Organisational factors influencing technology adoption and assimilation in the NHS: a systematic literature review

Report for the National Institute for Health Research Service Delivery and Organisation programme

June, 2009

prepared by

Dr Glenn Robert

- National Nursing Research Unit, King's College London

Professor Trisha Greenhalgh

- Department of Primary Care & Population Health, University College London

Dr Fraser MacFarlane

- School of Management, University of Surrey

Mr Richard Peacock

- Archway Healthcare Library, Middlesex University

Address for correspondence

Dr Glenn Robert

National Nursing Research Unit

King's College London

James Clerk Maxwell Building

57 Waterloo Road

London

SE1 8WA

E-mail: glenn.robert@kcl.ac.uk

Contents

1 Introduction

Key points

1 This systematic review of the organisational factors and processes that influence the adoption and assimilation of technological innovations within NHS organisations was commissioned in the spring of 2008 by the National Institute for Health Research Service Delivery & Organisation (SDO) programme. A much broader review by the same authors - exploring the diffusion, spread and sustainability of innovations in health service delivery and organisation - was published by the programme in 2004.

2 This review is narrower in scope and focuses solely on studies of the adoption and assimilation of non-pharmaceutical technological innovations in healthcare organisations. At the request of the SDO programme, the review explicitly excludes studies of: innovations in organisation and delivery, the adoption of National Institute for Health & Clinical Excellence (NICE) guidelines and the implementation of quality/service improvement programmes.

3 We define 'technological innovation' as 'a device, procedure or organisational support system that is perceived as new by a proportion of key stakeholders in a healthcare organisation, discontinuous with previous practice and which is intentionally introduced and directed at improving health outcomes.'

4 The purpose of this review is to make recommendations that will facilitate the increased adoption and use of beneficial technological innovations in NHS organisations. For this reason, the review encompasses not only identifying the organisational factors and processes that are more likely to lead to the adoption of technological innovations but also those that enable innovations once adopted to become part of - or assimilated into - daily practice.

5 Although the organisational factors and processes identified here are important determinants of the use of a technological innovation, it is important to place the findings in the broader - and more complex – context in which the attributes of a specific innovation, the characteristics of individual adopters, and wider external influences can all shape eventual levels of adoption and assimilation.

1.1 Aims

The overall research question for this review is: *what organisational factors and processes determine whether (and the extent and rate at which) technological innovations are adopted and assimilated within NHS organisations.* This review therefore sets out to:

(1) synthesise the existing literature on the organisational factors influencing the extent and rate of adoption and assimilation of technological innovations in the NHS, and

(2) provide recommendations that NHS organisations should consider in order to facilitate the increased adoption and assimilation of beneficial technological innovation.

1.2 Scope

Wolfe (1994) has noted that research on the adoption of innovations can be clustered into three categories with differing preoccupations: (1) explaining patterns of adoption in terms of where and when, (2) establishing determinants or correlates of adoption by individuals, and (3) explaining the processes by which innovations come to be adopted (Maguire, 2002). Drazin and Schoonhoven (1996) observe that most empirical research can be clustered into the first two categories. This review is concerned with the third

stream of research: understanding the processes by which innovations become adopted from an organisational standpoint. More specifically, we are interested in the process of adoption in healthcare organisations, and the interactions between an innovation and the complex organisational setting in which it is to be used; interactions that are often ignored[1].

Dynamics of innovation adoption are more complex in multi-professional organisations, like hospitals; indeed commentators suggest the healthcare context 'represents an extreme case in terms of complexity and ambiguity' (Fitzgerald et al, 2002: 1445). Healthcare organisations are commonly typified as professional bureaucracies (Scott, 1990), employing numerous types of professionals and often exhibiting a dual hierarchical structure that differentiates the professionals from the managers. More so than participants in typical organisations, it is argued that clinicians, both as individuals and as a group, enjoy considerable autonomy and exercise substantial discretion. As a consequence, healthcare organisations continue to be distinctive in their organisational characteristics; decision-making tends to be more decentralised and more localised to specialised units than in the typical organisation. These important differences mean that findings relating to innovation adoption in other sectors are not directly applicable to the healthcare context (although such findings can be helpful in generating hypotheses that can then be tested in studies of healthcare organisations). We therefore focus on empirical studies that have taken place in healthcare organisations but draw on seminal studies from outside healthcare to inform our thinking. Although this review draws on evidence from healthcare systems elsewhere in the world, we are primarily concerned with empirical studies undertaken in the particular context of the NHS and therefore privilege these throughout this review.

Wolfe (1994) also observed that 'the most consistent theme found in the organisational innovation literature is that its research results have been inconsistent', a finding more recently confirmed by Rye & Kimberly (2007) and a problem which stems from a lack of clearly 'specifying the characteristics of the innovation(s) studied, the stage(s) of the innovation process considered, and the type(s) of organisations included in an investigation' (Wolfe, 2004). From the outset it is important therefore to be very clear about the scope of this review in each of these three regards:

- *characteristics of the innovations studied in this review*: non-pharmaceutical technological innovations[2]
- *stages of the innovation process considered in this review*: studies of the adoption and assimilation of innovations

---

[1] For instance, Wilson (2008) argues that factors that determine the adoption and diffusion of a new technology fall into just two categories: characteristics of the technology itself, (for example, observability) and contextual factors that promote it (for example, manufacturer's aggressive promotion of the technology). Whilst such categories of factors are no doubt important they are far from being the only determinants of adoption and assimilation of technological innovations. Rather: 'it is the interaction among the innovation, the intended adopter(s), and a particular context that determines the adoption rate' (Greenhalgh et al, 2004: 598).

[2] As specified by the funding organisation in the original tender for this review. This criterion meant that some of the seminal papers exploring the influence of organisational characteristics on rates of innovation adoption were excluded - for instance, Aiken, Hage and Dewar's series of papers (1967; 1971; 1973) reporting on 16 health and welfare organisations providing rehabilitation and psychiatric services in the US in the 1960s and 1970s and their adoption of 'new programs or services' - although the findings of such studies informed many later studies that did focus explicitly on technological adoption and are therefore included in this review.

- *types of organisations included in this review*: public sector healthcare organisations[3]

We are explicitly not including in this review:

- studies focusing on innovations in organisations and delivery ('service innovations')[4]
- studies focusing on the adoption of NICE guidance, or of the implementation of quality/service improvement programmes[5]
- studies focusing on stages of the innovation process other than adoption and assimilation
- studies focusing solely on characteristics of (a) individual adopters or (b) technologies
- studies focusing on non-healthcare organisations.

1.3 Definitions

As we have previously noted (Greenhalgh et al, 2005: 26) there is not, nor will there ever be, a consensus on terminology in the field of innovation studies. This lack of consensus is significant because, as Rye & Kimberly (2007: 239) point out, distinctions between definitions 'reveal often deep-seated differences in the fundamental assumptions and viewpoints of researchers, differences that influence the character of research questions and analyses'. For the purposes of this review we use the following definitions of 'technological innovation in healthcare organisations', 'adoption' and 'assimilation'.

1.3.1 Technological innovation in healthcare organisations

Technological innovation in healthcare covers the wide range of events that includes basic research, applied research, targeted development, manufacturing and marketing, adoption and use (Gelijns, 1990; Robert et al, 1999). 'Biomedical technology' (drugs and devices), 'medical technology' (drugs, devices and procedures), 'healthcare technology' (drugs, devices, procedures and organisational support systems in the health sector) and 'health technology' (drugs, devices, procedures, and organisational support systems both in and outside the health sector) are all terms commonly encountered in the literature (Liaropoulos, 1997). The NIHR Health Technology Assessment programme defines the term 'health technology' as methods used to promote health, prevent and treat disease and improve rehabilitation and long term care including drugs, devices, procedures, settings of care and screening.

Osborne (1998) reviewed the organisational studies literature and found over 20 different definitions of innovation, from which he extracted four core characteristics:

---

[3] Similarly, this criterion meant that early studies which have informed later thinking have been excluded. For example, Daft's (1978) study of 13 high school districts in the US examining the respective role of administrators and technical employees in the process leading to innovation adoption (and which introduced the notion of different innovation processes (bottom-up and top-down) existing in the same organisation: 'a dual-core model of organisational innovation').

[4] For a comprehensive review of these studies see our previous review on the diffusion of innovations in the organisation and delivery of health services (Greenhalgh et al, 2005)

[5] As specified by the funding organisation in the original tender for this review.

- innovation represents newness
- it is not the same thing as invention[6]
- it is both a process and an outcome
- it involves discontinuous change.

More specifically, West & Farr (1990: 9) define innovation in an organisational context as 'the intentional introduction and application within a role, group or organisation of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, the organisation or wider society'.

In the context of this review, a technological innovation is therefore defined as a device, procedure or organisational support system[7] that is perceived as new by a proportion of key stakeholders in a healthcare organisation, discontinuous with previous practice and which is intentionally introduced and directed at improving health outcomes (Rogers, 1995; Greenhalgh et al, 2005).

1.3.2 Adoption

Damanpour (2006) summarises how the process of adoption of innovation in organisations has been divided into a variety of phases by several authors; for instance: evaluation, initiation, implementation and routinization (Hage and Aiken, 1967); awareness, selection, adoption, implementation and routinization (Klein and Sorra, 1996); knowledge awareness, attitudes formation, decision, initial implementation and sustained implementation (Zaltman, Duncan and Holbek, 1973); and initiation, development, implementation and termination (Angle and Van de Van, 2000). He suggests grouping these into three more general phases of pre-adoption, adoption decision and post-adoption, often referred to as initiation, adoption (decision) and implementation (Rogers, 1995; Pierce and Delbecq, 1977; Zmud, 1982).

In their recent systematic review, Rye & Kimberly (2007) differentiate between thinking about adoption as a distinct organisational event or as including both the adoption decision and implementation. The 'key dimension' of adoption for them is 'that the focal organisation secures or maintains access to innovations' (241). They defined organisational adoption as 'the discrete organisational decision to accept or reject an innovation … by using the phrase 'discrete organisational decision' we mean to focus our review on studies that examine adoption as a relatively distinct organisational event … we believe that the processes of adoption and implementation are fundamentally different'.

Following Meyer & Goes (1988), Denis et al noted that the adoption process in organisations is not a one-off, all-or-nothing event but a complex (and adaptive) process. 'Adoption' does not always results in widespread usage of a technological innovation in an organisation; after it is adopted 'it needs to be accepted, adapted, routinised and institutionalised' (Zhu, 2006: 1559). As we have noted previously (Greenhalgh et al, 2005: 106) - and for our stated purpose of seeking to help policy

[6] the latter is concerned with the discovery of new ideas or approaches whereas innovation is concerned with their application.

[7] Such a definition whould normally encompass pharmaceutical technologies as well but these were explicitly excluded from the scope of this review by the funding organisation.

makers and practitioners increase not only the rate and extent of adoption of beneficial technological innovations but also their use - we find the narrow definition of 'adoption' as operationalised by Rye & Kimberly (2007) unhelpful. For the purposes of our review, therefore, we need to broaden our definition to incorporate how innovations - once 'adopted' - are put into daily practice in an organisational context and for this we add the concept of assimilation (Meyer & Goes, 1988).

1.3.3 Assimilation

Meyer and Goes (1988: 897) define assimilation as 'an organisational process that (1) is set in motion when individual organisation members first hear of an innovation's development, (2) can lead to the acquisition of the innovation, and (3) sometimes comes to fruition in the innovation's full acceptance, utilization and institutionalization.' They characterised this process as having nine decision-making stages which we have summarised later in this review.

Taking these three core definitions into account, our review therefore focuses on identifying the organisational factors and processes that determine whether (and the extent and rate at which) technological innovations are adopted and assimilated within NHS organisations.

1.4 Limitations

We acknowledge that, in addition to having multiple stages (Van de Ven et al, 2008), innovation adoption and assimilation is also multidimensional; that is, it is influenced by factors within several dimensions, including environmental or contextual factors, characteristics of the individuals and organisations that adopt the innovation, and characteristics and attributes of the innovation itself (Rogers, 1995; Tornatzky and Fleischer, 1990; Wolfe, 1994).

Our earlier review (Greenhalgh et al, 2005) encompassed this much broader conceptualisation of the diffusion of innovations and presented a model for understanding the complexities of spreading and sustaining innovations in health services. With few exceptions, however, previous studies have mainly focused on factors within one dimension only. Hence, the salient factors of each dimension and their relative explanatory power on innovation adoption have not been determined (Kimberly and Evanisko, 1981). In this related review we have been asked to focus solely on the factors and processes within healthcare organisations (and not on environmental or contextual factors, the characteristics of the individuals that adopt the innovation, or the characteristics and attributes of the innovation itself). The results of this review must be understood in this context. In our case studies and conclusions we place the findings from this review in the broader context of our original model.

1.5 Structure of this review

Chapter 2 of this report provides a brief review of recent policy initiatives and debates relevant to the review question. Chapter 3 then sets out the 'state of the art' with regard to researching issues pertaining to the adoption of technological innovations in healthcare and explains how this review builds and extends upon an associated review carried out by the same authors on behalf of the SDO programme. Chapter 4 describes our search and appraisal methods and strategies. Chapter 5 details the findings of the review. Over and above the findings in chapter 5, Chapter 6 describes three 'technology

in practice' perspectives which may offer some valuable new insights for future research. Chapter 7 presents five retrospective case studies that illustrate how organisational factors and processes can shape the extent of adoption, implementation and assimilation of different types of technological innovations in healthcare. Finally, Chapter 8 presents our overall conclusions and recommendations.

2 Policy context

Key points

1 Concern at the slow adoption and use of beneficial technological innovations in the NHS has led to the establishment of the NHS National Innovation Centre and the NHS Technology Adoption Centre whose aims include to: increase the uptake of new technology in all areas of the NHS; work with partners to identify excellent technologies which will improve healthcare; and promote greater cooperation between relevant organisations involved in the development and use of healthcare technologies.

