D. Quantify the effects of implementing of NPfIT approved 'bolt on' applications. The study would again use similar quantitative methods but, potentially, using more relevant, appropriate or important indicators (see B). The same issue about the duration of study applies here as above (see C). We strongly recommend that the study should use qualitative methods in parallel, as we did in this project, specifically to study variation/discrepancies between Trusts during periods (b), (c) and (d). The qualitative research could study implementation processes, as in C, but could also explore [relative] successes and failures, to provide lessons about good practice. Selection of case studies for the qualitative research, would need to be informed by the quantitative research (i.e. extremes of variation). Timing of the qualitative field work would also be critical, to ensure memories of important issues were fresh and that findings could be reported sufficiently quickly for lessons to be applied.

E. Investigate synergies between NPfIT approved applications. This project would build on A and B, using both quantitative and qualitative methods. The aim would be to identify whether the co-implementation and use of multiple applications is associated with different effects compared to when applications are implemented singly. This research question is key to understanding the wider impact of IT modernisation. We do not have a definite prior hypothesis. It is possible that co-implementation of applications produces an overall effect that is smaller than the simple additive effect of the implementations

separately, because some shared effects can't be realised twice. Alternatively, co-implementation of applications might produce effects over-and-above a simple additive effect, because of synergy between applications.

F. Commission research into methods for evaluating the economic consequences of implementing organisation-wide technologies/systems. We recognise that this is a very broad question, which is likely to require considerable refinement through discussion with economists.

8.6. Implications for a National IT System

Many health systems aim to realise the potential benefits of health care IT through the widespread implementation of electronic health care records. The national programme was conceived from the perspective of the entire NHS in England, combining the goals of the original episode-focused electronic patient record and the longitudinal, cradle-to-grave health record.[1] The debate is how best to achieve this. An important lesson to emerge from our study of NPfIT implementation is the difficulty in achieving an appropriate balance of responsibility between government and local health care systems. As the experience of IT implementation in this country illustrates, devolving control of IT to local managers results in a lack of standards, and disparate functionality. Central control is equally problematic, with the sheer size of the task making communication and realistic goal setting difficult.

NPfIT has not made the progress that was expected.[44] However, the views of senior NHS staff in our study represent a warning of the continuing challenges ahead. The process of implementation needs to change rapidly for NHS staff to feel optimistic and to embrace IT changes with enthusiasm. Moreover, attributing benefits unequivocally to the NPfIT is likely to be difficult and to take time.[24,100]

The latest strategy in this country involves a third approach, setting central standards but with local implementation. As recommended by the British Computer Society,[114] CfH's role is shifting away from implementation towards providing a national infrastructure and standards-setting body. Implementation will now be devolved more locally, as set out in the NHS national business plan for 2007/08.[115] Even with these changes, the issues raised in our study still need to

be addressed. CfH, in its new guise, needs to involve local end users in discussions about what form the national infrastructure should take and in developing national standards – these should not be imposed above, as this would only repeat mistakes that have already been made. Further, devolving responsibility for implementation locally raises question about the degree of local customisation permitted. As we found in our study of PACS and CPOE, local customisation is an important factor in successful adoption however, too much customisation might weaken national standards and the ability to pass data between providers. Finally, a national infrastructure should include helping Trusts to prioritise IT modernisation against competing financial pressures, for example, by inclusion in performance management frameworks. Whatever changes are planned, they need to be communicated throughout the NHS with clear timetables to end the uncertainty and 'planning blight' that currently exists at local level.

8.7. Implications for local implementation of IT applications

Our study of NPfIT implementation at local level and end users' views of specific IT innovations has implications at the local level in the NHS.

The CPOE system within Trust A and PACS within Trust D were considered by managers and end-users to have been successful implementations of these types of health care IT system, preceding by several years the roll-out of similar systems under NPfIT. The UK NHS is leading the way in terms of the scale and homogeneity of its health care IT programme, and although running behind schedule and over budget, the programme continues to receive the support of managers and clinicians alike.[86,87,115]

It is possible that CPOE and PACS, when fully integrated with the other IT systems which comprise NPfIT (national electronic health records, patient administration systems, electronic booking, etc), will contribute to more dramatic quantitative changes, which raises the issue of where the responsibility for local implementation lies – at national or local level. In the meantime, the evidence base to support the procurement and implementation of IT systems by health care providers falls far short of the evidence base required to inform changes in clinical practice within these same providers. This is perhaps unsurprising, given the

different set of stakeholders involved, the top-down political pressure, the fierce competition among the companies which provide these systems, and the widespread assumption in the technological domain that newer is necessarily better.

At the local level, Trusts should be aware of the factors which enhance or impede IT implementation, and would be advised to undertake an analysis of these factors in relation to their own local context, before undertaking implementation, as follows:

1. Attributes of the innovation

   These factors include the ease of use and reliability of the innovation, and its compatibility with existing practices or the ability to customise it such that it is compatible.

2. Characteristics of the 'adopter'

   Regardless of the attributes of the innovation, there will be variations in how the innovation is received depending on the characteristics of the adopter e.g. how familiar they are with IT etc. These should be taken into account when planning implementation. However, these characteristics are not static and there will be an interaction between how the innovation is received, its attributes, and the implementation processes.

3. Implementation processes

   User consultation and involvement are crucial factors in the implementation process. Where Trusts had consulted and involved staff in the implementation, they were more successful. The quality of training for staff to use the innovation(s) and on-going IT support are also very important. Finally, achieving a critical mass of implementation i.e. implementing the IT application widely enough so that it is worthwhile for staff to use is important.

4. Organisational factors

   Trusts vary in their circumstances, which affect their ability to implement IT innovations. Issues such as recent structural changes, e.g. mergers, and the impact of financial deficits mean that for some Trusts it is much harder to prioritise IT implementation. These Trusts may require additional external support in order

to achieve this implementation. As we identified within our study of specific innovations, IT implementation requires a strong project management team with high level management support.

The design and implementation of IT innovations needs to be based on a thorough understanding of 'the business' that they are being designed for.

Finally, the level of the ability of the organization to work as a whole and in teams is an important factor in the implementation of IT innovations.

8.8. Conclusions

This study is one of the few carried out on the early stages of implementation of the national IT programme for the NHS in England. It provides useful insights into the challenges of attempting this very ambitious programme, from the perspective of the local level. It also provides data on the processes and impact of implementing specific IT applications on a scale not achieved before. The study has significant implications for the future direction of NHS IT policy. We have also raised important methodological issues for future studies of large scale IT implementation in health care.

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Appendix 1

EPR Implementation Project - Interview Schedule

Level 1, stage a. - Organisational Context

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Length of time respondent has been in that post:

Role in EPR implementation:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main Question -

What contextual factors (historically and currently) act as facilitators or barriers to the implementation of EPRs at acute trusts – specifically examining the impact of recent NHSCRS policy changes on EPR implementation.

Preamble -

Thank you for agreeing to take part in this research study.

Just to reiterate, the study has been funded by the NHS Service Delivery and Organisation R&D Programme. The aim is to evaluate the process of implementing electronic patient records, or NHS Care Record Systems, as they are now called, in acute trusts.

There are two main elements to the study, a quantitative analysis of the costs and savings associated with the implementation of EPRs, and a qualitative analysis of the organisational impact of implementation.

The focus of this set of interviews is to capture managers' experiences of EPRs, particularly factors that facilitate or hinder successful implementation. The interview will last no more than one hour and with your permission will be tape recorded – just to help me remember what was said later on. To reassure you, all information obtained will be anonymised. Neither the trust nor individual staff will be identified, when the research is written up, with all names and staff positions anonymised. You will have an opportunity to read the draft final report to make factual corrections. You will also receive an executive summary and be able to attend a seminar disseminating the findings.

Before we begin, do you have any questions, anything I have not covered?

Appendices

OK. Firstly, I'd like to ask you some general questions about the National Programme for IT, then I'd like to ask you about EPR implementation at (the trust).

NPfIT in general -

1. Previously, reaching national targets regarding the implementation of EPRs was primarily the responsibility of local trusts. The National Program for Information Technology (NPfIT) has now decided a more centrally controlled approach is needed. What do you think about this decision?

   Prompts: explore wider organisational factors specific to the NHS that have hindered IT implementation?
   What would have helped?
   Will centrally controlled solutions be better or worse?

EPR development at the trust -

2. In 1998, Information for Health set out six levels of EPR development. By April 2002 it was reported that only 3% of trusts (five in total) had complete EPR systems in place – way under the hoped for target. In trying to achieve some level of EPR implementation - can you give me any insights into how (the trust) got on?