2 The NHS Next Stage Review *High Quality Care for All* places further emphasis on the need to encourage and reward innovation, and accelerate the adoption of innovations through actions to 'simplify the pathway by which they pass from development into wider use, and develop ways to benchmark and monitor uptake.'

2.1 Contemporary NHS practice and policy recommendations

We provide below a brief overview of recent policy initiatives and debates relevant to the review question. This overview is not intended to be comprehensive but to illustrate the nature of the issues raised and recommendations forwarded, and to summarise the significant policy responses since 2004 onwards.

The adoption of innovative healthcare technologies with a proven ability to deliver increased patient benefits and significant efficiencies is perceived as slower in the NHS than other healthcare economies[8]. Sir Derek Wanless observed that the UK has 'been slow to adopt and diffuse new technologies' resulting in it 'lagging behind many other countries' (House of Commons Health Committee, 2005) [9]; others have described an 'NHS reluctance' to adopt new technologies (Darzi, 2008). Wanless also identified that while £3.6bn of public investment went into health innovation only 4% of that was spent on diffusion. Better understanding of the causes of this 'slow rate of progress' and developing strategies to deal with them is an NHS priority.

2.1.1 Recommendations of the Healthcare Industries Task Force (HITF), 2004

Given the type of concerns summarised above, the Department of Health established the Healthcare Industries Task Force (HITF) to improve co-operation between the Government and the healthcare industry. Its report (Healthcare Industries Task Force, 2004) - which described the NHS as a 'late and slow adopter of technology' - identified

[8] Source: http://www.technologyadoptioncentre.nhs.uk/index.php/, accessed October 2008.

[9] Witnesses to the House of Commons Health Committee (2005) highlighted evidence from other countries that have higher rates of take-up of new technologies. For example, in Germany over 40,000 diabetes patients use insulin pumps, while in the UK the figure was less than 2,000. This much lower rate of adoption was attributed to problems of silo budgeting in the UK and lack of 'involvement of clinicians in the procurement process and particularly the evaluation of technologies and translation of those through everyday use.'

several barriers in the NHS to the speedy uptake of useful new medical devices and technologies[10] (figure 1).

Figure 1. Barriers to uptake of new technologies

- multi-entry points to the NHS for companies marketing products
- no formal mechanism to disseminate device evaluation advice and guidance, or to share experience and best practice amongst purchasers - leads to risk-averse purchasing decisions
- insufficient data available to purchasers about cost and value of new products and technologies
- NHS budgeting arrangements can act as a disincentive to uptake of innovation where initial costs are high/higher than existing products and encourage a risk-averse approach to innovative ideas, particularly where the benefits of new technology do not fall into the budget holder's domain
- not enough sharing of information between purchasers/clinicians/industry, which can result in ill-informed purchasing decisions
- NHS culture is not entrepreneurial enough - needs to be a driver of innovation
- lack of financial and technical support for companies in translating promising new ideas into marketable products
- bureaucracy around procurement procedures and instigating clinical trials in the NHS
- reluctance/difficulty in changing the current configuration of health and social care services inhibits the introduction of disruptive technologies
- NHS staff need to be better trained in the use of new medical technologies and products

Source: HITF, 2004

As a lot of these issues are interlinked the HITF concentrated on finding practical ways to overcome or reduce the most important barriers and weaving these into an integrated strategy that would impact on all the key areas. The specific measures agreed by the Task Force are shown in figure 2:

[10] The Task Force identified four key areas for investigation: market access, R&D and the industrial base, regulatory issues, and international trade. The Task Force set up Working Groups in each of these four areas. Working Group members were drawn from experts and advisers from relevant public sector organisations and industry. Each Group was charged with exploring its respective area in detail and agreeing recommendations to improve the existing arrangements, for consideration by the Task Force. The Working Groups produced an extensive list of over 50 recommendations and actions. The Task Force decided to focus on key areas where the development of practical, workable measures would bring about the improvements envisaged. The following are the nine areas which emerged as priorities for the Task Force: improving device evaluation, more support for innovation, improving procurement processes through regional focus and significant clinician involvement, building R&D capacity, developing a pilot for Healthcare Technology Co-operatives based on existing centres of excellence within the NHS, maximising the UK's regulatory influence, developing an agreed export strategy, improving public understanding of the safety and value of medical devices and improving training and education on medical devices for NHS staff. The Task Force went on during the late summer and autumn of 2004 to develop proposals for translating these aspirations into actions.

Figure 2. HITF recommendations

- a modernised Device Evaluation Service which will be managed by the NHS Procurement and Supply Agency (PASA)
- development of an Innovation Centre to stimulate and promote innovation in the NHS as part of an appropriate organisation
- piloted Healthcare Technology Co-operatives as academic centres of excellence - pioneering specialist treatments and techniques
- building R&D capacity for medical devices through UK Clinical Research Collaboration Research
- improved training and education of NHS staff on the use of medical devices
- maximising the UK's influence in regulatory matters in the EU and worldwide
- a focused export strategy for the UK healthcare sector
- more informed, efficient procurement
- better communication with patients and the public on the valuable role played by healthcare products in our daily lives
- a new data collection system to gain a clearer picture of the industry and its performance

Source: HITF, 2004

2.1.2 House of Commons Health Committee: The Use of New Medical Technologies within the NHS, 2005

In 2005 the House of Commons Health Committee undertook a short inquiry into the use of new medical technologies within the NHS including consideration of:

- the recommendations of the Healthcare Industries Task Force (HITF) Report (see above)
- the speed of, and barriers to, the introduction of new technologies
- the effectiveness and cost benefit of new technologies.

The Health Committee (2005: 3) offered several reasons for what it reported to be the relative slow uptake of technological innovations in the NHS:

'The Department of Health has recognised that the potential benefits of new medical technologies are currently not being realised and that improvements are required. There are several reasons for the slow rate of progress. The NHS comprises a federation of 700 Trusts; inconsistent policies and practices in relation to the development of new technology, its application and purchasing policies create difficulties for suppliers and result in variations in the availability of technologies to patients. The use of different and incompatible makes of equipment leads to many problems, including the need for training in the use of each piece of equipment. The result is a drain on resources and the potential for mistakes. The inability to move money between Trusts' budgets can also result in a lack of integration.'

In addition to specific recommendations relating to telemedicine, the Committee made a number of more general recommendations:

- there should be improved techniques for determining the cost-effectiveness of new technologies
- nationally approved standards for the commissioning of new technologies should be developed to ensure inter-operability[11]
- there should be a greater engagement of clinical champions for new technologies
- the Government should address the problems for procurement caused by the inability to move money between budgets
- the Government should address the NHS preference for short-term savings as opposed to long-term advantages for patients.

2.1.3 NHS National Innovation Centre and the NHS Technology Adoption Centre, 2007

As part of the HITF recommendation to develop 'an Innovation Centre to stimulate and promote innovation in the NHS as part of an appropriate organisation', the NHS National Innovation Centre (NIC) was established with the aim of speeding up the development of pre-commercial technologies likely to benefit the NHS[12]. More specifically related to the scope of this review, the NHS Technology Adoption Centre (which is part funded by the NIC) was launched in September 2007 with the following key aims[13]:

- to increase the uptake of new technology in all areas of the NHS
- to work with partners to identify excellent technologies which will improve healthcare in the NHS
- to promote greater cooperation between all organisations involved in the development and use of healthcare technologies in the NHS

In the course of the first three years, the NHS Technology Adoption Centre is committed to reviewing a wide range of innovative medical technologies against strict criteria[14] and selecting up to 15 technologies to implement in a wide range of real-time clinical settings

---

[11] More specifically, the Department should 'ensure that Primary Care Trusts (PCT) and hospital trusts (and if possible SHAs) should commission new technologies according to nationally approved standards (determined by the new Device Evaluation Service [DES] in conjunction with HTA/National Institute of Clinical Excellence [NICE]). Such standards should provide the basis for the selection of base-line devices and technologies. It is important that the tendency towards technology 'creep' and uneven mix of systems that lack interoperability or require different competences to be used should be avoided'.

[12] The NIC is part of the NHS institute for Innovation and Improvement.

[13] Source: http://www.technologyadoptioncentre.nhs.uk/index.php/, accessed October 2008.

[14] A set of criteria have been established against which all the technologies will be evaluated. The project range is intended to enable the Technology Adoption Centre to explore a range of mass adoption strategies and provide a balanced portfolio of technology types/clinical areas/beneficiary organisations. A typical technology selected as the basis of an implementation project will need to meet the following criteria: has to involve step change innovation; has to have an adoption issue; the technology must have strong independently reviewed evidence (possibly NICE, HTA, CEP) of improved patient outcomes and / or systems efficiencies but still minimal uptake in the NHS; supports NHS national policy priorities and should be in a clinical area of major focus for the NHS.

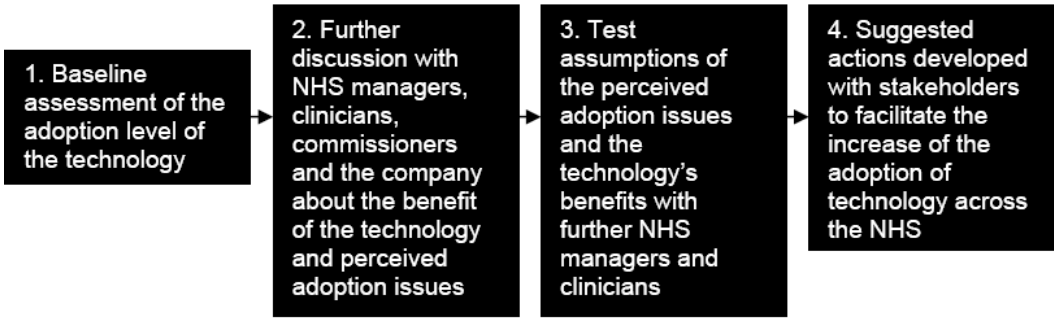
as 'technology implementation projects'[15]. These projects will involve managing implementation and systems integration issues of the technology as well as identifying where additional changes to a clinical pathway or service may need to be made in order to unlock the full benefit of each technology (table 1).

Table 1. Examples of technology adoption issues

Area	Example 'technology adoption' Issues
People	▪ Training
	▪ Staffing numbers
	▪ Workforce
	▪ Clinical practice
Process	▪ Procurement
	▪ Clinical pathways
	▪ Budget
	▪ Commissioning
Infrastructure	▪ Space
	▪ IM & T compatibility
	▪ Delivery systems

In addition to the selected Technology Implementation projects, Adoption Reviews (figure 3) will investigate the barriers to the adoption of technologies in the NHS from a variety of different perspectives[16]. The fundamental questions which will be asked throughout this process are: 'Will increased adoption of the technology bring a benefit of major significance to the NHS and what steps need to be undertaken to increase adoption?'

Figure 3. Technology Adoption Reviews as undertaken by the NHS Technology Adoption Centre



Source: NHS Technology Adoption Centre. Technology Adoption Review. June 2008

[15] The first 6 projects that are currently being undertaken are: cardiac resynchronisation therapy with remote patient monitoring; insulin pump therapy; retinal imaging ophthalmic imaging systems; virtual reality clinical skills training systems; photodynamic diagnosis of bladder cancer; and breast lymph node assay.

[16] Five further technologies have been selected for a Technology Adoption Review: biochip array technology; bariatric surgery; diagnostic and therapeutic hysteroscopy; SMS appointment reminders; innovative real-time polymerase chain reaction test.

The lessons learnt from managing the implementation of the chosen technologies and overcoming the barriers for individual projects will also be developed into a generic 'Adoption Map' which details how the groups engaged in the adoption process interact. An Adoption Navigator which helps those involved with an individual technology 'navigate' the landscape effectively will be developed for the benefit of both industry and the adoption community.

2.1.4 Other ongoing policy debates and inquiries

In 2008 the NHS Confederation launched a series of 'Futures Debate' papers to stimulate thinking on future challenges to the health and social care system in the NHS. One of these focused on the implications of 'disruptive innovations' and how difficult it was to predict the pace, and extent, of innovation in healthcare[17]. Examples of 'disruptive innovations' included those in fields such as genetics, tissue repair, drugs and diagnostics which, although benefiting some patients, would raise difficult questions for commissioners. The paper notes that:

'In part, the impact of innovation on the NHS is going to be determined by the speed of adoption. Large numbers of local, rapid experiments using common data sets and designed collaboratively within and between providers may be more appropriate than the current paradigm of pilots and demonstration projects.'

The paper also highlighted the challenge for healthcare organisations of assimilating small changes ('the creeping impact of large numbers of small changes') within their organisation, while managing their day-to-day business.

At around the same time the King's Fund published a report that aimed to improve the uptake of 'useful consumer-facing technology in healthcare' by analysing the main barriers to adoption and suggesting measure to overcome those (Liddell et al, 2008). This report was not based on a literature review or a survey but interviews with 16 key stakeholders and a subsequent workshop, and focused to a large extent on policy responses (relating to the Department of Health, Strategic Health Authorities, commissioners and industry) to increase the rate of adoption of technologies 'with an IT element'. Taking what the authors identified as the predominant adoption model in the NHS being where decision-making resides with commissioners in local healthcare organisations and technologies are then disseminated locally, the review suggested some universal barriers to technology uptake:

[17] The views in it are drawn from a sample of people who were interviewed and those who participated in three seminars to discuss the results of those interviews.