   Prompts: explore the trust's past experiences of implementation.
   Previous in-house IT successes and failures
   Any specific difficulties encountered - medical/ legal/ staffing problems.

3. What do you think were some of the barriers to implementation, and what could the trust could have done differently to achieve a higher level of EPR development?

   Prompts: explore physical, informational and organisational resources (costs) that have facilitated or hindered IT implementation.

Explore the relationship between Trust Managers and the information system in use.

Explore the role of wider organisational pressures – such as achieving operational targets.

4. In terms of preparing for the new LSP solutions what do you think needs to be done at (trust)?

Prompts: explore the change management associated with planning for the LSP solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

5. Who is driving these changes within the trust?

Prompts: explore the role of leaders and super-users - the organisational impact of key players.

6. How do you see your role impacting on the process of implementation?

Prompts: explore how motivated, efficacious, and involved they are.

Explore the organisational impact of their personal investment (or lack of it).

7. Across the trust, how much agreement do you think there is about the importance of achieving NCRS?

Prompts: explore organisational commitment to implementation – across the trust and within different groups.

The role of constant change in management teams and the NHS generally.

Explore whether high levels of change has impacted on IT focus and staff commitment? Explore the perceived commitment of different groups.

8. In implementing the LSP solutions – where do you see potential areas of difficulty?

Prompts: explore issues of 'organisational fit' and goal conflict – other pressures and priorities.

Differing agendas – how the EPR implementation programme needs to address the priorities of 'everyman' - trust, SHA, and National Program.

Explore the role of in-house IT innovations and their future.

Explore perceptions of what NCRS should deliver against what is perceived as being rolled out -

Any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables?

9. What are the consequences of achieving the NPfIT goals – electronic patient records that support an integrated care records service?

Prompts: explore positive and negative outcomes - national and organisational. Explore impact on staff roles, relationships and patient care.

10. For you what constitutes EPR implementation success?

Prompts: explore how the meaning of success is defined, at what level, and for whom – the trust, the LSP or the National Program?

11. How can this success be best achieved?

Prompts: explore factors they consider necessary for success – such as staff relations, clinician engagement and finance.

How these can be factors be achieved and whether they think these factors will be forthcoming?

If time –

12. Regarding NPfIT - what do you think will be happening in the future?

Prompts: explore whether they think NPfIT will deliver long term – and the consequences of (non) delivery.

13. How do you think (trust) will respond to these changes?

Prompts: explore both positive and negative responses.

14. Lastly – whether they would like to make any other comments before ending

Thank them again – please call me if you have any future questions.

Appendix 2

EPR Implementation Project - Interview Schedule

Level 1, stage b. - Organisational Context

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Length of time respondent has been in that post:

Role in EPR implementation:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main Question -

What contextual factors (historically and currently) act as facilitators or barriers to the implementation of EPRs at acute trusts – specifically examining the impact of recent NHSCRS policy changes on EPR implementation.

Preamble -

Thank you for agreeing to take part in this research study.

Just to reiterate, the study has been funded by the NHS Service Delivery and Organisation R&D Programme. The aim is to evaluate the process of implementing electronic patient records, or NHS Care Record Systems, as they are now called, in acute trusts.

There are two main elements to the study, a quantitative analysis of the costs and savings associated with the implementation of EPRs, and a qualitative analysis of the organisational impact of implementation.

The focus of this set of interviews is to follow up on information gathered about the (NPfIT) in 2004. The aim to gather further information about professionals' and managers' experiences and their views on the NPfIT, particularly factors that facilitate or hinder successful implementation. The interview will last no more than one hour and with your permission will be tape recorded – just to help me remember what was said later on. To reassure you, all information obtained will be anonymised. Neither the trust nor individual staff will be identified, when the research is written up, with all names and staff positions anonymised. You will have an opportunity to read the draft final report to make factual corrections. You will also receive an executive summary and be able to attend a seminar disseminating the findings.

Before we begin, do you have any questions, anything I have not covered?

Appendices

OK. Firstly, I'd like to ask you some general questions about the National Programme for IT, then I'd like to ask you about EPR implementation at (the trust).

NPfIT in general -

1. Previously, reaching national targets regarding the implementation of EPRs was primarily the responsibility of local trusts. The National Program for Information Technology (NPfIT) has now decided a more centrally controlled approach is needed. What do you think about this decision?

   Prompts: explore wider organisational factors specific to the NHS that have hindered IT implementation?
   What would have helped?
   Will centrally controlled solutions be better or worse?

EPR development at the trust -

2. In trying to achieve some level of EPR implementation - can you give me any insights into how (the trust) has been getting on?

   Prompts: explore the trust's past experiences of implementation.
   Previous in-house IT successes and failures
   More recent dealings with NPfIT
   Any specific difficulties encountered - medical/ legal/ staffing problems.

3. What do you think were some of the barriers to implementation, and what could the trust could have done differently to achieve a higher level of EPR development? What could central NPfIT have done differently?

   Prompts: explore physical, informational and organisational resources (costs) that have facilitated or hindered IT implementation.

Explore the relationship between Trust Managers and NPfIT central and LSP contractors.

Explore the role of wider organisational pressures – such as achieving operational targets.

4. In terms of preparing for the new LSP solutions what do you think needs to be done at (trust)?

Prompts: explore the change management associated with planning for the LSP solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

5. Who is driving these changes within the trust?

Prompts: explore the role of leaders and super-users - the organisational impact of key players.

Explore the role of LSPs in driving things forward

6. How do you see your role impacting on the process of implementation?

Prompts: explore how motivated, efficacious, and involved they are.

Explore the organisational impact of their personal investment (or lack of it).

7. Across the trust, how much agreement do you think there is about the importance of achieving NCRS?

Prompts: explore organisational commitment to implementation – across the trust and within different groups.

The role of constant change in management teams and the NHS generally.

Explore whether high levels of change has impacted on IT focus and staff commitment? Explore the perceived commitment of different groups.

8. In implementing the LSP solutions – where do you see potential areas of difficulty?

Prompts: explore issues of 'organisational fit' and goal conflict – other pressures and priorities.

Differing agendas – how the EPR implementation programme needs to address the priorities of 'everyman' - trust, SHA, and National Program.

Explore the role of in-house IT innovations and their future.

Explore perceptions of what NCRS should deliver against what is perceived as being rolled out -

Any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables?

9. What are the consequences of achieving the NPfIT goals – electronic patient records that support an integrated care records service?

Prompts: explore positive and negative outcomes - national and organisational. Explore impact on staff roles, relationships and patient care.

10. For you what constitutes EPR implementation success?

Prompts: explore how the meaning of success is defined, at what level, and for whom – the trust, the LSP or the National Program?

11. How can this success be best achieved?

Prompts: explore factors they consider necessary for success – such as staff relations, clinician engagement and finance.

How these can be factors be achieved and whether they think these factors will be forthcoming?

If time –

12. Regarding NPfIT - what do you think will be happening in the future?

Prompts: explore whether they think NPfIT will deliver long term – and the consequences of (non) delivery.

13. How do you think (trust) will respond to these changes?

Prompts: explore both positive and negative responses.

14. Lastly – whether they would like to make any other comments before ending

Thank them again – please call me if you have any future questions.

Appendix 3

EPR Implementation Project - Interview Schedule

Level 2 – EPR use

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Department/ speciality:

Length of time respondent has been in that post:

Use of EPR in post:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main Questions -

How are specific areas of EPR functionality experienced by end-users?
How is the process of implementation?
Does EPR use impact on current working practices? And if so how?

Preamble –

Thank you for agreeing to take part in this research study.
Just to reiterate, the study has been funded by the NHS Service Delivery and Organisation R&D Programme. The aim is to evaluate the process of implementing electronic patient records, or NHS Care Record Systems, as they are now called, in acute trusts.

There are two main elements to the study, a quantitative analysis of the costs and savings associated with the implementation of EPRs, and a qualitative analysis of the organisational impact of implementation.

The focus of this set of interviews is to explore your experiences of using information technology (EPRs) in doing your job. The interview will last no more than one hour and with your permission will be tape recorded – just to help me remember what was said later on. To reassure you, all information obtained will be anonymised. Neither the trust nor individual staff will be identified, when the research is written up, with all names and staff positions anonymised. You will have an opportunity to read the draft final report to make factual corrections. You will also receive an executive summary and be able to attend a seminar disseminating the findings.

Before we begin, do you have any questions, anything I have not covered?

OK. Firstly, I'd like to ask you some general questions about what's its like to use the current system, then I'd like to ask you about how using the system impacts on your work.

Appendices

Part 1. Experience of EPR use -

1. **Can you talk me through how you use the current system to do (EPR function)?**

Prompts: explore -
What is it that they do? When, where, how and with whom?
How does the EPR influence the way they think, make decisions?
How does the EPR impact on their interaction with other staff/patients?
Do they think the EPR affects the care patients receive? If so how?

2. **Did you use the previous system? If so how does the current (EPR function) compare with previous ways of working?**

Prompts: explore negative/positive changes in their -
Behaviour - How they used to think, make decisions
Their relationships with other staff/patients

3. **How easy or difficult is it to use the current system to do (EPR function)?**

Prompts: explore -
Ease of access (physical and cognitive barriers and facilitators)
Changes in the organisation (flow) of their work
What stops them using it – what helps them use it?
Their knowledge of the EPR – how was the information given?
Training and support received & the process of info. giving and sharing of ideas
The perception of their personal capabilities

Part 2. Process of implementation

4. **Were you involved the process of implementation? If so how involved?**

Prompts: explore – the relationship between themselves and management
How happy were they about any consultation process?
Do they feel their views were heard/ valued?
Do they feel their input was valued/ is valuable?

5. **How important do you think having (EPR function) is?**

Prompts: explore -
User acceptance and satisfaction
How motivated, efficacious, do they feel about the using the EPR function?
Areas of resistance - conflict - are there other priorities/pressures?

Part 3 Impact on work -

6. **What are the consequences (negative and positive) of using (not using) the EPR?**

Prompts: explore impact on -
Staff relationships/roles
Work efficiency – clinical decision-making
Patient care – do patients receive better/worse care?

7. **Do you think (the EPR) could be improved? If so how?**

Prompts: explore -

Appendices

Users expectations of the EPR versus the current reality.
How can the positive effects of EPRs be maximised?
What physical or resource factors hinder or facilitate use of the EPR?
What social/organisational influences hinder or facilitate use of the EPR?

8. **Do you think the EPR and NCRS will impact on your future working practices? If so how?**

Prompts: explore -
Future impact on working practices, clinical management and individual patient care.

<u>If time</u>

9. **Do you think EPRs and NPfIT in general will impact on the future of the NHS?**

Prompts:
General impact on the organisation and patient care.
What are their perceptions of the best way forward?

10. **How will the Trust respond to these changes?**

Prompts: explore both positive and negative responses.

11. **Lastly – whether they would like to make any other comments before ending**

Thank them again – please call me if you have any future questions.

Appendix 4

NCRS Implementation Project - Interview Schedule

Level 2a – EPR use (Project management)

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Length of time respondent has been in that post:

Role in EPR implementation:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main Questions -

1. **How is the process of implementation?**

2. **What contextual factors (historically and currently) act as facilitators or barriers to the implementation of (function)** – specifically examining the impact of NHSCRS policy.

3. **How is (function) experienced by end-users? Does (function) currently impact on working practices? And if so how?**

Preamble -

Thank you for agreeing to take part in this research study.
Just to reiterate, the study has been funded by the NHS Service Delivery and Organisation R&D Programme. The aim is to evaluate the process of implementing electronic patient records, or NHS Care Record Systems, as they are now called, in acute trusts.

There are two main elements to the study, a quantitative analysis of the costs and savings associated with the implementation of EPRs, and a qualitative analysis of the organisational impact of implementation.

The focus of this set of interviews is to capture your experiences of implementing (function), particularly factors that have facilitated or hindered implementation. We are also interested in users experiences of the system. The interview will last no more than one hour and with your permission will be tape recorded – just to help me remember what was said later on. To reassure you, all information obtained will be anonymised. Neither the trust nor individual staff will be identified, when the research is written up, with all names and staff positions anonymised. You will have an opportunity to read the draft final report to make factual corrections. You will also receive an executive summary and be able to attend a seminar disseminating the findings. Do you have any questions before we start?

1. **Previously, providing (function) was the responsibility of local trusts. The National Program for Information Technology (NPfIT) has now decided a more centrally controlled standardised approach is needed. What do you think about this decision?**

   Prompts: explore wider [political/ organisational] factors that have influenced this decision
   Will centrally controlled solutions be better or worse?

2. **In implementing (function) - can you give me any insights into how things went?**

   Prompts: explore the trust's past experiences of implementation.
   Previous in-house successes and failures
   Any specific difficulties encountered - medical/ legal/ staffing problems.

3. **How does the new system differ from the previous way of doing things?**

   Prompts: explore negative/positive changes in –
   Output – speed, accuracy, detail
   Availability of information - Integrity, completeness, compliance with best practice

4. **What do you think have been some of the barriers to implementation?**

   Prompts: explore -
   Ease of use/access (physical and cognitive barriers)
   Changes in the organisation (flow) of work
   Changes in culture
   Physical, informational and organisational resources (costs) that have facilitated or hindered IT implementation.

5. What could the trust could have done differently to achieve a higher level of (function) implementation?

Prompts:
Explore the relationship between Trust Managers and NPfIT.
The information systems currently in use.
Explore the role of wider organisational pressures – such as achieving operational targets.

6. In terms of further preparing for NCRS solutions what do you think needs to be done at (trust)?

Prompts: explore the change management associated with planning for the national solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

7. Who is driving these changes within the trust?

Prompts: explore the role of leaders and super-users - the organisational impact of key players.

8. How do you see your role impacting on the process of implementation?

Prompts: explore how motivated, efficacious, and involved they are.
Explore the organisational impact of their personal investment (or lack of it).

9. Across the trust, how much agreement do you think there is about the importance of (function)?

Prompts: explore organisational commitment to implementation – across the trust and within different groups.
The role of constant change in management teams and the NHS generally.
Explore whether high levels of change has impacted on IT focus and staff commitment? Explore the perceived commitment of different groups.

10. In implementing (function) – where do you see future potential areas of difficulty?

Prompts: explore issues of 'organisational fit' and goal conflict – other pressures and priorities.
Differing agendas
Explore perceptions of what NCRS should deliver against what is perceived as being rolled out -
Any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables?

11. Do you think (function) could be improved? If so how?

Prompts: explore -
How can the positive effects be maximised?
What physical or resource factors hinder or facilitate use?
What social/organisational influences hinder or facilitate use?

12. What are the consequences of achieving a fully electronic (function) service?

Prompts: explore positive and negative outcomes - national and organisational. Explore impact on staff roles, relationships and patient care.

13. For you what constitutes implementation success?

Prompts: explore how the meaning of success is defined, at what level, and for whom – the trust, the LSP or the National Program?

14. How can this success be best achieved?

Prompts: explore factors they consider necessary for success – such as staff relations, clinician engagement, improved communication and finance.
How these can be factors be achieved and whether they think these factors will be forthcoming?

If time -

15. How do you think (function) and NCRS will impact on the future of the NHS?

Prompts:
General impact on the organisation and patient care.
What are their perceptions of the best way forward?

Lastly – whether they would like to make any other comments before ending

Thank them again – please call me if you have any future questions.

Appendix 5

NCRS Implementation Project - Interview Schedule

Level 2ai – EPR use (e-booking project management)

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Length of time respondent has been in that post:

Role in EPR implementation:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main Questions -

4. **How is the process of implementation?**

5. **What contextual factors (historically and currently) act as facilitators or barriers to the implementation of e-booking?** – specifically examining the impact of NHSCRS policy.

6. **How is e-booking experienced by end-users? Does e-booking currently impact on working practices? And if so how?**

Preamble -

Thank you for agreeing to take part in this research study.
Just to reiterate, the study has been funded by the NHS Service Delivery and Organisation R&D Programme. The aim is to evaluate the process of implementing electronic patient records, or NHS Care Record Systems, as they are now called, in acute trusts.

There are two main elements to the study, a quantitative analysis of the costs and savings associated with the implementation of EPRs, and a qualitative analysis of the organisational impact of implementation.

The focus of this set of interviews is to capture your experiences of implementing e-booking (also Choose & Book), particularly factors that have facilitated or hindered implementation. We are also interested in users experiences of the system. The interview will last no more than one hour and with your permission will be tape recorded – just to help me remember what was said later on. To reassure you, all information obtained will be anonymised. Neither the trust nor individual staff will be identified, when the research is written up, with all names and staff positions anonymised. You will have an opportunity to read the draft final report to make factual corrections. You will also receive an executive summary and be able to attend a seminar disseminating the findings. Do you have any questions before we start?

Appendices

1. **Previously, booking appointments was the responsibility of local trusts. The National Program for Information Technology (NPfIT) has now decided a more centrally controlled standardised approach is needed. What do you think about this decision?**

   Prompts: explore wider [political/ organisational] factors that have influenced this decision
   Will centrally controlled solutions be better or worse?