Figure 4. The key barriers to adoption

- lack of availability of resources including a lack of funding to invest in new technology, a lack of organisational resource (people) necessary for the implementation of the new technology, and a lack of time to invest in adopting the technology
- lack of strategic leadership by the Department of Health, and a somewhat fragmented approach reflected in the number of national organisations and structures with an innovation or technology remit. Furthermore, there is also a lack of local leadership in PCTs and SHAs
- lack of incentives for clinicians: clinicians do not sometimes see the benefit of technology when it is fulfilling an administrative, rather than clinical, function
- the commissioning process is geared towards assessing new technologies on a 'least cost' basis. There exist few incentives for commissioners to invest in technologies that represent any form of risk such as longer-term return on investment or those that require change in the care pathway

The report went on to make 16 recommendations relating to national leadership, local performance, funding mechanisms, better management of the 'technology trial' process, better communication with consumers and strengthening the NHS/industry partnership.

Finally, Policy Exchange' - a policy think tank – is currently undertaking an inquiry as to how best to improve the NHS' performance in taking up and spreading innovations. A preliminary research note (figure 5) was published in the summer of 2008[18] (Barlow et al, 2008) with a full report due for publication.

Figure 5. Preliminary recommendations

- linking the current payment system to an innovation agenda, through the introduction of a new tariff based on best practice, incorporating bonus payments for high quality interventions.
- creating a one-stop shop for gathering and disseminating evidence for innovations. In the future, the guidance producing bodies could be merged into a single authoritative source in order to simplify the system.
- developing metrics for the measurement of clinical outcomes and systematically collecting patient reported outcome data, in order to produce public tables benchmarking the quality of performance.
- using the commissioning process to actively improve the uptake of innovations and best practices, and to foster cooperation between providers in regional health economies

From the brief overview above, it is clear that there is no shortage of high level, policy focused reviews relating to technology adoption in the NHS with similar recommendations emerging from each, resulting in initiatives such as the NHS Technology Adoption Centre. Most recently, the DH has restated its intention to reward innovation and accelerate adoption (Darzi, 2008) by:

- the continued role of the Health Innovation Council to champion innovation for the NHS

[18] The preliminary paper was based on an 'extensive' literature review, 36 interviews with leading decision-makers from healthcare in the UK, and a round table discussion of early findings

- a new legal duty on strategic health authorities (SHAs) to promote innovation, with new innovation funds to be held by SHAs, and new prizes for innovations that directly benefit patients and the public
- the creation of health innovation and education clusters to set strategic goals across organisations and to run joint innovation programmes.

But these reviews have not attempted to systematically explore the factors and processes within a healthcare organisation that influence not only the (in the NHS context, often mandated) adoption and implementation of technological innovations but also their assimilation into routine practice. Establishing what we know - and do not know - about the formal and informal processes and other factors that determine the speed and success with which technological innovations become part of day-to-day clinical practice is the focus of this review.

3 An initial overview of the literature

Key points

1 The literature reveals that there are two broad ways of thinking about - and studying - innovation adoption and assimilation. The first assumes that innovations typically move through a number of common, sequenced stages leading to their eventual use in an organisation and that specific organisational variables (for example, size or features of the organisational structure) are associated with higher or lower rates of adoption; these associations are typically studied through large-scale quantitative surveys of organisations in a specific sector. The second approach sees innovation adoption and assimilation as a much more complex, iterative and multi-dimensional process which is best studied through longitudinal and qualitative approaches.

2 To date, the adoption of innovation literature has predominantly taken the first of these approaches but recent commentators have highlighted the shortcomings of the resulting evidence-base for drawing practical recommendations that might improve the uptake and use of innovations. Of particular relevance to this review is the increasing attention being paid to the political, social and cultural characteristics of organisations as key determinants of the adoption of innovations.

3 Our previous review for the SDO programme identified a number of (a) organisational antecedents for innovation in general, and (b) factors associated with an organisation's readiness for a specific innovation that influences adoption and assimilation. These antecedents and factors encompassed both structural and non-structural determinants.

'how innovative has the innovation research itself recently become? Might it even now be bordering on 'works to formula' … the 'works to formula' being replication–extension empirical journal articles, and … routinized studies into facilitator and inhibitor variables of innovation? Without doubt major advances have been made in several aspects of the research base, … Surely, if any area of research in organisation behavior should display innovative theories, models, themes of research, and field- and laboratory-based studies, it should be the field of innovation and creativity at work?' (Anderson, 2004: 148)

In recent years numerous commentators have increasingly characterised approaches to the study and practice of the management of innovations in terms of two schools of thought: the staged school and the process school. The former sees innovation in organisations unfold through an anticipated sequence of ordered stages; the latter see innovations in organisations as iterative, complex and multi-directional. Staged or sequential models commonly use deterministic studies to quantify associations between innovation adoption (typically conceptualised as a discrete event) and organisational level variables (for example, organisational size). However, as we have noted elsewhere, 'one important weakness of the literature on structural determinants of innovativeness is the assumption that they can be treated as variables whose impact can be isolated and independently quantified … an alternative theoretical approach … suggests that the determinants of organisational innovativeness interact in a complex, unpredictable and non-generalisable way with one another' (Greenhalgh et al, 2005: 12). Furthermore, quantitative studies to date have been largely inattentive to organisational decision-making or even organisational context (for example, one paper we reviewed stated that 'our analyses could not control for hospital effects because we did not know the hospitals where surgeons practised' (!); this typifies much of the research in this field in the sense that there is no - or very little - accounting for the organisational context in which

adoption of an innovation takes place. In relation to the staged school there has therefore been 'considerable lack of theory development, and corresponding empirical investigation, addressing the impacts of both individual variables and organisational context on innovation adoptions within strategic decision-making contexts' (Tabak, 1999: 248). Just as Rogers' early (and indeed later) work has been criticised for adopting a rational (staged) view of how change is achieved in organisational contexts and for its simplicity in relation to the complexity of the change process (Dopson, 2002)[19], so others have argued that the adoption of innovations is shaped by the internal change capacity of the receiving organisation and the context in which it is situated.

This developing literature challenges the sequential view of the innovation journey and stresses the messy, dynamic and fluid nature of the innovation journey (Van de Ven, Polley et al, 2008). Such process theories have 'major advantages over the staged approach by highlighting the non-rational nature of decision-making, the political context within which innovations are introduced, and the iterative, dynamic and changing nature of innovation' (Walker, 2003: 94). Several general models of the innovation process have been proposed at differing levels of analysis (most notably: Van de Ven et al., 1999; West, 1990, 2002; Zaltman et al., 1973) and have received some validation from longitudinal observation studies (e.g., King, 1992; Van de Ven et al., 1999). This research confirms unequivocally that innovation processes in organisations are iterative, non-linear (that is, the sequence of events cannot easily be portrayed as a neat, step-by-step unfolding series of phases), disjunctive, cyclical, and often stressful to those involved either as initiators or being affected by their implementation.

3.1 The 'state-of-the-art' and recent reviews

Recent reviews of the innovation literature in the healthcare context have highlighted the continuing deficiencies, despite decades of research, in the existing evidence-base:

'We have no widely accepted theory of innovation adoption in organisations, and this along with other empirical problems frustrates our efforts to make sense of the empirical results. Also, the complexity of the adoption is rarely appreciated in the theoretical models that do exist, and studies of interactions between constructs at similar and different levels of analysis are rare though essential to our understanding of the phenomenon.' (Rye & Kimberly, 2007, 254)

Such critiques have called for empirical research that includes a wide array of constructs and can capture complex, theoretical linkages in order to help identify deeper reasons for adoption and untangle apparent conflicting research findings (*ibid*; 260) (as we (Greenhalgh et al, 2005), and others have already suggested).

This is not to say that no studies have examined multiple types of adoption correlates or explored interactions between categories. Rye & Kimberly (2007) identify a small number of qualitative studies that they describe as having gained some 'theoretical purchase' (papers that we review later in this report). One particular deficiency which we would highlight at this point - as Rye & Kimberly did - is that of the lack of attention paid to organisational decision-making research and 'the impact of complex authority structures, political dynamics and conflict/consensus within an organisation or organisational adoption of an innovation …' (*ibid*: 263). As Gosling (2007) notes - in the context of IT

[19] Viewing innovation diffusion and adoption as a rational-linear process has been the subject of criticism for some decades (McLoughlin, 1999).

adoption and assimilation - organisational, psychological, and sociological research within the healthcare system has consistently identified the importance of factors such as hierarchy, professional subcultures, local communication networks, and clinical team functioning, and yet empirical research examining the role of these elements has been relatively sparse. Such research recommendations accord with those made in our own earlier review.

3.2 Our previous review

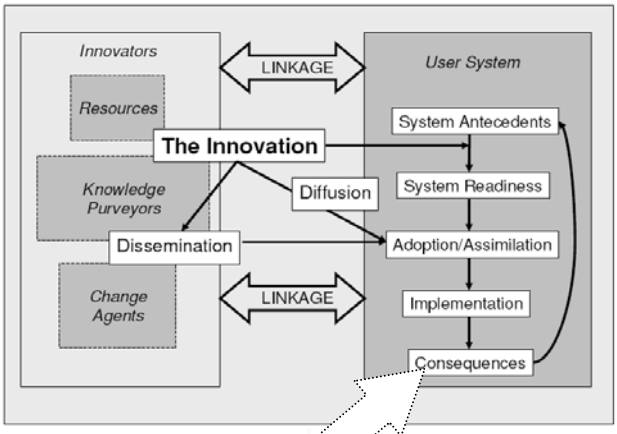
As highlighted in the introduction to this review our original model recognised that the available literature on the issue of diffusion of innovations in healthcare is large, diverse and complex, and highlighted the problem of the multiple and often unpredictable interactions arising in particular contexts and settings that determine the success or failure of implementing changes. We grouped our findings from 213 empirical primary studies under six broad themes:

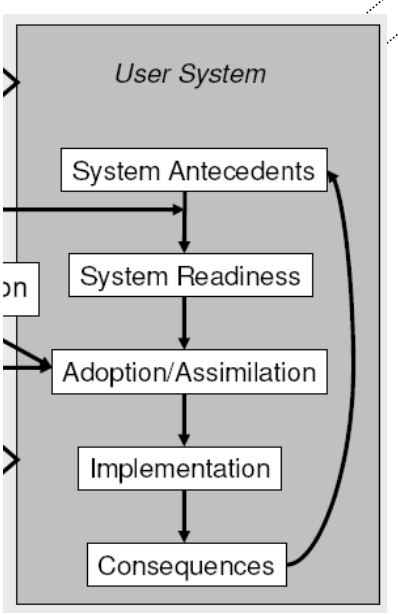
- the innovation itself
- the adoption process
- communication and influence (including social networks, opinion leadership, and change agents)
- the inner (organisational) context
- the outer (inter-organisational) context
- the implementation/sustainability process.

Within each of these themes, we further divided data from the primary studies into subtopics. The fourth of the themes - the inner context or ‘user system’ - is the specific focus of this review which seeks to deepen and extend our previous work by focusing on the issue of technological innovation adoption and assimilation in healthcare organisations (see figure 6).

Figure 6. Relationship of this review to our original model

Broad focus of original review (Greenhalgh et al, 2005)





Specific focus of current review

3.2.1 The inner context

As discussed in our earlier review (Greenhalgh et al, 2005), the focus of diffusion research began to shift to organisations and organisational context rather than individuals (Baldridge and Burnham, 1975; Kimberly, 1981). As well as their specific structural features (size, complexity etc.), organisations have particular political, social, cultural, technological and economic characteristics. Abelson (2001, as cited by Fitzgerald et al., 2002) separates context into outer, societal 'predisposing' influences, inner institutional 'enabling' influences, and 'precipitating' political influences. Our earlier review considered the inner (organisational) context as it influences the adoption, spread and sustainability of innovations in service delivery and organisation. 'Inner context' comprises both the 'hard' medium of visible organisational structure and the 'soft' medium of culture and ways of working, both of which vary enormously between organisations. These variations have important implications for how any one organisation responds to innovations (whether they are innovations in service delivery and organisation or technological innovations).

In our original review, we found that empirical research in organisational studies has sought to identify the key determinants and moderators of organisational innovativeness. We included a total of 18 studies (3 related meta-analyses from outside the healthcare

context, and 15 additional primary studies, most of which were set within a healthcare context). We then distilled from these studies the key factors that have been found to influence the adoption and implementation of an innovation in an organisational context. To explain why organisations adopt (or do not) innovations, we forwarded notions of (1) organisational antecedents, and (2) organisational readiness for innovation.

Organisational antecedents for innovation

Organisational antecedents are those features of an organisation that have been shown to influence the likelihood that an innovation will be successfully assimilated (i.e., adopted by all relevant individuals and incorporated into 'business as usual'). Such antecedents can be either *structural* (for example, size/maturity; formalisation; differentiation; decentralisation; slack resources) or *non-structural* (absorptive capacity for new knowledge[20]; receptive context for change[21]).

Organisational readiness for innovation

Such antecedents may mean that an organisation is amenable to innovation in general but not ready or willing to assimilate a particular innovation (Greenhalgh et al, 2004: 607). Formal consideration of the innovation allows the organisation to move (or perhaps choose not to move) to a specific state of system readiness for that innovation. The elements of system readiness we identified were: tension for change, innovation-system fit, power balances (supporters vs opponents), assessment of implications, support and advocacy, dedicated time and resources and the capacity to evaluate the innovation.

In our findings (section 5) we use these two notions as a starting point for our review of the literature, and in so doing, seek to deepen and extend that part of our original model that focused on the adoption/assimilation of innovations.

3.3 Drawing lessons for practice

Following our original review one of us (TG) developed a series of practical exercises to help practitioners assess an organisation's capacity to innovate. Based directly on our findings, one of these exercises was designed to help individuals assess how an organisation ranked in its ability to assimilate innovations in general (see figure 7):

Figure 7. Assessing an organisation's ability to assimilate innovations

[20] Including, for example: pre-existing knowledge/skills base; ability to find, interpret, re-codify and integrate new knowledge; and the enablement of knowledge sharing via internal and external networks.