2. **Before becoming an earlier adopter of Choose & Book the Trust had a pilot e-booking system in place - can you give me any insights into how things went?**

   Prompts: explore the trust's past experiences of implementation.
   Previous in-house successes and failures
   Any specific difficulties encountered - medical/ legal/ staffing problems.

3. **How does the new system differ from the pilot?**

   Prompts: explore negative/positive changes in –
   Output – speed, accuracy, detail
   Availability of information - Integrity, completeness, compliance with best practice

4. **What do you think have been some of the barriers to implementation?**

   Prompts: explore -
   Ease of use/access (physical and cognitive barriers)
   Changes in the organisation (flow) of work
   Changes in culture

Physical, informational and organisational resources (costs) that have facilitated or hindered IT implementation.

5. What could the trust could have done differently to achieve a higher level of e-booking implementation?

Prompts:
Explore the relationship between Trust Managers and NPfIT.
The information systems currently in use.
Explore the role of wider organisational pressures – such as achieving operational targets.

6. In terms of further preparing for e-booking and NCRS what do you think needs to be done at (trust)?

Prompts: explore the change management associated with planning for the national solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

7. Who is driving these changes within the trust?

Prompts: explore the role of leaders and super-users - the organisational impact of key players.

8. How do you see your role impacting on the process of implementation?

Prompts: explore how motivated, efficacious, and involved they are.
Explore the organisational impact of their personal investment (or lack of it).

9. Across the trust, how much agreement do you think there is about the importance of e-booking/Choose & Book?

Prompts: explore organisational commitment to implementation – across the trust and within different groups.
The role of constant change in management teams and the NHS generally.
Explore whether high levels of change has impacted on IT focus and staff commitment? Explore the perceived commitment of different groups.

10. In implementing e-booking – where do you see future potential areas of difficulty?

Prompts: explore issues of 'organisational fit' and goal conflict – other pressures and priorities.
Differing agendas
Explore perceptions of what NCRS should deliver against what is perceived as being rolled out -
Any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables?

11. Do you think e-booking could be improved? If so how?

Prompts: explore -
How can the positive effects be maximised?
What physical or resource factors hinder or facilitate use?
What social/organisational influences hinder or facilitate use?

12. What are the consequences of achieving a fully electronic booking service?

Prompts: explore positive and negative outcomes - national and organisational. Explore impact on staff roles, relationships and patient care.

13. For you what would constitute implementation success?

Prompts: explore how the meaning of success is defined, at what level, and for whom – the trust, the LSP or the National Program?

14. How can this success be best achieved?

Prompts: explore factors they consider necessary for success – such as staff relations, clinician engagement, improved communication and finance.
How these can be factors be achieved and whether they think these factors will be forthcoming?

If time -

15. How do you think e-booking/Choose & Book and NCRS will impact on the future of the NHS?

Prompts:
General impact on the organisation and patient care.
What are their perceptions of the best way forward?

Lastly – whether they would like to make any other comments before ending

Thank them again – please call me if you have any future questions.

Appendix 6

EPR Implementation Project - Interview Schedule
Level 2 - Organisational Context and e-booking project management - Chief Executive

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Length of time respondent has been in that post:

Role in EPR implementation:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main Questions -

7. **How is the process of implementation?**

8. **What contextual factors (historically and currently) act as facilitators or barriers to the implementation of e-booking?** – specifically examining the impact of NHSCRS policy.

Preamble -

Thank you for agreeing to take part in this research study.

Just to reiterate, the study has been funded by the NHS Service Delivery and Organisation R&D Programme. The aim is to evaluate the process of implementing electronic patient records, or NHS Care Record Systems, as they are now called, in acute trusts.

There are two main elements to the study, a quantitative analysis of the costs and savings associated with the implementation of EPRs, and a qualitative analysis of the organisational impact of implementation.

The focus of this set of interviews is to capture managers' experiences of EPRs, particularly e-booking, looking at factors that facilitate or hinder successful implementation. The interview will last no more than one hour and with your permission will be tape recorded – just to help me remember what was said later on. To reassure you, all information obtained will be anonymised. Neither the trust nor individual staff will be identified, when the research is written up, with all names and staff positions anonymised. You will have an opportunity to read the draft final report to make factual corrections. You will also receive an executive summary and be able to attend a seminar disseminating the findings.

Before we begin, do you have any questions, anything I have not covered?

OK. Firstly, I'd like to ask you some general questions about the National Programme for IT, then I'd like to ask you about EPR implementation at (the trust).

NPfIT in general -

1. **Previously, reaching national targets regarding the implementation of EPRs was primarily the responsibility of local trusts. The National Program for Information Technology (NPfIT) has now decided a more centrally controlled approach is needed. What do you think about this decision?**

   Prompts: explore wider organisational factors specific to the NHS that have hindered IT implementation?
   What would have helped?
   Will centrally controlled solutions be better or worse?

2. **What do you think were some of the barriers to implementation, and what could the trust could have done differently to achieve a higher level of EPR development?**

   Prompts: explore physical, informational and organisational resources (costs) that have facilitated or hindered IT implementation.
   Explore the relationship between Trust Managers and the information system in use.
   Explore the role of wider organisational pressures – such as achieving operational targets.

3. **In terms of preparing for the new LSP solutions what do you think needs to be done at (trust)?**

Prompts: explore the change management associated with planning for the LSP solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

4. In terms of further preparing for e-booking/Choose& Book and NCRS what do you think needs to be done at (trust)?

Prompts: explore the change management associated with planning for the national solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

5. What could the trust could have done differently to achieve a higher level of e-booking implementation?

Prompts:
Explore the relationship between Trust Managers and NPfIT.
The information systems currently in use.
Explore the role of wider organisational pressures – such as achieving operational targets.

6. Who is driving these changes within the trust?

Prompts: explore the role of leaders and super-users - the organisational impact of key players.

7. How do you see your role impacting on the process of implementation?

Prompts: explore how motivated, efficacious, and involved they are.
Explore the organisational impact of their personal investment (or lack of it).

8. Across the trust, how much agreement do you think there is about the importance of e-booking?

Prompts: explore organisational commitment to implementation – across the trust and within different groups.

The role of constant change in management teams and the NHS generally.

Explore whether high levels of change has impacted on IT focus and staff commitment? Explore the perceived commitment of different groups.

9. In implementing e-booking – where do you see future potential areas of difficulty?

Prompts: explore issues of 'organisational fit' and goal conflict – other pressures and priorities.

Differing agendas

Explore perceptions of what NCRS should deliver against what is perceived as being rolled out -

Any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables?

10. Do you think e-booking could be improved? If so how?

Prompts: explore -

How can the positive effects be maximised?

What physical or resource factors hinder or facilitate use?

What social/organisational influences hinder or facilitate use?

11. What are the consequences of achieving a fully electronic booking service?

Prompts: explore positive and negative outcomes - national and organisational. Explore impact on staff roles, relationships and patient care.

12. For you what would constitute implementation success?

Prompts: explore how the meaning of success is defined, at what level, and for whom – the trust, the LSP or the National Program?

13. How can this success be best achieved?

Prompts: explore factors they consider necessary for success – such as staff relations, clinician engagement, improved communication and finance.

How these can be factors be achieved and whether they think these factors will be forthcoming?

If time -

14. How do you think e-booking/Choose & Book and NCRS will impact on the future of the NHS?

Prompts:

General impact on the organisation and patient care.

What are their perceptions of the best way forward?

15. Lastly – whether they would like to make any other comments before ending

Thank them again – please call me if you have any future questions.

Appendix 7

NCRS Implementation Project - Interview Schedule

Level 2b – EPR use (e-booking project management: second interview)

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Length of time respondent has been in that post:

Role in EPR implementation:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main focus -

9. **How is implementation progressing?**
10. **How is the process of implementation?**
11. **What contextual factors (historically and currently) act as facilitators or barriers to the implementation of e-booking?** – specifically examining the impact of NHSCRS policy.
12. **How is e-booking experienced by end-users? Does e-booking currently impact on working practices? And if so how?**

1. **What are your current thoughts about Choose & Book? Do you think it's achievable? Do you think it's something that's worth achieving?**

   Prompts: explore wider [political/ organisational] factors that have influenced this decision

   Will centrally controlled solutions be better or worse?

   Do people <u>want</u> choice? Is the choice <u>real</u>?

2. **As an earlier adopter of Choose & Book can you tell me how implementation has been going?**

   Prompts: explore the trust's experiences of implementation.