[21] A composite construct which we broke down into: leadership and vision; good managerial relations; risk-taking climate; clear goals and priorities; and high-quality data capture.

An organisation likely to assimilate innovations readily has 11 key characteristics:

1	Slack resources	Money, staff and other resources that are available to be allocated to new projects	☐
2	Specialisation	Clear division of labour between departments and units, with each concentrating on its own strengths and not meddling too much in the work of others	☐
3	Decentralised management	Semi-autonomous units who do not have to pass decisions up the line very often	☐
4	Sound knowledge and skills base	In relation to a particular area of innovation, lots of people in the organisation are familiar with basic concepts and can apply these to new projects	☐
5	Ability to access new knowledge	Staff have the skills and capacity to horizon-scan and capture new ideas in this area	☐
6	Knowledge sharing is enabled and promoted	Senior staff encourage and facilitate exchange and sharing of knowledge and ideas (a) within the organisation and (b) beyond the organisation	☐
7	Leadership	Top management provides strong and competent leadership and vision	☐
8	Middle management	Relationships and communication at middle management level are good	☐
9	Risk-taking climate	People are rewarded not punished for taking risks, even if these sometimes lead to failure	☐
10	Goals	Goals and priorities are clearly articulated	☐
11	Data capture	There is high-quality data capture to gain timely feedback on the success of innovations	☐

However, recognising the limitations of much of the existing empirical literature for making recommendations to practitioners (see section 3.1), in section 6 we also note the promising but as-yet, relatively untested approach by Professor Carl May and his team on the 'normalisation process model'[22] (May et al, 2007) and other 'technology-in-practice' perspectives which could potentially offer insights into the process of innovation adoption and assimilation in healthcare organisations. In the final section of this review we incorporate these into our overall findings and suggest some broad 'design principles' for practitioners who are interested in enhancing their organisations ability to assimilate technological innovations into their routine practice.

[22] This model comprises four components: interactional workability (does the innovation fit with the micro-environment of the clinical encounter?); relational integration (does it fit with the network of relationships within which the clinical encounter sits, and especially, how does it impact on issues such as interpersonal trust?); skill set workability (does it fit with the formal and informal division of labour between staff?) and contextual integration (does the organisation understand the innovation and agree to allocate material and human resources to its implementation?).

4 Methods

Key points

1 We undertook electronic searches of four databases, handsearched six key journals and conducted electronic citation tracking searches of three key research papers. The abstracts of the resulting references were sifted by two members of the research team in terms of whether they were relevant to our research questions and worthy of further consideration. A short set of inclusion criteria were then applied to the remaining 233 full text papers and book chapters retrieved by these methods. This resulted in a total of 106 references informing this final report (comprising 99 empirical studies and 7 non-empirical studies).

2 In appraising and synthesising the 106 references we gave priority to processual as opposed to deterministic studies, and to studies undertaken in the NHS as opposed to those undertaken in healthcare systems elsewhere.

4.1 Outline of method

This review took place between May and November 2008 and we used the following methods to identify relevant papers and publications in the published and 'grey' literatures.

Our approach to searching was guided by our experience of conducting an earlier review of the literature (Greenhalgh et al, 2005) where we learnt that in reviews of complex and heterogeneous evidence (such as the case in this review) formal protocol-driven search strategies may fail to find important evidence (Greenhalgh & Peacock, 2005)[23]. Rather, informal approaches such as browsing and being alert to serendipitous discovery can substantially increase the yield and efficiency of search efforts. Other methods - such as pursuing references of references and electronic citation tracking are especially powerful for identifying high quality sources in obscure locations (*ibid*).

4.1.1 Electronic searching of four databases

Electronic searching was undertaken by an experienced librarian (RP) in close liaison with the lead researcher (GR). As with our original review, RP refined electronic search strings iteratively in response to emerging data and the search string was modified for different databases to take account of different index terms. The four databases searched were Medline (1996 onwards), EMBASE, CINAHL and HMIC. The final search string for the MedLine database was:

1. Technolog* accept* (txt)
2. Technolog* adopt* (txt)
3. Exp. Diffusion of innovation (MeSH)

[23] In our earlier review only 30% of sources used in the final review were obtained from the protocol defined at the outset of the study (i.e. from the database and hand searches). Fifty-one percent were identified by 'snowballing' (such as pursuing references of references) and 24% by personal knowledge or personal contacts.

4. Absorptive capacity (txt)
5. 3 and 4
6. Exp. Organisational innovation (MeSH)
7. Technolog* (txt)
8. Exp. Telemedicine (MeSH)
9. Exp. Medical Records Systems, Computerized (MeSH)
10. Exp. Information Systems (MeSH)
11. Exp. Medical Informatics (MeSH)
12. 7 or 8 or 9 or 10 or 11
13. 3 and 6 and 12
14. Exp. Decision making (MeSH)
15. Adopt*
16. 14 or 15
17. 3 and 13 and 16
18. 1 or 2 or 5 or 13 or 17

4.1.2 Hand searching of key journals

In our original review, the yield from hand searching of biomedical journals was disappointing[24]. In this related review we therefore focused on organisation and management journals. The lead researcher (GR) hand searched the following six key journals:

- British Journal of Management
- Journal of Organisational Behaviour
- Organisational Science
- Administrative Sciences Quarterly
- Organisational Studies
- Human Relations

In addition, we conducted an on-line search of the Academy of Management' journals and proceedings database[25] (http://apps.aomonline.org/ArticleRetrieval/login.asp) using the key search terms 'technology', 'innovation' and 'adoption' and pulled all relevant abstracts.

[24] For example, we found a single article related to our search from 8000 articles in the *Annals of Internal Medicine* and the *British Medical Journal*, although providing many background articles, did not provide any empirical papers that contributed to the final report.

[25] Contents include ***Academy of Management Journal*** articles since 1958, ***Academy of Management Review*** starting in 1976, ***Academy of Management Executive*** 1987-2005, ***Academy of Management Perspectives,*** starting with the 2006 issue, ***Academy of Management Learning and Education*** since 2002 and the ***Proceedings*** since 1954.

4.1.3 Citation searches

In our original review, electronic citation tracking of papers that we had identified as likely to be 'seminal' provided a significant number of valid and relevant hits. We therefore undertook electronic citation tracking using the ISI Web of Knowledge Citation Indexes to search through articles citing what we identified as three key research papers[26]:

- Greer, AL. (1985). Adoption of medical technology. The hospital's three decision systems. *International Journal of technology Assessment in healthcare*, 1985, 1: 669-680
- Kimberly, JR, and Evanisko, JM. (1981) Organisational innovation: the influence of individual, organisational and contextual factors on hospital adoption of technological and administrative innovations. *Academy of Management Review* , 24: 689-713
- Meyer, AD, and Goes, JB. (1988). Organisational assimilation of innovations: a multi-level contextual analysis. *Academy of Management Review* , 31: 897-923

4.1.4 Inclusion and exclusion criteria

As with our original review we used a simple, semi-structured checklist to guide our judgement and exclude references that were unlikely to add value to our latest review (figures 8 and 9):

Figure 8. Inclusion criteria for primary research papers

(1) *Relevance*. Is the paper about the process of adoption and assimilation of a (non-pharmaceutical) technological innovation in a healthcare organisation?

(2) *Depth*. Does the paper go beyond superficial description or commentary – i.e. is it a broadly competent attempt at research, enquiry, investigation or study?

(3) *Utility*. Will the paper offer added value for the NHS?

Adapted from Greenhalgh et al, 2005

At the first sift we excluded non-relevant primary studies that were:

- set in the non-healthcare sector
- focused on a pharmaceutical technology
- focused on an organisational innovation (as opposed to a technological innovation)
- not about either the process of adoption, implementation and/or assimilation
- only about individual adopter/user characteristics (i.e. non-organisational)

[26] In our original review it was clear that papers less than 5 years old had generally not yet shown a direct influence on empirical research. In this review we therefore deliberately selected seminal articles that had been published over 10 years previously.

Papers that were relevant but that did not go beyond superficial description or commentary were also excluded.

Figure 9. Inclusion criteria for theoretical papers and reviews

(1) Is the paper part of a recognised research tradition – i.e. does it draw critically and comprehensively upon an existing body of knowledge and attempt to further that body of knowledge?

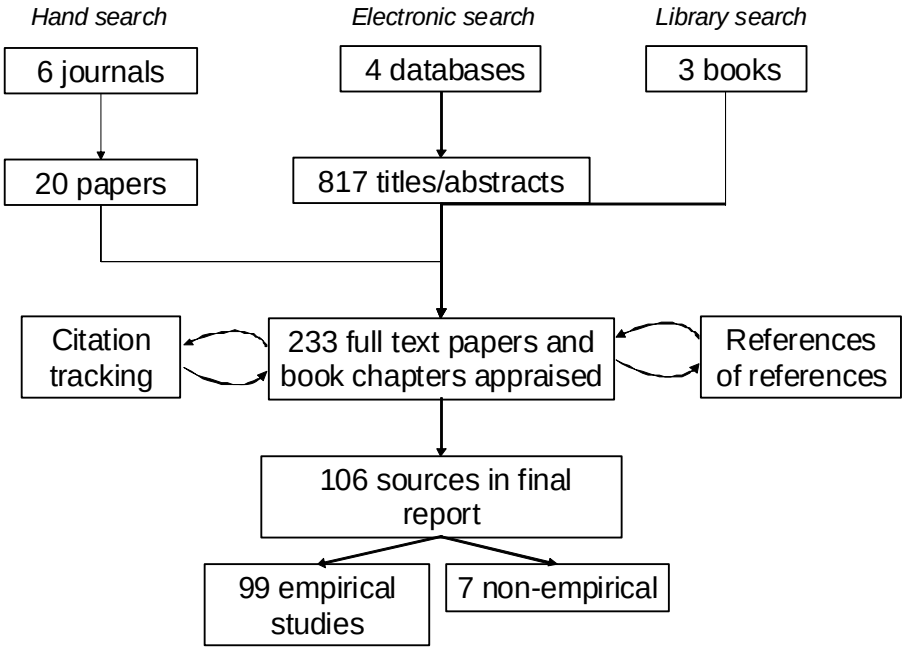
(2) Does the paper make an original and scholarly contribution to research into the adoption and assimilation of (non-pharmaceutical) technological innovations in a healthcare organisation?

(3) If more than 3 years old, has the paper subsequently been cited as a seminal contribution by respected researchers in that tradition?

Adapted from Greenhalgh et al, 2005

The contribution from different sources to our final report is summarised in figure 10. Having browsed a total of 817 titles/abstracts we pulled 233 references of which 106 contributed to our final report:

Figure 10.



Of the 233 references retrieved by the various search methods outlined above, 127 were appraised and then excluded for at least one of the reasons listed on the previous page.

4.2 Mapping phase

In our earlier, wider ranging review we identified through a mapping phase major research traditions that had, largely independently of one another, addressed (or provided evidence relevant to) the issue of diffusion and/or dissemination and/or

sustainability of innovations in health service delivery and organisation (Greenhalgh et al, 2005: 37). We classified four of these as 'early diffusion research':

- rural sociology
- medical sociology
- communication studies
- marketing and economics

Research traditions that built on, and to a greater or lesser extent challenged, the work of the early sociologists, social psychologists, and economists, and in particular that have gone beyond the widely cited Rogers model, included:

- development studies
- health promotion
- evidence-based medicine and guideline implementation
- organisational studies
- knowledge-based approaches to innovation in organisations
- narrative organisational studies
- complexity and general systems theory

We noted that these different research traditions vary considerably in how they conceptualise innovation and its diffusion.

As we noted in our original review (Greenhalgh et al, 2005: 48), the study of how organisations adopt and assimilate innovations (the focus of this current review) has been addressed in several of these research traditions, including studies of the structural determinants of organisational innovativeness. More recent traditions within organisational studies have focused on the process of innovation, the culture/climate and leadership of the organisation, and the role of interorganisational networks in establishing norms and spreading 'organisational fads and fashions'. Slappendel (1996) helpfully maps out the literature on innovation in organisations in terms of three theoretical perspectives. These are referred to as the individualist perspective, the structuralist perspective, and the interactive process perspective; the first two of these perspectives take a largely deterministic approach. Table 2 provides an overview of the three perspectives (the perspectives are shown in an order that reflects their historical development and relative influence) that is useful as it provides a framework for understanding the key theoretical and methodological differences that are evident within this field.

Table 2. Three theoretical perspectives on innovation in organisations

	Determinist		Processual
	Individualist	Structuralist	
Basic assumptions	Individuals cause innovation	Innovation determined by structural characteristics	Innovation produced by the interaction of structural influences and the actions of individuals
Conceptualisation of an innovation	Static and objectively defined objects or processes	Static and objectively defined objects or processes	Innovations are subject to reinvention and reconfiguration. Innovations are perceived
Conceptualisation of the innovation process	Simple linear, with focus on the adoption stage	Simple linear, with focus on the adoption stage	Complex process
Core concepts	Champion Leader Entrepreneur	Environment Size Complexity Differentiation Formalization Centralization Strategic type	Shocks Proliferation Innovative capability Context
Research methodology	Cross-sectional survey	Cross-sectional survey	Case studies Case histories
Main authors	Rogers March and Simon	Zaltman et al.	Van de Ven et al. Pettigrew

Adapted from Slappendel, 1996

4.3 Appraisal and synthesis phase

The data extraction form used in the review is in Appendix 1. We draw on the distinction between determinist and processual perspectives in the framework in table 2 above to help appraise and synthesise the results of our review in the next section. Justification for prioritising NHS based studies is that research evidence (Swan, 1999) shows that there is a high likelihood of national differences in the diffusion and utilisation of technological innovation (irrespective of the methodological difficulties of making comparisons (de Kervasdoué, 1981)).