   In-house successes and failures

   Any specific difficulties encountered - medical/ legal/ staffing problems.

3. **How does the new version differ from the previous versions? How will/has this make a difference?**

   Prompts: explore negative/positive changes in –

   Output – speed, accuracy, detail

   Availability of information - Integrity, completeness, compliance with best practice

4. **What do you think have been some of the barriers to implementation?**

   Prompts: explore - **GP's input**

   Ease of use/access (physical and cognitive barriers)

   Changes in the organisation (flow) of work

Changes in culture

Physical, informational and organisational resources (costs) that have facilitated or hindered IT implementation.

5. What could the 1. the national programme and 2. the trust could have done differently to achieve a higher level of e-booking implementation?

Prompts:

Explore the relationship between Trust Managers and NPfIT.

The information systems currently in use.

Explore the role of wider organisational pressures – such as achieving operational targets.

6. In terms of further preparing for e-booking and NCRS what do you think needs to be done at 1. national level and 2. trust level ?

Prompts: explore the change management associated with planning for the national solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

7. Across the trust and nationally, how much agreement do you think there is about the importance of e-booking/Choose & Book?

Prompts: explore organisational commitment to implementation – across the trust and within different groups.

The role of constant change in management teams and the NHS generally.

Explore whether high levels of change has impacted on IT focus and staff commitment? Explore the perceived commitment of different groups.

8. In implementing e-booking – where do you see future potential areas of difficulty?

Prompts: explore issues of 'organisational fit' and goal conflict – other pressures and priorities. Differing agendas

Explore perceptions of what NCRS should deliver against what is perceived as being rolled out -

Any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables?

9. Do you think e-booking could still be improved? If so how?

Prompts: explore -

How can the positive effects be maximised?

What physical or resource factors hinder or facilitate use?

What social/organisational influences hinder or facilitate use?

10. What are the consequences of achieving a fully electronic booking service?

Prompts: explore positive and negative outcomes - national and organisational. Explore impact on staff roles, relationships and patient care.

11. For you what would constitute implementation success?

Prompts: explore how the meaning of success is defined, at what level, and for whom – the trust, the LSP or the National Program?

12. How can this future success be best achieved?

Prompts: explore factors they consider necessary for success – such as staff relations, clinician engagement, improved communication and finance.

How these can be factors be achieved and whether they think these factors will be forthcoming?

If time -

13. How do you think e-booking/Choose & Book and NCRS will impact on the future of the NHS?

Lastly – whether they would like to make any other comments before ending

Thank them again – please call me if you have any future questions.

Appendix 8

NCRS Implementation Project - Interview Schedule

Level 2b – EPR use (test-ordering: second interview)

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Length of time respondent has been in that post:

Role in EPR implementation:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main focus -

13. **How is implementation progressing?**
14. **How is the process of implementation?**
15. **What contextual factors (historically and currently) act as facilitators or barriers to the implementation of e-test ordering?** – specifically examining the impact of NHSCRS policy.

1. **What are your current thoughts about national e-test ordering? Do you think it's achievable? Do you think it's something that's worth achieving?**
   Prompts: explore wider [political/ organisational] factors that have influenced this decision
   Will centrally controlled solutions be better or worse?
   Do people <u>want</u> choice? Is the choice <u>real</u>?

2. **As an earlier adopter of e-test ordering at Barnet - but not at chase - you tell me how future implementation has been going?**
   Prompts: explore the trust's experiences of implementation.
   In-house successes and failures
   Any specific difficulties encountered - medical/ legal/ staffing problems.

3. **What do you think have been some of the barriers to implementation?**
   Prompts: explore – **PFI**
   Ease of use/access (physical and cognitive barriers)
   Changes in the organisation (flow) of work
   Changes in culture
   Physical, informational and organisational resources (costs) that have facilitated or hindered IT implementation.

4. **What could the 1. the national programme and 2. the trust could have done differently to achieve a higher level of implementation?**
   Prompts:

Explore the relationship between Trust Managers and NPfIT.
The information systems currently in use.
Explore the role of wider organisational pressures – such as achieving operational targets.

5. In terms of further preparing for e-test ordering and NCRS what do you think needs to be done at 1. national level and 2. trust level ?

Prompts: explore the change management associated with planning for the national solutions - setting goals, staff consultation, training etc. Explore any structural changes and strategy documents (obtain if available).

6. Across the trust and nationally, how much agreement do you think there is about the importance of e-test ordering?

Prompts: explore organisational commitment to implementation – across the trust and within different groups.
The role of constant change in management teams and the NHS generally.
Explore whether high levels of change has impacted on IT focus and staff commitment? Explore the perceived commitment of different groups.

7. Who is driving these changes within the trust?

Prompts: explore the role of leaders and super-users - the organisational impact of key players.

8. How do you see your role impacting on the process of implementation?

Prompts: explore how motivated, efficacious, and involved they are.
Explore the organisational impact of their personal investment (or lack of it).

9. In implementing e-test ordering – where do you see future potential areas of difficulty?

Prompts: explore issues of 'organisational fit' and goal conflict – other pressures and priorities. Differing agendas

Explore perceptions of what NCRS should deliver against what is perceived as being rolled out -

Any organisational divide between mangers/clinicians/IT staff's expectations and the deliverables?

10. Do you think e-test ordering could still be improved? If so how?

Prompts: explore -

How can the positive effects be maximised?

What physical or resource factors hinder or facilitate use?

What social/organisational influences hinder or facilitate use?

11. What are the consequences of achieving a fully electronic ordering service across both sites?

Prompts: explore positive and negative outcomes - national and organisational. Explore impact on staff roles, relationships and patient care.

12. For you what would constitute implementation success?

Prompts: explore how the meaning of success is defined, at what level, and for whom – the trust, the LSP or the National Program?

13. How can this future success be best achieved?

Prompts: explore factors they consider necessary for success – such as staff relations, clinician engagement, improved communication and finance.

How these can be factors be achieved and whether they think these factors will be forthcoming?

If time -

14. How do you think NCRS will impact on the future of the NHS?

Lastly – whether they would like to make any other comments before ending

Thank them again – please call me if you have any future questions.

Appendix 9

EPR Implementation Project - Interview Schedule

Level 2c – EPR use – trainer

Date and time of interview:

Interview code no:

Name of Trust:

Name of respondent:

Title of respondent:

Department/ speciality:

Length of time respondent has been in that post:

Use of EPR in post:

Duration of interview:

	YES	NO	Date
Information sheet GIVEN			
Anonymity EXPLAINED			
Verbal permission to be taped REQUESTED			
Verbal permission to be taped RECEIVED			
Consent form GIVEN			
Consent form RECEIVED			
Thank you letter sent			

Appendices

Main Questions -

How is the process of implementation and specifically training ?
How are specific areas of EPR functionality experienced by end-users?
Does EPR use impact on current working practices? And if so how?

Preamble –

Thank you for agreeing to take part in this research study.
Just to reiterate, the study has been funded by the NHS Service Delivery and Organisation R&D Programme. The aim is to evaluate the process of implementing electronic patient records, or NHS Care Record Systems, as they are now called, in acute trusts.

There are two main elements to the study, a quantitative analysis of the costs and savings associated with the implementation of EPRs, and a qualitative analysis of the organisational impact of implementation.

The focus of this set of interviews is to explore your experiences of using information technology (EPRs) in doing your job. The interview will last no more than one hour and with your permission will be tape recorded – just to help me remember what was said later on. To reassure you, all information obtained will be anonymised. Neither the trust nor individual staff will be identified, when the research is written up, with all names and staff positions anonymised. You will have an opportunity to read the draft final report to make factual corrections. You will also receive an executive summary and be able to attend a seminar disseminating the findings.

Before we begin, do you have any questions, anything I have not covered?

OK. Firstly, I'd like to ask you some general questions about what's its like to use the current system, then I'd like to ask you about how using the system impacts on your work.

Appendices

Part 1. Experience of EPR use -

12. **Can you talk me through how staff use the current (EPR function) system?**

Prompts: explore -
What is it that they do? When, where, how and with whom?
How does the EPR influence the way they think, make decisions?
How does the EPR impact on their interaction with other staff/patients?
Do they think the EPR affects the care patients receive? If so how?

13. **Did you teach people to use the previous system? If so can you talk me through what they have to do differently?**

Prompts: explore negative/positive changes in their -
Behaviour -
How they used to think, make decisions
Their relationships with other staff/patients

14. **How does using the (EPR function) compare with previous ways of working?**

Prompts: explore negative/positive changes in changes in –
Output – speed, accuracy, detail of results
Availability of information - Integrity, completeness, compliance with best practice

15. **How easy or difficult is it to teach staff to use the current (EPR function)?**

Prompts: explore -
Ease of access (physical and cognitive barriers)
Changes in the organisation (flow) of their work
Their knowledge of the EPR – how was the information given?
Training and support received & the process of info. giving and sharing of ideas
The perception of their personal capabilities

Part 2. Process of implementation

16. **Were you involved the process of implementation? If so how involved?**

Prompts: explore – the relationship between themselves and management
How happy were they about any consultation process?
Do they feel their views were heard/ valued?
Do they feel their input was valued/ is valuable?

17. **How important do you think having (EPR function) is?**

Prompts: explore -
User acceptance and satisfaction
How motivated, efficacious, do they feel about the using the EPR function?
Areas of resistance - conflict - are there other priorities/pressures?

Part 3 Impact on work -

18. **What are the consequences (negative and positive) of using (not using) the EPR?**

Prompts: explore impact on -
Staff relationships/roles
Work efficiency – clinical decision-making
Patient care – do patients receive better/worse care?

19. **Do you think (the EPR) could be improved? If so how?**

Prompts: explore -
Users expectations of the EPR versus the current reality.
How can the positive effects of EPRs be maximised?
What physical or resource factors hinder or facilitate use of the EPR?
What social/organisational influences hinder or facilitate use of the EPR?

20. **Do you think the EPR will impact on your future working practices? If so how?**

Prompts: explore -
Future impact on working practices, clinical management and individual patient care.

If time

21. **Do you think EPRs and NPfIT in general will impact on the future of the NHS?**

Prompts:
General impact on the organisation and patient care.
What are their perceptions of the best way forward?

22. **How will the Trust will respond to these changes?**

Prompts: explore both positive and negative responses.

23. **Lastly – whether they would like to make any other comments before ending**

Thank them again – please call me if you have any future questions.

APPENDIX 10 - Data sources

CDS Inpatient variables*	Related outcomes
LOCAL PATIENT IDENTIFIER	All primary outcomes
ADMISSION METHOD	Emergency re-admission (within 28 days)
START DATE (HOSPITAL PROVIDER SPELL)	All outcomes
END DATE (HOSPITAL PROVIDER SPELL)	All outcomes
DISCHARGE METHOD	Deaths Time-to-death
TREATMENT FUNCTION	All outcomes
INTENDED MANAGEMENT	Ratio of actual to intended day cases

* NHS Data Dictionary v3.0

CDS Outpatient variables*	Related outcomes
LOCAL PATIENT IDENTIFIER	All primary outcomes
TREATMENT FUNCTION	All outcomes
ATTENDED OR DID NOT ATTEND	Attendance (Attended vs Did Not Attend)
OUTCOME	Outcome (discharged vs follow-up)
ATTENDANCE DATE	All outcomes

* NHS Data Dictionary v3.0

Pathology laboratory variables	Related outcomes
Local patient identifier	All primary outcomes
Test type	All primary outcomes
Date test ordered	All primary outcomes

Radiology department variables	Related outcomes
Local patient identifier	All primary outcomes
Examination type	All primary outcomes
Date exam requested	All primary outcomes

APPENDIX 11.1 - CPOE, primary outcomes, between-Trust comparisons

Shading represents the 'intervention' Trust.

Pathology test type=Full Blood Count		Period	Trust 1	Trust 2	Trust 3	Trust 4
IP	Tests per inpatient day - non-zero vs zero response	2000	64.4%	-	43.9%	73.9%
		2001-2002	65.1%	-	40.7%	75.4%
		2003-2005	66.3%	74.0%	48.8%	71.2%
	Tests per inpatient day - continuous non-zero response (tests/day)	2000	0.59	-	0.60	0.62
		2001-2002	0.61	-	0.62	0.61
		2003-2005	0.64	0.69	0.66	0.61
	Tests per day case - proportion with non-zero response	2000	4.4%	-	6.6%	14.0%
		2001-2002	4.9%	-	6.5%	15.0%
		2003-2005	10.9%	19.6%	11.6%	13.3%
	Test within 48hrs of previous test of same type - proportion of all tests	2000	45.3%	-	43.0%	45.4%
		2001-2002	46.6%	-	46.5%	45.1%
		2003-2005	46.9%	52.9%	49.0%	47.0%
OP	Proportion of outpatient appointments at which one or more tests requested	2000	11.2%	-	5.4%	9.7%
		2001-2002	9.8%	-	7.2%	13.5%
		2003-2005	9.3%	10.4%	9.7%	14.5%
	Test of same type at next outpatient appointment - proportion of outpatient appointments with test(s)	2000	17.9%	-	12.3%	16.1%
		2001-2002	19.6%	-	20.3%	20.4%
		2003-2005	18.5%	23.0%	18.3%	18.7%

Pathology test type=Urea & Electrolytes		Period	Trust A	Trust B	Trust C	Trust D
IP	Tests per inpatient day - non-zero vs zero response	2000	49.6%	-	35.4%	61.2%
		2001-2002	51.2%	-	36.7%	63.1%
		2003-2005	57.4%	-	42.3%	64.8%
	Tests per inpatient day - continuous non-zero response (tests/day)	2000	0.56	-	0.50	0.64
		2001-2002	0.58	-	0.52	0.62
		2003-2005	0.64	-	0.59	0.65
	Tests per day case - proportion with non-zero response	2000	2.2%	-	4.7%	9.9%
		2001-2002	2.7%	-	5.5%	10.7%
		2003-2005	10.2%	-	7.7%	18.7%
	Test within 48hrs of previous test of same type - proportion of all tests	2000	50.1%	-	49.0%	52.4%
		2001-2002	51.6%	-	50.6%	50.6%
		2003-2005	49.9%	-	52.6%	49.8%
OP	Proportion of outpatient appointments at which one or more tests requested	2000	6.9%	-	5.3%	5.9%
		2001-2002	6.2%	-	7.5%	7.9%
		2003-2005	6.3%	-	9.3%	9.0%
	Test of same type at next outpatient appointment - proportion of outpatient appointments with test(s)	2000	10.0%	-	6.9%	14.7%
		2001-2002	10.4%	-	12.4%	16.4%
		2003-2005	14.3%	-	14.5%	19.0%

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Pathology test type=Urine Culture		Period	Trust 1	Trust 2	Trust 3	Trust 4
IP	Tests per inpatient day - non-zero vs zero response	2000	25.8%	-	12.0%	32.9%
		2001-2002	23.2%	-	14.6%	34.0%
		2003-2005	21.5%	22.9%	17.4%	34.8%
	Tests per inpatient day - continuous non-zero response (tests/day)	2000	0.37	-	0.33	0.40
		2001-2002	0.35	-	0.40	0.39
		2003-2005	0.36	0.35	0.41	0.41
	Tests per day case - proportion with non-zero response	2000	1.4%	-	1.5%	5.0%
		2001-2002	1.3%	-	4.6%	5.0%
		2003-2005	3.3%	3.5%	3.9%	5.0%
	Test within 48hrs of previous test of same type - proportion of all tests	2000	8.6%	-	6.7%	9.7%
		2001-2002	6.9%	-	5.7%	9.7%
		2003-2005	7.2%	9.7%	6.0%	10.2%
OP	Proportion of outpatient appointments at which one or more tests requested	2000	4.0%	-	1.2%	3.5%
		2001-2002	3.6%	-	1.6%	4.7%
		2003-2005	3.5%	2.4%	1.5%	6.2%
	Test of same type at next outpatient appointment - proportion of outpatient appointments with test(s)	2000	10.6%	-	5.3%	11.2%
		2001-2002	9.8%	-	6.4%	12.4%
		2003-2005	11.0%	9.6%	5.9%	15.1%

APPENDIX 11.2 - CPOE, primary outcomes, within-Trust comparison

Shading represents the 'intervention' specialties.