5 Findings

Key points

1 Of the 99 empirical studies we reviewed, 5 were meta-analyses and 7 were systematic reviews. Of the 87 primary empirical studies, 54 (62%) took a deterministic approach to studying the adoption of technological innovations (usually by means of a cross-sectional postal questionnaire); the remaining 33 (38%) of studies were process-based employing an in-depth case study approach. Only 12 (14%) of the 87 studies were undertaken in the NHS but the vast majority of these (10 studies, 83%) were process-based. In contrast, of the 75 (86%) of studies undertaken outside of the NHS, only 31% were process-based.

2 None of the 5 meta-analyses we reviewed were exclusively focused on the adoption of technological innovations in healthcare organisations and most made no specific reference to the healthcare context at all. These studies are included here as their findings raised hypotheses which have informed later, more qualitative and process-based, research in the healthcare sector.

3 Of the 7 systematic reviews relevant to our research objective 2 were particularly wide-ranging in scope and applied to healthcare organisations (albeit with significant differences in focus to our review). Both confirmed the importance of paying attention not only to (a) pre-existing conditions that encourage innovation adoption generally, but also to (b) interventions and conditions that facilitate the adoption and assimilation of specific innovations into an organisation at a certain point in time. These 2 reviews also confirm the atheoretical nature of the vast majority of adoption research in healthcare to date; research which has also largely taken the 'adoption' decision as a discrete event and the primary outcome measure of interest, ignoring how and why 'adopted' innovations are thereafter assimilated into routine clinical practice.

4 The 10 NHS-based processual studies are important to increasing our understanding of why and how technological innovations are adopted and assimilated in NHS healthcare organisations. Their findings highlight:

- the importance of the history, culture and quality of interprofessional relationships
- that there is often no single adoption decision
- the vital role of power and politics in determining the outcome of decision-making processes relating to innovation adoption and assimilation
- the impact of different types of decision-making processes (and that a short-term perspective predominates)
- that professionalism in healthcare can be a negative influence on adoption and assimilation.

5 The 23 processual studies from other healthcare systems (largely in the US) provide further insights into key elements shaping the adoption and assimilation of technological innovations in healthcare organisations, albeit with necessary reservations about their direct applicability to the NHS context.

6 There were 54 deterministic studies (2 in the NHS and 52 from other healthcare systems). Typically, such studies undertake a large scale (usually postal) questionnaire survey of 2-4 key decision-makers in healthcare organisations. The focus of the studies varies but is most commonly placed on establishing which organisational factors influence adoption (for example, size or extent of decentralisation of decision-making), although a small minority take a more practice-oriented perspective and seek to develop tools and frameworks for practitioners to apply in their organisational settings. Relevant findings for this review are that:

- senior physicians are key decision-makers, thus supporting the importance of the 'medical-individualistic' system of decision-making along with the political nature of these processes
- the dynamics between the internal decision-making structures of an organisation and it's relationships with it's external environment (for example, external networks).

7. Two key messages emerge from these findings:

- the different determinants discussed interact in a complex way and the nature of importance of these interactions vary depending upon the specific innovation concerned, the different actors involved in the various stages of an innovations adoption and assimilation into routine practice, and the particular organisational context, systems and processes in which 'formal' and 'informal' adoption decisions are made
- in order to realise (and study) the potential benefits to patient care of technological innovations it is important to see 'adoption' as a process rather than as a discrete event, and as a process that comprises both 'formal' organisational decisions and a series of 'informal' decisions by individual users which ultimately leads to implementation and then the assimilation of the innovation into routine practice.

5.1 Overview

We begin our findings with a brief overview of the two broad perspectives (determinist and processual) that typically characterise the primary and secondary studies we found. After detailing the number and type of studies reviewed, we then summarise the studies and the implications of their findings for our overall research question according to the following classification:

- narrative overviews,
- meta-analyses,
- systematic reviews,
- process-based studies in the NHS,
- process-based studies from other healthcare systems,
- deterministic studies in the NHS, and
- deterministic studies in other healthcare systems.

At the end of each of these 7 sections we discuss the implications that the findings have for (a) our understanding of the components of the 'inner context' (namely, organisational antecedents and organisational readiness[27]), and (b) the influence of these components on the extent and rate at which technological innovations are adopted and assimilated within NHS organisations.

Our rationale for presenting the findings in this way is twofold. Firstly, although large numbers of deterministic studies have helped to generate hypotheses relating to the adoption and assimilation of technological innovations in healthcare organisations, if we are to seek to make detailed recommendations to policy makers and practitioners as to how to facilitate the introduction of beneficial technologies - the explicit purpose of this review - then we must look mainly to the relatively limited number of rich, in-depth case studies for guidance. Secondly, of particular value in developing such guidance is the evidence-base derived from studies undertaken in the contemporary NHS. Ferlie et al (2000) suggest important differences between the NHS and other healthcare systems in terms of where discussions about technological innovation take place and how decisions are made, suggesting that findings from other settings may not be particularly generalisable to the NHS:

[27] As detailed in our original model of the diffusion of innovations (Greenhalgh et al, 2005) and summarised in section 3 of this review.

'We speculate that the shift to greater managerial or corporate control may have had fewer effects at the level of the service delivery system in the UK than in the USA. Many healthcare managers [in the NHS] have been preoccupied with financial control or activity levels, so that service or research implementation issues have not been important. Many managers lack technical knowledge and have deferred to the near monopoly of clinical expertise.' (102)

We then end this section with an overall summary which emphasises that the different determinants of organisational innovativeness interact in a complex way with one another. This 'interlocking interactions' perspective (Fitzgerald et al, 2002) should be borne in mind when interpreting the studies described in the sections that follow.

5.1.1 Determinist and processual perspectives

As outlined in the previous section, studies of the adoption and assimilation of technologies in organisations can broadly be classified as determinist or processual.

Following Slappendel (1996), Black (2004) suggests that the mainstream literature in organisation studies generally offers two basic perspectives from which to view the impact of new technologies on organisations. Black characterises those taking what we term a determinist stance as starting with the physical properties of technology and using them to guide the search for ways those properties influence behaviour. Over time, however, to maintain such an 'imperative' view of technology (Khandwalla, 1974) in the face of increasingly contradictory findings, researchers from an determinist or objectivist tradition have augmented their theories with additional variables on which technological outcomes are contingent, including organisational size, task complexity, and amount of centralisation. This perspective has remained, however, 'largely inattentive' (Rye & Kimberly, 2007) to issues of conflict/consensus, power and politics within organisations. As Waterman et al (2007) suggest this dominant research method of innovation diffusion originated in agriculture (Ryan & Gross, 1943), and researchers in this field had a tendency toward experimental research, and their initial questions on the rate of uptake of innovations fitted with a quantitative methodology. This approach has been influential in developing knowledge of innovations, adopters (i.e., people who adopt innovations), and diffusion of innovations. However, according to Potvin (1996), it is decontextual and unilevel focusing on causal relationships between a few variables. It plays down relationships between different variables at micro and macro levels (Green, 2001; Green & Johnson, 1996). Greenhalgh et al. (2005) stated that the endeavor to achieve generalizability usually means that important contingent variables are stripped away.

'The need for something more' was recognised as long ago as 1994 when Wolfe argued that highly generic and linear models of diffusion lack empirical validity and that the current challenge to researchers lies in delineating the complex, context-sensitive nature of the phenomenon itself, in much greater depth (Fitzgerald 2002: 1429). Indeed, the predominant description of the adoption and assimilation of a new technology as a rational-linear process has been the subject of criticism for some decades (McLoughlin (1999) as cited in Dawson & Buchanan, 2005). Consequently, those favouring a more processual view (Fitzgerald, 2002: 1447) have focused on a different causal path:

'Using qualitative investigative or process-type methods may appear to be taking a wrecking ball to the edifice of scientifically rigorous academic intervention research. In some academic circles, the premium placed on being ''right'' appears so high that there is little room for speculation and imagination. It would be a mistake for academic … health researchers to be so focused on technique that they miss key variables and relationships related to effective implementation of new treatments … . The process of

implementation is rarely linear, and understanding it involves more than administering a survey pre- and post-implementation interventions.' (Kimberly, 2008)

However, Black (2004) suggests that more recent studies of new technology implementation suggest that neither the determinist or processual approach is adequate, for the simple reason that both capture important aspects of the phenomenon in question (Barley, 1986; Poole and DeSanctis, 1990; Orlikowski, 1992). Building on the structuration framework of Giddens (1984), this line of research suggests that causality runs in both directions: technology influences the patterns of human activity, and the technology changes as it is modified in the course of day-to-day activity (Barley, 1986; Orlikowski, 1992): 'Such a view of process is in line with, and draws upon, the non-linear, complex, recursive, and emergent view of organisational change processes developed by Pettigrew (1997) and continued in Dawson (1994, 2003).' (McLoughlin, 2005). We discuss this third, emerging perspective in more detail in section 6.

5.1.2 Nature of the evidence

Of the 99 empirical studies we reviewed, 5 were meta-analyses and 7 were systematic reviews. In addition, 7 narrative overviews helped inform our thinking (table 4).

Table 3. Types of study included in review

Type of study	No. of studies
Meta-analysis	5
Systematic review	7
Empirical studies	87
Narrative overview	7
Total	106

As noted below, Kimberly (2008) argues that researchers have traditionally used four categories of variables when examining organisational influences on innovation assimilation and implementation: (1) structure, (2) culture or climate, (3) internal processes, and (4) leadership. As anticipated we found a preponderance of empirical studies of structural determinants of organisational innovation adoption (for example, various measures of organisational size) and significantly fewer qualitative (ethnographic) studies of decision-making processes and the impact of harder to (meaningfully) quantify variables, like organisational climate or culture, or leadership (table 5). Fifty-four of the 87 primary empirical studies (62%) took a deterministic approach (usually by means of cross-sectional postal questionnaires) and typically studied the impact of specified organisational variables on the rate of adoption of technological innovations amongst a sample of organisations (table 4). The 33 (38%) remaining studies were process-based studies employing an in-depth, case study approach. Only 12 (14%) of the 99 studies were undertaken in the NHS but the vast majority of these (10 studies, 83%) were process-based. In contrast, of the 75 (86%) studies undertaken outside of the NHS, only 31% were process-based.

Table 4. Empirical studies included in review by theoretical perspective

	Deterministic	Process-based	Total
NHS	2	10	12
Non-NHS	52	23	75
Total	54	33	87

5.2 Narrative overviews of the field

We found seven narrative overviews to be particularly helpful both in describing and delineating the scope of this review, and in informing our thinking. Two of these overviews (Strang & Soule, 1998; Wolfe, 1994) also informed our earlier, broader review of the diffusion of innovations; brief details of these two overviews are provided in appendix 3.

Anderson et al (2004) pose a series of questions and challenges to the 'state-of-the science' of innovation research drawing on a content analysis of selected research published between 1997 and 2002 (which resulted in the inclusion of 15 studies, albeit not exclusively based in the healthcare sector). They propose various dimensions of five factors at the organisational level of analysis that have been found to be facilitators of innovation (for example, specific dimensions of organisational culture reported to facilitate innovation are: support for experimentation, tolerance of idea failure and risk-taking norms). They suggest that important advances have been made in understanding innovation processes in organisations, and that these advances confirm that 'innovation processes in organisations are iterative, non-linear … disjunctive, cyclical and often stressful to those involved either as initiators or being affected by their implementation' (152). However, their content analysis revealed that 80% of the papers published in the nine top-rated journals in management science and organisational psychology over the 5-year period were replication-extensions of existing lines of enquiry and research; only 2 of the studies could reasonably be categorised as theory-driven and only 1 was derived from a 'real-world' problem. They therefore suggest that there has been a 'routinisation' of innovation research that is heavily focused on replication-extension, cross-sectional designs and a single level of analysis. Anderson (168) suggests five priorities for future research including studying innovation as an independent variable, including cross-cultural aspects of innovation initiation and implementation, using multi-level designs, conducting meta-analyses and relying more on multi-method research.

Written from the perspective of the Veterans Administration in the US Greer's (1981) overview precedes her later empirical work on the nature of decision-making systems related to technology adoption (Greer, 1984; 1985). In this earlier paper she argues that the promotion of appropriate diffusion of medial technology is hampered by (1) challenges in undertaking technology assessment, (2) lack of consistency on the factors affecting technology adoption and utilisation and (3) a lack of connection between assessment, adoption and utilisation. It is the second and third of these issues that we focus on here. Greer argues that the second issue is important because an effective public policy concerning technology cannot be developed without, in part, knowledge of the diffusion process sufficient to allow the creation of effective incentives and regulations. Writing in the early 1980s Greer suggests that interest in organisational - as

against individual - adoption of innovations has risen and that efforts to explain patterns of adoption have frequently examined such properties as organisational size, complexity, centralisation of decision-making, normalisation of rules and behaviour and resource base, as well as characteristics of employees and administrators (135). However, she describes this literature as generally characterised by contradictory and inconclusive findings. Greer comments (137) that:

'To a remarkable extent, the fact that the hospital is composed of a diverse set of persons pursuing different goals in different ways, having different interests in different issues at different times, and possessing different amounts of leverage is largely omitted from discussion. Yet of all organisations, hospitals are probably the most extreme case of … 'multiple leadership' … no other organisation exhibits such a striking division in authority and control as that which exists between administrative and medical hierarchies in hospitals'.

The third issue raised by Greer relates to the tendency in the literature to treat adoption and implementation of innovations as a single topic. This continues despite the fact that numerous organisational theorists have highlighted the failure of diffusion researchers to distinguish stages in the diffusion process as a major reason studies have failed to produce consistent findings. Greer highlights that an increasingly substantial literature suggest that adoption and utilisation may be at best tenuously related - hence our interest in this review to study both the adoption and assimilation phases of the diffusion process as it is only once an innovation has passed through both of these stages that the full benefits from its application can be realised.

Writing from a human factors engineering perspective, Karsh (2004) reviews several literatures (technology acceptance, technology implementation, diffusion of innovations, organisational justice) - with no clear search strategy - to 'show that process design principles and guidelines exist which can be followed to reduce the likelihood of technology rejection and increase the likelihood of acceptance' (389). He reports that organisational factors that have been found to predict end user technology acceptance include:

- how well the new technology will be integrated with existing technologies, workflow, the environment and other social systems
- management commitment to the new technology
- the presence of a structured program for implementation (for example, a multidisciplinary transition team, structured communication networks)
- well-designed training programmes (which can increase self-efficacy and intrinsic motivation as well as heightening involvement)
- participation (which can improve end user job satisfaction and performance through motivational and cognitive processes)

Karsh provides a helpful critique of survey-based studies that employ 'satisfaction with technology' or 'technology acceptance/willingness to use' measures (for example the Technology Acceptance Model (TAM)), rather than measures of actual use: in some studies neither perceived ease of use or usefulness - the key determinants of acceptance according to the TAM - were predictive of behavioural intentions.

In seeking to draw lessons for implementation research in mental health settings, Kimberly et al, (2008) reviewed organisational measures related to the implementation

of new practices and technologies in other sectors ('implementation' here being defined as the 'steps required in order to ensure that the new practice or technology is both adopted and used by members of the organisation'). They identified four categories of variables that have been traditionally used when studying organisational influences on implementation (but unfortunately only focus on the first two in their overview):

- structure (where they draw on Damanpour's (1991) findings relating to 13 organisation level variables such as specialization and centralisation - see next section for an overview of this meta-analysis)
- organisation culture/climate (where they highlight generic instruments for measuring (a) organisational culture - such as Cameron & Quinn's (1999) *Organisational Culture Assessment Instrument* -and (b) organisational readiness for change - such as Lehman et als (2002) Organisational Readiness for Change (ORC)
- internal processes
- leadership

Although it is disappointing that this review did not go into detail regarding these latter two categories (which would have been of more value to this review) the authors wisely caution that:

'Organisational measures that are included in research designed to examine implementation should not just be taken off-the-shelf and plugged into a study, but carefully screened for their appropriateness and relevance … Assessment of the appropriateness of instruments in the context in which they be will used should be a necessary precursor to use. This involves more for the researcher than 'plug and play'.' (16)

Citing Pettigrew's and Van De Ven's work as exemplars, they strongly advocate the use of 'process research designs' for studying and understanding the organisational factors that influence the implementation of new practices and technologies, and cite five criteria for such research:

- flexibility of research approach (that is, it should be context-sensitive, multi-method and adaptable)
- longitudinal perspective
- focus on behaviour
- focus on the systemic nature of change
- provision of feedback to key stakeholders

Finally, Williams et al (2008), writing from a knowledge management perspective (and on behalf of the NHS Institute for Innovation & Improvement), examine the relationship between the role of knowledge-based interventions in technology adoption and options for knowledge-related improvement, and review the evidence on knowledge-related strategies for overcoming barriers to technology adoption. This 'review of reviews' draws the usual conclusion that barriers to technology adoption range from factors relating to the technologies themselves (and the individuals adopting them), to the organisational and structural contexts of adoption. Whilst emphasising that there is no knowledge-related 'magic bullet' that will trigger or facilitate technology adoption behaviour, the authors suggest that knowledge-related interventions to counter these barriers can be grouped under five headings:

- technology specification and assessment

- dissemination techniques
- electronic decision support tools
- networks and facilitated interaction
- skills and leadership development

The narrative summaries briefly reviewed above (and in appendix 3) provide a representative flavour of the 'state of the art' of research into technological adoption and assimilation processes in the healthcare context at various points in time over the last thirty years. Greer (1981) and Kimberly (2008) both emphasise the crucial importance of paying attention to context when considering what factors and processes may impact on the adoption and assimilation of innovations in healthcare organisations; and Anderson (2004) and Kimberly (2008) highlight the tendency for researchers in this area to conduct 'more of the same' research using 'validated' measures without due regard to seeking to explain the context in which they are being applied or the reasons for the (often inconsistent) results. Importantly, Greer (1981) - and to a lesser extent Karsh (2004) - also draws attention to a problem that remains common in much contemporary research; the assumption that once an innovation is adopted (or in Karsh's terms 'accepted') then it will naturally follow that that innovation will be successfully implemented and used.

In terms of *organisational antecedents of innovation* - the first of the two 'inner context' components in our original model - only the narrative reviews by Anderson (2004) and Kimberly (2008) identify structural determinants as being important (specifically identifying size and slack resources) whereas all of the reviews draw attention to the non-structural determinant of what we termed a 'receptive context for change' (highlighting especially cultural and leadership factors). Williams (2008), not surprisingly given that they are writing on the topic from a knowledge management perspective, recommend several interventions to increase the absorptive capacity for new knowledge, our other non-structural determinant. Factors within our second component - *organisational readiness for innovation* - were consistently mentioned with particular emphasis on interventions to encourage participation in the adoption and assimilation process (whether through facilitated networks or dissemination programmes) and the provision of dedicated time and resources (such as training programmes). Several factors raised in these reviews were however seemingly missing or insufficiently specified in our original components; for example, internal decision-making processes and strategy. We consider the implications of these findings for our model at the end of this section, after we have also described the findings from the 87 empirical studies we reviewed.

5.3 Empirical studies

5.3.1 Meta-analyses of size as an organisational determinants of innovativeness

None of the 5 meta-analyses reviewed below were exclusively focused on the adoption of technological innovations in healthcare organisations (i.e. the focus of this review) and most made no specific reference to the healthcare context at all; they are included as they provide a helpful overview to the findings from the vast number of deterministic studies that have reported on the association between size and 'innovativeness', mostly from other sectors and other countries, and which have raised many hypotheses that

have helped - and continue to help - to inform later, more qualitative and process-based, research.

In the 1990s Damanpour conducted three meta-analyses (1991, 1992, 1996) all addressing the adoption of innovations in organisations ('organisational innovativeness') as the dependent variable, and considering different organisational properties ('determinants') that might enhance or hinder the tendency to adopt. We extensively reviewed these three meta-analyses in our previous report (Greenhalgh et al, 2005). To summarise, the literature Damanpour reviewed strongly supports the notion that organisational size and complexity (that is, specialisation, functional differentiation and professional knowledge) is associated with innovativeness. However, this relationship is moderated by various factors and tends to be stronger in the service sector than in the commercial sector. The magnitude of the effect should be noted, however (the contribution to overall innovativeness score is of the order of 15 per cent). Furthermore, it should be noted that the primary studies reviewed by Damanpour do not show that size determines innovativeness.

Since publication of our previous review in 2005 two further relevant meta-analyses have been reported. The first of these is a deliberate replica of one of Damanpour's studies. Camisón-Zornosa (2004) explicitly set out to update Damanpour's (1992) study of the strength of association between organisational size and organisational innovativeness, and to delineate the role of various moderators of this association. Searching of electronic databases and hand searching of leading journals resulted in 52 primary studies (including 87 correlation coefficients). The findings confirmed a significant and positive correlation between size and innovation (albeit with a quite low average size effect - again, of again 15%). This updating of Damanpour's 12-year old meta-analysis provided evidence that the contradictory results found in previous studies (and highlighted subsequently by many commentators) were likely due to divergences in methods used to operationalise key variables[28]. Interestingly, this later analysis contradicted Damanpour's finding that size is less positively related with innovation in service firms than in industrial firms.

Lee et al (2006) conducted a similar meta-analysis to that of Camisón-Zornosa (2004) but focused specifically on the association between organisational size and IT innovation adoption (although again not limited to the healthcare sector). Through electronic searching of databases covering the period 1980-2004 they found 21 studies including 54 correlations of the size-IT adoption relationship. As with the studies described above Lee et al found a significant, positive relationship between organisational size and IT adoption, that was moderated by a number of key variables (again consistent with previous findings): type of innovation (product; process; mixed), type of adoption organisation (for-profit; non-for-profit), adoption stage (adoption; post-adoption), scope of size measure (firm; IS organisation) and type of size measure (personnel; non-personnel). Unlike Camisón-Zornosa (2004), Lee et al found that industry sector (manufacturing; service) was not a significant moderator of the size-adoption relationship. The authors then went further than either Damanpour or Camisón-Zornosa and speculated as to the implications of this research for practice. They suggested that:

[28] For example, 'size' has been variously measured in terms of: number of beds in hospitals (Kimberly & Evanisko, 1981), number of employees, number of students enrolled in a school (Baldridge & Burnham, 1975), sales volume and the wealth of an organisation (Camisón-Zornosa et al, 2004: 337).

- managers should be aware that the effect of their organisation's size on IT innovation adoption depends on the specific contexts under which the IT innovation is being adopted and on how size is measured
- managers need to strategize their approach to adopting an IT innovation based on various moderators specific to the innovation
- managers can use the results to predict the likelihood of the adoption of an IT innovation by analyzing moderators and by assessing the size of their organisation
- importantly, there is no one-size-fit-all relationship between organisational size and IT innovation adoption. In order to increase IT innovation adoption success, managers need to understand and effectively manage those important moderators before they make adoption decision[29]
- organisational size had different effects on IT innovation adoption, depending on the specific stages of the adoption process. While large organisations tend to have advantage in the early stages, they face critical challenges in the latter ones. As such, to achieve success, managers in large organisations should understand and effectively manage the later adoption stages.

The meta-analysis by Camisón-Zornosa et al (2004) highlights the difficulties in generalising from previous studies that have employed a wide range of ways of operationalising key variables under study (i.e. 'size'). As we noted (Greenhalgh et al, 2005), one important weakness of much of the literature covered by the studies included in these meta-analyses is the implicit assumption that the determinants of innovation can be treated as variables whose impact can be isolated and independently quantified. For example, empirical studies on organisational size implicitly assume that there is a 'size effect' that is worth measuring and which is to some extent generalisable. More recent theoretical work (House et al., 1995) and the more in-depth qualitative studies reviewed in the following two sections (for example, Fitzgerald et al., 2002; Champagne et al., 1991; Ferlie et al., 2000; Dopson et al., 2002) suggest that in reality the different determinants of organisational innovativeness interact in a complex way with one another.

The implications of these 5 meta-analyses for the 'inner context' component of our original model is, put simply, that larger organisations generally adopt more innovations - including IT innovations - than smaller ones. Both the later Camisón-Zornosa et al (2004) and Lee et al (2006) studies contradicted Damanpour's earlier finding that size is less positively related with innovation in service firms than in industrial firms. However, perhaps most importantly, Lee et al found that only the non-for profit organisation subgroup showed a non-significant effect while all other subgroups showed positive effects.

5.3.2 Systematic reviews of adoption of innovations

We found seven systematic reviews relevant to our research objective, none of which were included in our original review. Two are particularly wide-ranging in scope - Fleuren et al, 2004; Rye & Kimberly, 2007 - and so we firstly provide detailed descriptions of these, before summarising the main findings from the remaining 5 reviews.

[29] for example, it is important to distinguish adoption decisions regarding IT process innovations from those for IT product innovations, as while organisational size does not affect IT product innovations, managers must recognize the advantages and disadvantages of their size in the adoption of IT process innovation

Fleuren et al (2004) undertook a systematic literature review of 11 electronic databases covering the period 1990 and 2000, and supplemented this with a Delphi study with 44 'implementation experts' to achieve consensus on the determinants of innovations in healthcare identified from their review. Although the authors initially propose the traditional definition of an 'innovation' ('an idea, practice, or object that is perceived as new by an individual or other unit of adoption, (Rogers, 1995)), the inclusion criteria for the review included 'studies in which the innovations were aimed at changing the behaviour of health professionals (e.g. guidelines)' (109), and 1,963 abstracts were excluded either 'because no determinants were reported, or because the innovation was not aimed at changing health professional behaviour' (111). This would suggest that the review was not concerned with technological innovations but rather solely with the implementation of clinical protocols and guidelines. However, given that such protocols and guidelines increasingly have a significant technological component and that the review was focused on the healthcare context, we have included the review here (albeit with reservations as to how directly applicable the findings are to our specific research question).

Fifty-seven studies met the inclusion criteria and 49 determinants were identified that either impeded or facilitated the innovation process. One final determinant was identified through the Delphi survey. Of the 50 determinants, 12 were 'related to the organisation'[30] and identified as having either facilitating or impeding effects on the innovation process, or both (table 5):

Table 5. Description of the determinants related to the organisation and the nature of their influence

Determinant	Facilitating	Impeding
Decision-making process and procedures in the organisation: top-down or bottom-up/participatory	Centralised and decentralised	*No studies*
Hierarchical structure: extent to which decision-making process is formalised through hierarchical procedures	High formalisation	Low formalisation
Formal reinforcement by management to integrate innovation into organisational policies	Formal reinforcement	No formal reinforcement
Organisational size (number of employees): large, medium, small	*No consensus*	
Functional structure (task oriented) versus product structure (output oriented)	Task oriented	Output oriented
Relationship with other departments or organisations: introvert or outreaching	*No consensus*	
Nature of the collaboration between departments involved in the innovation	Good collaboration	Poor collaboration
Staff turnover: high, average, low	Medium turnover	High turnover
Degree of staff capacity in the organisation or department that implements the innovation	Complete	Incomplete
Available expertise, in relation to the innovation in the organisation or department	Much expertise	Little expertise
Logistical procedures related to the innovation, e.g. logistical problems in scheduling patients	Well arranged	Badly arranged
Number of potential users to be reached: many, few	Few	*No studies*

[30] Six of the remaining 38 determinants were related to the *socio-political context*, 15 to the *adopting person/user/health professional*, 9 to the *innovation* and 8 to *facilities needed to implement the innovation*.