Pathology test type=Full Blood Count		Period	Obstetrics	All other specialties
IP	Tests per inpatient day - non-zero vs zero response	2000	48.8%	73.1%
		2001-2002	51.3%	73.3%
		2003-2005	56.7%	74.1%
	Tests per inpatient day - continuous non-zero response (tests/day)	2000	0.62	0.54
		2001-2002	0.67	0.54
		2003-2005	0.74	0.58
	Tests per day case - proportion with non-zero response	2000	9.5%	4.6%
		2001-2002	11.4%	5.6%
		2003-2005	13.4%	11.6%
	Test within 48hrs of previous test of same type - proportion of all tests	2000	27.2%	48.0%
		2001-2002	29.8%	49.2%
		2003-2005	33.3%	51.0%
OP	Proportion of outpatient appointments at which one or more tests requested	2000	16.5%	10.3%
		2001-2002	16.5%	8.6%
		2003-2005	17.8%	7.9%
	Test of same type at next outpatient appointment - proportion of outpatient appointments with test(s)	2000	9.8%	19.7%
		2001-2002	9.7%	22.8%
		2003-2005	11.7%	20.7%

Pathology test type= Urea & Electrolytes		Period	Obstetrics	All other specialties
IP	Tests per inpatient day - non-zero vs zero response	2000	15.2%	63.5%
		2001-2002	14.6%	65.5%
		2003-2005	18.4%	72.3%
	Tests per inpatient day - continuous non-zero response (tests/day)	2000	0.54	0.52
		2001-2002	0.56	0.53
		2003-2005	0.65	0.60
	Tests per day case - proportion with non-zero response	2000	4.8%	2.3%
		2001-2002	5.1%	3.4%
		2003-2005	7.1%	10.7%
	Test within 48hrs of previous test of same type - proportion of all tests	2000	30.6%	51.3%
		2001-2002	34.0%	52.8%
		2003-2005	38.9%	53.0%
OP	Proportion of outpatient appointments at which one or more tests requested	2000	3.8%	7.3%
		2001-2002	4.4%	6.4%
		2003-2005	6.4%	6.2%
	Test of same type at next outpatient appointment - proportion of outpatient appointments with test(s)	2000	10.7%	9.9%
		2001-2002	12.4%	10.1%
		2003-2005	16.1%	14.1%

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Pathology test type=Urine Culture		Period	Obstetrics	All other specialties
IP	Tests per inpatient day - non-zero vs zero response	2000	33.5%	28.6%
		2001-2002	28.7%	26.4%
		2003-2005	18.6%	27.9%
	Tests per inpatient day - continuous non-zero response (tests/day)	2000	0.48	0.28
		2001-2002	0.46	0.26
		2003-2005	0.57	0.27
	Tests per day case - proportion with non-zero response	2000	6.6%	1.0%
		2001-2002	4.8%	0.9%
		2003-2005	4.6%	3.0%
	Test within 48hrs of previous test of same type - proportion of all tests	2000	8.4%	9.1%
		2001-2002	7.1%	7.1%
		2003-2005	8.0%	8.0%
OP	Proportion of outpatient appointments at which one or more tests requested	2000	16.0%	2.3%
		2001-2002	12.9%	2.1%
		2003-2005	14.5%	1.9%
	Test of same type at next outpatient appointment - proportion of outpatient appointments with test(s)	2000	14.6%	6.6%
		2001-2002	12.3%	7.2%
		2003-2005	15.9%	5.8%

APPENDIX 12.1 - PACS, primary outcomes, between-Trust comparisons

Shading represents the 'intervention' Trust.

Radiology examination type = Plain Film		Period	Trust 1	Trust 2	Trust 3	Trust 4
IP	Exams per inpatient day - non-zero vs zero response	2000	39.8%	36.6%	39.2%	42.4%
		2001-2002	39.3%	39.2%	36.2%	41.4%
		2003-2005	39.9%	45.5%	42.4%	43.4%
	Exams per inpatient day - continuous non-zero response (exams/day)	2000	0.49	0.43	0.49	0.41
		2001-2002	0.48	0.39	0.44	0.42
		2003-2005	0.50	0.46	0.50	0.43
	Exams per day case - proportion with non-zero response	2000	5.0%	5.2%	2.6%	3.8%
		2001-2002	4.6%	5.4%	2.2%	5.5%
		2003-2005	9.8%	11.8%	6.7%	10.8%
	Exam within 48hrs of previous exam of same type - proportion of all exams	2000	20.8%	26.5%	22.5%	18.8%
		2001-2002	21.1%	21.8%	19.9%	16.9%
		2003-2005	19.9%	21.4%	15.6%	15.6%
OP	Proportion of outpatient appointments at which one or more exams requested	2000	3.3%	5.9%	8.6%	4.0%
		2001-2002	3.1%	6.2%	8.3%	5.1%
		2003-2005	3.0%	6.1%	8.7%	5.0%
	Exam of same type at next outpatient appointment - proportion of outpatient appointments with exam(s)	2000	14.2%	21.1%	16.2%	22.5%
		2001-2002	16.5%	20.1%	24.1%	20.4%
		2003-2005	17.5%	22.1%	25.7%	21.3%

Radiology examination type = Computed Tomography		Period	Trust 1	Trust 2	Trust 3	Trust 4
IP	Exams per inpatient day - non-zero vs zero response	2000	5.4%	5.3%	4.9%	8.1%
		2001-2002	7.1%	6.7%	5.1%	8.9%
		2003-2005	8.9%	8.9%	6.7%	10.2%
	Exams per inpatient day - continuous non-zero response (exams/day)	2000	0.22	0.19	0.25	0.19
		2001-2002	0.24	0.18	0.24	0.20
		2003-2005	0.28	0.21	0.31	0.21
	Exams per day case - proportion with non-zero response	2000	0.3%	0.4%	0.2%	0.4%
		2001-2002	0.4%	0.5%	0.3%	0.6%
		2003-2005	1.1%	0.8%	1.0%	1.2%
	Exams per day case - proportion with non-zero response	2000	0.3%	0.4%	0.2%	0.5%
		2001-2002	0.4%	0.5%	0.3%	0.6%
		2003-2005	1.1%	0.8%	1.0%	1.2%
	Exam within 48hrs of previous exam of same type - proportion of all exams	2000	4.0%	2.2%	2.1%	1.2%
		2001-2002	4.5%	1.7%	1.6%	2.5%
		2003-2005	4.4%	1.8%	1.7%	2.4%
OP	Proportion of outpatient appointments at which one or more exams requested	2000	0.03%	0.07%	0.18%	0.02%
		2001-2002	0.08%	0.08%	0.19%	0.09%
		2003-2005	0.25%	0.07%	0.23%	0.21%
	Exam of same type at next outpatient appointment - proportion of outpatient appointments with exam(s)	2000 2001-2002 2003-2005	n/a	n/a	n/a	n/a

Radiology examination type = Ultrasound		Period	Trust 1	Trust 2	Trust 3	Trust 4
IP	Exams per inpatient day - proportion with non-zero response	2000	11.0%	14.0%	13.7%	14.3%
		2001-2002	11.9%	13.6%	13.1%	13.0%
		2003-2005	14.2%	13.5%	12.5%	13.0%
	Exams per inpatient day - continuous non-zero response (exams/day)	2000	0.035	0.047	0.052	0.046
		2001-2002	0.038	0.045	0.052	0.040
		2003-2005	0.055	0.041	0.048	0.039
	Exams per day case - proportion with non-zero response	2000	2.4%	2.2%	3.8%	1.3%
		2001-2002	2.7%	2.0%	3.7%	1.9%
		2003-2005	3.3%	1.8%	2.7%	1.8%
	Exams per day case - proportion with non-zero response	2000	2.4%	2.2%	3.8%	1.8%
		2001-2002	2.7%	2.0%	3.7%	1.9%
		2003-2005	3.3%	1.8%	2.7%	1.8%
	Exam within 48hrs of previous exam of same type - proportion of all exams	2000	5.3%	3.3%	3.6%	3.0%
		2001-2002	4.8%	3.1%	3.7%	2.7%
		2003-2005	6.3%	3.3%	3.3%	3.2%
OP	Proportion of outpatient appointments at which one or more exams requested	2000	0.4%	2.8%	2.6%	1.9%
		2001-2002	0.7%	2.4%	2.4%	3.1%
		2003-2005	1.8%	1.6%	2.1%	3.8%
	Exam of same type at next outpatient appointment - proportion of outpatient appointments with exam(s)	2000	4.8%	20.7%	18.3%	22.2%
		2001-2002	3.7%	19.2%	21.8%	10.7%
		2003-2005	7.1%	10.6%	19.6%	11.8%

APPENDIX 12.2 - PACS, primary outcomes, within-Trust comparison

No shading, because the 'intervention' specialties depended on the time period / comparison considered (see Methods for quantitative elements of the study).