Source: adapted from Fleuren, 2004

Of relevance to our conceptualisation of the 'inner context' in our earlier review, another of the categories used to classify the determinants by Fleuren et al was 'facilities needed to implement the innovation'. Determinants within this category included:

- financial resources needed to implement the innovation
- reimbursement for health professionals/organisations to facilitate extra efforts in applying the innovation
- other resources made available for implementing the innovation (e.g. equipment, manuals)
- administrative support available to the users (health professionals) of the implementation
- time available to implement the innovation
- availability of staff responsible for coordinating implementation in the organisation/department
- health professionals are involved in the development of the innovation
- opinion leaders who influences opinion of others in the organisation or department (not the co-ordinator)

Many of these determinants map onto dimensions we included as part of the 'organisational readiness for innovation' component of the 'inner context' (which included, for example, dedicated time and resources and support and advocacy). Similarly, the determinants 'related to the organisation' within Fleuren et al's framework (table 7) are very similar to those in our 'organisational antecedents for innovation' component (for example, formalisation, decentralisation and size). We draw these comparisons simply to highlight the importance not only of paying attention to (a) pre-existing conditions that encourage innovation adoption generally, but also of (b) interventions and conditions that facilitate the adoption and assimilation of specific innovations into an organisation at a certain point in time.

Strikingly, Fleuren et al report that 'although, in many studies, one or more innovation strategies were applied, none were based on a theory (theoretical methods for change)' (120), echoing others (for example, Anderson et al, 2004; Rye & Kimberly, 2007) that studies of innovation adoption and assimilation (both within and outside the healthcare sector) remain largely atheoretical. Finally, another important observation that has again been raised by others (for example, Greer, 1981) is that 'the degree of implementation was assessed in different ways[31] … this means that the degree of implementation and the association with particular determinants depend on the operationalisation of implementation'. (120-121)

Rye & Kimberly, (2007) recently completed a systematic review with a broadly similar focus to this review (namely 'on provider organisations [in healthcare] and the adoption

[31] For example, level of use (non-use, full use, adapted use); completeness of use (applied proportion of recommended activities); frequency of use (number of times used); intensity of use (number of people who use innovation); and duration of use.

stage of the diffusion process' (237)). However, there are a number of significant differences between the two reviews to bear in mind:

- Rye & Kimberly's review covers 'administrative' as well as all types of 'clinical' innovations (including pharmaceuticals), whereas this review focuses solely on non-pharmaceutical technological innovations
- Rye & Kimberly's review does not aim to derive lessons for practitioners or policymakers (as this ones does) but rather to 'offer a number of recommendations for theory and research design' (237)
- Rye & Kimberly define organisational adoption as 'the discrete organisational decision to accept or reject an innovation … by using the phrase 'discrete organisational decision' we mean to focus our review on studies that examine adoption as a relatively distinct organisational event'; this review conceptualises the process of 'adoption' in a different way
- partly due to the differences above, Rye & Kimberly's review is based on a significantly different search strategy[32] (and one that is applied to different electronic databases)

In total 55 studies were included in this review. Of these 55 studies, 28 were outside the scope of this review[33] (see appendix 2 for details of excluded studies). The remaining studies (Denis et al, 2002; Fendrick et al, 1994; Ferlie et al, 2005; Friedman, 2000; Goes, 1997; Greer, 1984; Kaluzny, 1974; Kimberly, 1978; Kimberly, 1981; Knudsen & Roman, 2004; Meyer & Goes, 1988; Moch & Morse, 1977; Nathanson & Morlock, 1980; Nystrom et al, 2002; Poulsen et al, 2001; Robertson & Wind, 1980; Robertson & Wind, 1983; Sloan et al, 1986; Teplensky et al, 1995; Wang et al, 2005) are included in this review; six of these were published after the year 2000 and only one was a study based in the NHS (Ferlie et al, 2005). Based on these 55 studies, an organising framework for the theoretical ideas was developed to represent 'a road map of what previous researchers have explored' (table 6):

[32] Search strategy: (1) searched PubMed (1960-June 2005) and used 3 MeSH terms ('diffusion of innovation'; 'organizational innovation'; 'information dissemination') and then searched abstracts of 'hits'; (2) citations from five literature reviews that included organisational innovation adoption (including Greenhalgh et al, 2005); (3) searched references of all papers found through 1 and 2. Inclusion criteria were: at least one level of analysis was at the organisational level; had to be empirical; innovation(s) had to be developed outside of organisation; one dependent variable had to be adoption or disengagement from an innovation or innovations; and organisation studied had to be a healthcare provider.

[33] 13 of these 28 studies largely related to the adoption of a non-technological innovation, 6 focused on environmental or contextual factors effecting adoption, 3 related to a 1964-1967 study in which it was unclear whether technological innovations were the focus of study, 2 did not consider organisational factors or processes, 1 related to a 1969 study with the same limitation, 1 related to the diffusion of a technology across the healthcare sector, 1 related to the 'de-adoption' of an innovation, 1 was a narrative review from 1973 and 1 study could not be retrieved.

Table 6. Framework of theoretical ideas in existing research

Environmental influences	Connectedness	Organisational attributes	Innovation characteristics
– demand – competition – regulation – other characteristics of location	– connections between organisations – connections between organisational actors	– organisational structure – individuals and collectivities within organisations – organisational learning, climate and attitudes – resources available for innovation – strategic positioning	– benefits of innovation – costs of innovation – usage characteristics

Source: Rye & Kimberly, 2007

These four categories (environmental influences; connectedness; organisational attributes; and innovation characteristics), 'constitute - at a highly abstract level - a comprehensive set of influences on adoption'. The authors state that '[t]his body of research [on organisational attributes] examines how internal characteristics, resources, motivations, and coalitions act on organisational innovation adoption behaviour' (248), i.e. their concept of 'organisational attributes' is what we termed the 'inner context' in our earlier review and is the focus of our current review. Indeed, our earlier review is cited as one of a number of previous studies that have provided conceptual models proposing similar classifications.

Within the 'organisational attributes' category, the review identifies five concepts each comprising several constructs and provides a brief summary of the evidence for each (table 7). It should be noted that most of the associations shown in table 7 are derived from either only one or a small number of studies:

Table 7. Organisational attributes: concepts, constructs and evidence of associations

Concept	Constructs	Summary of Evidence of association with innovative behaviour
Organisational structure	centralisation; formalisation; functional differentiation; professionalism; specialisation; complexity; internal communication; size; age; type of organisation	*Positive association*: greater professionalism, internal communication and organisational age *Usually positive association*: greater specialisation, complexity and size *Negative association*: greater centralisation and formalisation *Mixed association*: functional differentiation
Strategic positioning	market strategies	Positive association: market and technology strategies (for example: price competitive; technology leader)
Individuals and collectivities within organisations	values, attitudes and involvement of leaders; tenure and experience of executives; executive educational background; executive age;	Inconsistent effect but believed to be *positively associated*: higher constituency involvement and support for an innovation, elite and organisational cosmopolitanism, and elite change values (see text below table)
Resources available for innovation	cost position and management; slack resources; insurance arrangements	*Positive association*: greater slack, high costs (cost-reducing technologies), actual and expected patients with generous insurance
Organisational learning, climate and attitudes	learning; climate; attitudes	*Positive association*: hospital perceived to be meeting community needs, perceived community reputation, 'local' administrator/'cosmopolitan' professional

Source: adapted from Rye & Kimberly, 2007

It is suggested that the effect of characteristics of *individuals and collectivities within organisations* are dependent upon the combination of:

- which organisational actors (and in which combination of consensus and conflict) are differentially involved, are cosmopolitan and hold change values
- the type of organisation in which such combinations of involvement, attitudes, and values take place, and
- the type of innovations that are being researched.

In relation to these 'combinations', Rye & Kimberly (2007) suggest that:

'Qualitative studies in our sample have particularly thorough treatments of the properties of individuals and collectivities. For example, Denis et al, (2002) emphasize the importance of the interests, values and power distribution of the adopting system on the ultimate adoption of innovation. Greer (1985, 1986) describes how different decision systems, or combinations of decision-making activity within organisations influence adoption. Finally, among other findings, Weiner et al (2004) show how enterprising CIOs or small clinician groups, instead of senior managers, often lead adoption decision-making processes for CIS in integrated delivery systems.' (250-251).

We review the 3 studies cited above, and an additional 30 similar process-based studies, in section 5.3.3 below.

Overall, Rye & Kimberly (2007: 254) suggest that:

‘ … despite much effort, we still do not know as much as we would like, and what we do know, we may not know for sure … We have no widely accepted theory of innovation adoption in organisations, and this along with other empirical problems frustrates our efforts to make sense of the empirical results. Also, the complexity of the adoption of innovations is rarely appreciated in the theoretical models that do exist, and studies of interactions between constructs at similar and different levels of analysis are rare though essential to our understanding of the phenomenon.’

Helpfully, Kimberly & Rye also present analysis of the 55 studies they reviewed in terms of how many examined constructs from more than one of the four research categories. They found that many studies explored particular categories of research in ‘total or near isolation. Thus the relative contribution of different categories and the importance of potential linkages between categories were impossible to ascertain’. They also highlight that ‘only a handful of quantitative studies explore theoretically or empirically driven interactions between types of influences at any level’. In summary, they conclude (in keeping with our own earlier review):

‘Examining the adoption and diffusion of organisational innovation in healthcare is a complex problem, and thus, it is unfortunate that so few studies have taken this complexity into account. We believe that some correlates in all categories are important and will continue to be so in a middle range theory of adoption based on organisational decision making. Considering only one or two major theoretical categories or a small number of concepts/constructs within each theoretical category – or both – leaves the analyst with incomplete theoretical and empirical models.’ (260)

We discuss the implications of these findings for future research in the final section of this review.

Of the five remaining systematic reviews, the first by England (2000) - which did not present a clear search strategy or report on inclusion/exclusion criteria and had insufficient detail of the studies included in their analysis - drew largely on mass communication theory (e.g. Rogers) and explored the adoption and implementation of IT in healthcare organisations by means of a review of ‘organisational variables’ (leader characteristics; internal characteristics; external characteristics) and ‘technological variables’ that impact on diffusion of innovations. In terms of organisational variables in healthcare organisations, they suggest that the formalisation which exists for patient safety, the reduction of organisational slack, strong professional alignments and the centralisation of control of major IT all act to reduce the rate of innovation.

Kukafka et al (2003) conducted a review of IT use behaviour (not exclusively in healthcare organisations) in order to plan multi-level interventions to enhance IT use, adopting a hierarchy of evidence approach (with randomised trials seen as ‘best evidence’); 24 of 142 references retrieved met their inclusion criteria. They found that 61% of studies mentioned theory but none considered two or more levels and concluded therefore that studies typically omit two fundamental propositions: (1) IT usage is influenced by multiple factors, and (2) interventions must be multi-dimensional.

Lansisalmi et al (2006) conducted a systematic review of electronic databases to help summarise the evidence regarding conditions and factors facilitating and inhibiting innovations in healthcare. Of 704 studies identified only 31 were empirical studies, in

peer-reviewed international journals on the topic of generation, adoption or diffusion of innovations, or determinants of innovativeness in healthcare organisations. The majority of the included studies were cross-sectional designs applying quantitative methods, or multiple case studies applying qualitative methods. Sixty-two per cent of the studies were replication-extension in orientation while only 19% were derived from real-world problems; 19% were based on theoretical frameworks. Regarding internal organisational factors facilitating or inhibiting innovation, the results indicated that strong leadership, shared and clear objectives, task orientation, participative safety, reflective team practises, active internal marketing, correct timing, motivation and participation of personnel, lack of stress and sufficient resources all seem to be positively related to innovation in healthcare organisations. The review identified leadership and leader behaviour as a complex issue in innovation research, as well as five 'pathways' for future research (which we discuss in the final section of this review).

Lu et al (2005) conducted a review on Medline specifically focused on the adoption of handheld computers or personal digital assistants (PDAs) in healthcare. They used Davis's Technology Acceptance Model as a reviewing framework for the 95 papers they retrieved and organised the results in terms of (a) system characteristics, (b) benefits, (c) adoption, and (d) barriers. Major barriers to adoption were identified as usability, security concerns and lack of technical and organisational support (the latter based on the findings from just one empirical study).

Finally, Yusof et al (2007) carried out a systematic review - using the 'Human, Organisation and Technology-fit' evaluation framework - to determine dominant factors influencing healthcare information systems adoption. They only included case studies of the adoption of health information systems and explicitly excluded other study designs (such as surveys). 55 studies were included and, as well as the fit between the human, organisation and technology factors, specific critical adoption factors related to the organisation were: leadership and support (more than half of the case studies reviewed cited specific individuals in both leadership and support positions as one of the most important factors), clinical process (the ability of the system to fir with clinical practices), user involvement, internal communication and resources. It should be noted that these 'critical adoption factors' were identified by a simple count of their occurrences on the reviewed studies.

Although the scope of the review conducted by Fleuren et al (2004) is, as noted, not the same as in this review, the division made between determinants 'related to the organisation' and those 'related to facilities needed to implement the innovation' mirror the two components of our 'inner context': organisational antecedents for innovation and organisational readiness for innovation. However, the nature of the innovations under study by Fleuren et al (clinical guidelines and protocols) would appear to have led to some findings contradictory to those derived from studies of service delivery and technological innovations, such as Rye & Kimberly (2007). For example, whilst Fleuren et al see 'formalisation' ('extent to which decision-making process is formalised through hierarchical procedures') as being a facilitating factor, Rye & Kimberly see it as being negatively associated with innovation. This contrast between the findings of these two systematic reviews serves to reinforce the need for caution when generalising not only between types of innovation but also across sectors.