Radiology examination type = Plain Film		Period	Trauma & Orthopaedics	All other specialties
IP	Exams per inpatient day - non-zero vs zero response	01/2000-11/2001	72.2%	35.1%
		12/2001-10/2002	70.9%	33.3%
		11/2002-12/2005	66.0%	35.7%
	Exams per inpatient day - continuous non-zero response (exams/day)	01/2000-11/2001	0.495	0.364
		12/2001-10/2002	0.515	0.382
		11/2002-12/2005	0.574	0.378
	Exams per day case - proportion with non-zero response	01/2000-11/2001	10.1%	3.1%
		12/2001-10/2002	7.6%	3.4%
		11/2002-12/2005	22.1%	4.6%
	Exam within 48hrs of previous exam of same type - proportion of all exams	01/2000-11/2001	23.1%	16.6%
		12/2001-10/2002	20.6%	15.1%
		11/2002-12/2005	19.1%	14.8%
OP	Proportion of outpatient appointments at which one or more exams requested	01/2000-11/2001	30.4%	2.1%
		12/2001-10/2002	28.1%	2.1%
		11/2002-12/2005	30.1%	1.7%
	Exam of same type at next outpatient appointment - proportion of outpatient appointments with exam(s)	01/2000-11/2001	22.9%	5.3%
		12/2001-10/2002	26.8%	7.1%
		11/2002-12/2005	27.6%	6.2%

Radiology examination type = Computed Tomography		Period	Trauma & Orthopaedics	All other specialties
IP	Exams per inpatient day - non-zero vs zero response	01/2000-11/2001	5.6%	8.1%
		12/2001-10/2002	6.0%	8.5%
		11/2002-12/2005	7.1%	9.1%
	Exams per inpatient day - continuous non-zero response (exams/day)	01/2000-11/2001	0.201	0.181
		12/2001-10/2002	0.154	0.189
		11/2002-12/2005	0.281	0.195
	Exams per day case - proportion with non-zero response	01/2000-11/2001	0.5%	0.4%
		12/2001-10/2002	0.6%	0.5%
		11/2002-12/2005	2.5%	0.6%
	Exam within 48hrs of previous exam of same type - proportion of all exams	01/2000-11/2001	(6/220) 2.7%	2.2%
		12/2001-10/2002	(2/118) 1.7%	2.2%
		11/2002-12/2005	(17/540) 3.2%	2.4%
OP	Proportion of outpatient appointments at which one or more exams requested	01/2000-11/2001 12/2001-10/2002 11/2002-12/2005	n/a	n/a
	Exam of same type at next outpatient appointment - proportion of outpatient appointments with exam(s)	01/2000-11/2001 12/2001-10/2002 11/2002-12/2005	n/a	n/a

Radiology examination type = Ultrasound		Period	Trauma & Orthopaedics	All other specialties
IP	Exams per inpatient day - non-zero vs zero response	01/2000-11/2001	4.9%	13.0%
		12/2001-10/2002	4.9%	12.6%
		11/2002-12/2005	6.4%	12.1%
	Exams per inpatient day - continuous non-zero response (exams/day)	01/2000-11/2001	0.127	0.309
		12/2001-10/2002	0.166	0.305
		11/2002-12/2005	0.211	0.298
	Exams per day case - proportion with non-zero response	01/2000-11/2001	0.2%	1.2%
		12/2001-10/2002	0.1%	1.5%
		11/2002-12/2005	1.2%	1.2%
	Exam within 48hrs of previous exam of same type - proportion of all exams	01/2000-11/2001	(8/207) 3.9%	2.9%
		12/2001-10/2002	(1/98) 1.0%	3.1%
		11/2002-12/2005	(16/515) 3.1%	3.4%
OP	Proportion of outpatient appointments at which one or more exams requested	01/2000-11/2001 12/2001-10/2002 11/2002-12/2005	n/a	n/a
	Exam of same type at next outpatient appointment - proportion of outpatient appointments with exam(s)	01/2000-11/2001 12/2001-10/2002 11/2002-12/2005	n/a	n/a

APPENDIX 13.1 - CPOE and PACS, secondary outcomes, between-Trust comparison

Shading represents the 'intervention' Trusts.

Secondary outcomes		Period	Trust 1	Trust 2	Trust 3	Trust 4
IP	Mean length of stay (days), excluding day cases	2000	5.96	7.18	5.02	6.81
		2001-2002	6.00	6.93	5.11	7.19
		2003-2005	5.67	6.66	4.73	7.11
	Day cases as proportion of admitted patients	2000	41.1%	31.8%	41.4%	32.3%
		2001-2002	40.4%	33.7%	42.0%	30.1%
		2003-2005	45.4%	37.2%	48.4%	35.0%
	Actual to intended day cases (proportion of intended day cases admitted overnight)	2000	no data available	12.0%	5.3%	6.6%
		2001-2002		10.0%	4.5%	6.0%
		2003-2005		6.2%	4.3%	3.6%
	Emergency re-admission (within 28 days)	2000	2.8%	2.8%	2.4%	4.3%
		2001-2002	3.4%	2.8%	2.4%	4.5%
		2003-2005	4.1%	4.2%	3.1%	5.8%
	Deaths	2000	2.0%	1.8%	1.3%	2.2%
		2001-2002	1.8%	2.1%	1.5%	2.3%
		2003-2005	1.7%	2.1%	1.1%	1.9%
	Mean time-to-death (days)	2000	21.2	14.8	13.2	17.5
		2001-2002	23.1	14.6	13.9	17.7
		2003-2005	23.5	15.8	14.5	18.4
OP	Attendance (proportion attending)	2000	85.8%	80.1%	89.0%	81.9%
		2001-2002	85.5%	80.0%	90.1%	82.7%
		2003-2005	86.0%	82.3%	91.1%	83.4%
	Outcome (proportion discharged)	2000	61.1%	no data available	45.3%	46.7%
		2001-2002	61.9%		51.9%	46.4%
		2003-2005	63.7%		55.4%	43.3%

APPENDIX 13.2 - CPOE, secondary outcomes, within-Trust comparison

Shading represents the 'intervention' specialties.

Secondary outcomes		Period	Obstetrics	All other specialties
IP	Mean length of stay (days), excluding day cases	2000 2001-2002 2003-2005	2.88 2.80 2.49	6.66 6.69 6.37
	Day cases as proportion of admitted patients	2000 2001-2002 2003-2005	26.3% 28.5% 22.0%	43.6% 42.4% 48.7%
	Actual to intended day cases (proportion of intended day cases admitted overnight)	2000 2001-2002 2003-2005	n/a	n/a
	Emergency re-admission (within 28 days)	2000 2001-2002 2003-2005	n/a	3.3% 4.0% 4.7%
	Deaths	2000 2001-2002 2003-2005	n/a	2.3% 2.2% 2.0%
	Mean time-to-death (days)	2000 2001-2002 2003-2005	n/a	21.2 23.1 23.5
OP	Attendance (proportion attending)	2000 2001-2002 2003-2005	90.4% 89.7% 87.3%	85.4% 85.1% 85.9%
	Outcome (proportion discharged)	2000 2001-2002 2003-2005	74.1% 76.1% 80.7%	59.1% 59.6% 60.9%

APPENDIX 13.3 - PACS, secondary outcomes, within-Trust comparison

No shading, because the 'intervention' specialties depended on the time period / comparison considered (see Methods for quantitative elements of the study).

Secondary outcomes		Period	Trauma & Orthopaedics	All other specialties
IP	Mean length of stay (days), excluding day cases	01/2000-11/2001	9.07	6.60
		12/2001-10/2002	9.71	7.08
		11/2002-12/2005	7.99	6.99
	Day cases as proportion of admitted patients	01/2000-11/2001	34.4%	31.2%
		12/2001-10/2002	32.2%	29.5%
		11/2002-12/2005	49.4%	31.9%
	Actual to intended day cases (proportion of intended day cases admitted overnight)	01/2000-11/2001	6.3%	6.5%
		12/2001-10/2002	8.1%	5.3%
		11/2002-12/2005	3.5%	3.8%
	Emergency re-admission (within 28 days)	01/2000-11/2001	3.1%	4.4%
		12/2001-10/2002	3.4%	4.9%
		11/2002-12/2005	5.5%	5.8%
	Deaths	01/2000-11/2001	1.0%	2.4%
		12/2001-10/2002	1.4%	2.4%
		11/2002-12/2005	0.7%	2.2%
	Mean time-to-death (days)	01/2000-11/2001	30.1	17.5
		12/2001-10/2002	24.0	15.7
		11/2002-12/2005	25.6	17.9
OP	Attendance (proportion attending)	01/2000-11/2001	84.1%	81.9%
		12/2001-10/2002	84.7%	82.7%
		11/2002-12/2005	85.7%	83.0%
	Outcome (proportion discharged)	01/2000-11/2001	55.7%	44.6%
		12/2001-10/2002	56.6%	44.3%
		11/2002-12/2005	56.2%	40.5%

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Addendum

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