Given the deliberate and specific focus on the adoption 'decision' (rather than 'process' or assimilation/implementation of an innovation) in Rye & Kimberly's (2007) review it is not surprising that the constructs they identified in their 'organisational attributes' category only relate to what we termed 'organisational antecedents for innovation' (and Fleuren et

al termed 'determinants related to the organisation'). By choosing not to extend their analysis beyond the 'decision to adopt', Kimberly & Rye exclude consideration of factors that facilitate or impede successful assimilation/implementation of an innovation. In our concluding section to this review we draw together the various frameworks described above and provide a revised version of the 'inner context' component of our model of the diffusion and spread of innovations in healthcare organisations. Lansisalmi et al (2006) was the most relevant and helpful of the remaining 5 reviews we included; their analysis of the limitations of the existing evidence-based was consistent with many of the other papers we have reviewed (for example, the inadequacy of cross-sectional questionnaire studies, and the need for more processual research designs incorporating a multi-level perspective). Similarly, the recommendations for future research made by both Fleuren et al (2004) and Rye & Kimberly (2007) largely echo our own findings; these are all discussed in the final section of this review.

5.3.3 Processual studies

Processual studies in the NHS

Processual studies focus on dynamic behaviour within organisations, researching organisational context, activity and actions which unfold over time (Pettigrew, 1990). In this regard, leading US researchers have noted that, 'Some of the most highly visible and innovative work on the effect of organisational variables on change in healthcare organisations has come from a group of researchers in UK. In the British health services literature, there are numerous qualitative interview-based assessments'[34] (Kimberly & Cook, 2008: 17). Perhaps illustrating this, of the 13 NHS-based empirical studies retrieved for this review, 85% (11) were process-based studies whereas for empirical studies undertaken in other healthcare systems this figure fell to only 31% (23/75). We begin our review of these NHS-based processual studies of technological adoption and assimilation with 4 related studies (Ferlie et al, 2000; Ferlie et al, 2005; Fitzgerald et al, 2002; Fitzgerald et al, 2003).

In the first two of four related papers, Ferlie et al (2000; 2005) studied the 'careers' of a total of eight innovations in the NHS, two of which we would define as being largely technological innovations (the remaining six being either pharmaceutical technologies or innovations in service and delivery). Figure 11 summarise these two technological innovations. The study sought to explain barriers to the spread of innovation in multi-professional settings like healthcare. The design had two stages: in the first stage, factors affecting the career of the selected innovations across an NHS region were assessed through 144 interviews with opinion leaders in three professional groups (clinicians in public health, nursing and physiotherapy). In the second stage, micro-system case studies were undertaken in four hospitals involving 88 interviews with doctors, nurses and allied health professional, and secondary data collection.

[34] Citing in particular Pettigrew, Ferlie & McKee's (1992) work.

Figure 11. Summary of technological case studies (Ferlie et al, 2000; 2005)

Managing anticoagulation service provision with a computer support system

The introduction of a new computer-supported system to manage the delivery of oral anticoagulants to potential stroke victims was the third acute care innovation studied. A common cause of death in the United Kingdom for which people with high blood pressure are at risk, stroke can be prevented by oral anticoagulants, drugs that prevent blood clots. There is a strong evidence base to support such treatments. Presently, therapy is delivered through pressed hospital clinics run by interns, who often do not provide expert service. Technological advances in testing suggest that this service could be devolved to primary care, where it would be led by a senior nurse rather than by a doctor and supported by a diagnostic computer program. Patients, who can be monitored in local and userfriendly settings when this innovation is adopted, have welcomed it.

Minimal access surgery for inguinal hernia repair

The very common inguinal hernia, in which organs of the stomach extrude through the abdominal lining, has traditionally been repaired with a radical surgery, a laparotomy, involving a ten-centimeter incision. Standard repairs can have poor results, especially in the hands of interns. From the late 1980s, less invasive laparoscopic ('closed' or 'keyhole') surgical techniques have been used for inguinal hernia repairs. At the time of our data collection, evidence for the value of the use of laparoscopic surgery for inguinal hernia repair was still developing, and few RCTs had been conducted. Surgeons are the key professional group involved in the potential use of this innovation.

Source: adapted from Ferlie et al, 2005

Table 8 presents an overview of the findings relating to the two technological innovations from the two papers with respect to:

- evidence for the medical value of an innovation (judged on the basis of results from randomised controlled trials (RCTs) and advice
- innovation complexity; calculated in terms of number of organisations and occupational groups involved
- intergroup issues needing to be resolved before the innovations could spread
- assessment of the change outcomes at end of fieldwork
- key features of each change issue

Table 8. Technological innovations studied by Ferlie et al (2000; 2005)

Technology	Scientific evidence	Stakeholders; professional groups involved	Is argument within and/or between professionals? Is there an active or passive debate around the research base	Change outcome	Issue characteristics
Laparoscopic inguinal hernia repair	Weaker	One focal stakeholder; general surgeons	Within professions Low-level debate due to weak research base	Debated and some spread	Uni-disciplinary; a rapidly emerging technology; different camps; scientific contest; 'action-led'
Managing anticoagulation service provision with a computer support system	Stronger	Range of stakeholders; cardiologists, primary care doctors, practice nurses, computer system designers, health service researchers, regional R & D	Between professions Active debates between researchers/practitioners and between RCTs and health service researchers	Pilot	Multi-disciplinary; cross-sectoral; role and technology change; time-limited support through research project

Across all the eight innovations studied 'complex, contested and nonlinear innovation careers emerged'. Only in the case of aspirin for prevention of secondary cardiac incidents was 'spread assessed as wide' by the research team; more generally the research found that 'professional groupings retained a key role in decision-making. Proposals for change driven from outside did not influence local clinical groups in which much discretion resided[35]. The learning and change capability of these groups was shaped by prior history and their pattern of roles and relationships' (Ferlie et al, 2000: 100). The authors argued that social and cognitive boundaries between different boundaries slowed spread, as individual professionals operate within uni-disciplinary communities of practice. The findings therefore confirmed nonlinear models of innovation (Van de Ven et al, 1999) and highlighted multi-professionalisation within and between healthcare organisations as a barrier to spread[36] (in contrast to the conventional theory in which high professionalisation is seen as enhancing innovation spread[37]).

Fitzgerald et al (2002) drawing on qualitative data from the same eight case studies in the NHS (two of which were largely technological as mentioned above), focus on three aspects of diffusion and adoption processes:

[35] These findings are similar to Denis et als (2002) study in Canada, showing that the interests, power and values of actors in an adopting hospital affect their interpretation of science, although Ferlie et al note that their study did not consider issues of differing access to power.

[36] Interestingly, one of the technological innovations - laparoscopic inguinal hernia surgery - was a 'deviant' case in the analysis of the eight innovations under study. This potential adoption involved only one professional group with no important boundaries and yet it was slow to diffuse (as adoption was followed by 'unadoption'). Ferlie et al suggest that this was the result of change in research and experience base, arguing that early over adoption took place in advance of good evidence, and difficulties and reservations accumulated slowly (i.e. this technological innovation was not as evidence-based as initially thought, so limited adoption was indeed indicated).

[37] For example, Damanpour's (1991) meta-analysis found a positive and significant relationship between 'professionalisation' (professional knowledge of organisational members) and organisational innovation.

- the role of certain forms of knowledge in the process of adoption and diffusion
- the nature of adoption decisions
- influence of differing contexts on the diffusion process

The most significant finding in the context of this review - related to the second of these aspects - was that there is no single, all-or-none adoption decision:

'the research data do not support the idea of a single adoption decision, but rather a more prolonged and negotiated process between individuals and groups … adoption decisions involve active, not passive adopters, with interaction between actors and innovations and between groups of actors. With multiple professional groups, these interactions assume far greater importance than would be predicted from the extant literature'. (1441, 1444)

The authors also concluded that the nature of diffusion is highly interactive, influenced by interplay of (a) credibility of evidence (b) characteristics of multiple groups of actors; (c) features of the organisation; and (d) context , although they did note that 'one common theme across the sectors and the different specialisms was the prime influence exercised by the medical profession in the decisions to adopt an innovation at local level'. (1440).

Fitzgerald et al (2003) in the fourth and final related study reviewed here, explored in greater depth the four of the eight innovations that that were adopted in a primary care setting. We include the study in this review as - although none of the 4 innovations under study had a significant non-pharmaceutical technological component – the results demonstrated 'that primary care must be conceived of as an organisational form that has dramatically different characteristics to those of the acute sector'. Consequently, when formulating policy and practice-based recommendations to encourage the adoption of beneficial technologies it should not be assumed that the effective management of change will be the same as in the acute hospital sector (where traditionally most adoption research has taken place).

Mantzana & Theristocleous (2005) conducted 16 interviews in a single case study of the adoption of Enterprise Application Integration (EAI) technology to develop an integrated IT infrastructure in a single case-study of an acute specialist NHS Trust. Although the authors claim that their study involved a novel approach that (a) identifies the healthcare actors that are involved in the EAI adoption process, and (b) combines these actors with the factors influencing the adoption of EAI, the research as reported appears of relatively poor quality and the analysis is somewhat simplistic. Nonetheless, the research was at least actor-centred, identifying sixteen 'healthcare actors' involved in the adoption process and categorised each as either 'acceptors' (patients; next of kin), 'providers' (clinicians, non-clinicians, clinical – students, hospitals, medical clinics), 'supporters' (administrators, legal professionals, researchers, suppliers, technologists, insurance companies) and 'controllers' (managers, government, health authorities). The authors then combined these 16 actors with 14 'adoption factors' derived from two previous models of EAI adoption[38] (Themistocleous, 2002; 2004; Khoumbati et al, 2003) to develop what they present as a 'validated framework of actors and factors that affect EAI adoption in healthcare'.

[38] These factors were: cost; barriers; benefits; support; internal pressures; external pressures; IT infrastructure; IT sophistication; evaluation of integration technologies; packages assessment framework; readiness of organisation; telemedicine; clinical support; and patient satisfaction.

Of greater substance and interest, May et al (2003) draw together the findings of three separate studies of the 'normalisation' of telehealthcare in 11 sites in the United Kingdom. The authors define 'normalisation' as the 'take-up or local reinvention of an innovation in highly contextualised settings' where the technology becomes 'one of the normal arms of clinical practice' (and therefore relates to the final phase of Meyer & Goes (1988) definition of 'assimilation' – 'comes to fruition in the innovation's full acceptance, utilization and institutionalization.') Based on observational data and semi-structured interviews (totalling approximately 582 discrete data collection episodes) the authors adopt a process-oriented approach, and argue that a rationalised linear diffusion model of 'telehealthcare' is inadequate in assessing the potential for normalization; rather, the political, organisational, and 'ownership' problems that govern the process of development, implementation, and normalization need to be accounted for. The study presents a model for assessing the potential for successful implementation of telehealthcare services which defines the requirements for the successful 'normalization' of telemedicine systems in clinical practice, and is based on four propositions:

- implementation of telemedicine services depends on a positive link with a (local or national) policy level sponsor, so that telemedicine is defined as an appropriate means of delivering care, and appropriate infrastructures are developed
- adoption of telemedicine systems in service depends on successful integration at the level of structural legitimation so that it is supported as, and thus practically incorporated into, healthcare delivery through the development of organisational structures
- translation of telemedicine technologies into clinical practice depends on the enrolment of heterogenous actors into relatively cohesive, cooperative groups, in which functional identities are negotiated and established a priori and powers relatively well defined
- stabilization of telemedicine systems in practice depends on integration at the level of professional knowledge and practice, where clinicians are able to accommodate telemedicine in their clinical activities through the development of new procedures and protocols.

The authors argue that the normalization of telemedicine as a means of healthcare delivery (in whatever setting and at whatever level of healthcare provision) is conditional on all four of these propositions.

Rosen & Mays (1998) studied three technologies (vascular stenting, triple test screening and excimer laser) in three NHS hospitals in three health authority sites (selected to include adopting and non-adopting hospitals and teaching and non-teaching hospitals) by means of retrospective case studies of decision-making processes and involving 51 semi-structured interviews with those involved with introduction of the technologies. The main research question was whether the purchaser-provide split in the NHS was contributing to 'rational' technology diffusion. Of direct relevance to this review, the study found that clinicians were the main advocates for new technologies and decisions about introducing the technologies were made within hospitals unless additional funding was required. Decisions not to adopt the triple-test (in two sites) and to start using vascular stents (in one site) were made by clinician-only groups. These decisions were made through informal discussions and influenced by previous personal experience of using the technology and advice from colleagues. If money or resources were explicitly required then the decision-making group inevitably expanded to include a wider group of clinical and non-clinical managers. Style, membership and level of authority of decision-making

groups varied; for example, in one hospital an 11-page business case was submitted for the ultrasound scanner needed to offer the alternative Down's screening test and this was then scrutinised by members of two committees whilst, in contrast, in a teaching hospital with a highly decentralised management structure a decision to introduce the excimer laser was made at clinical directorate level and 'rubber stamped' by senior managers. Exception to within-hospital decision-making was seen in a district general hospital where greater emphasis was placed on the need to justify new technology in terms of clinical appropriateness; this hospital had established an in-hospital clinical evaluation unit. The findings suggested that a short-term view is taken of the clinical and organisational impact of new technologies in hospitals; this is consistent with findings from the US (Weingart, 1993) and Greer's (1984) 'fiscal-managerial' emphasis of within-hospital decision-making. Consistent with other NHS-based process studies, this study supports the central role of clinicians in advocating and deciding upon adoption.

Timmons (2001) explored perceived barriers to the use of a new computer system by nurses (a computerised care-planning system) in three UK hospitals by means of 31 semi-structured interviews. He found that a wide range of tactics was employed by nurses, aimed at ensuring non-adoption. These actions were explained in terms of internal power relations and the meaning of the system for staff. Of interest to this review are the notion of 'resistive compliance' and the importance of understanding resistance to the adoption of technological innovations as part of the longer-term assimilation process. Although the technology in this study was 'successfully implemented' in the eyes of hospital managers, resistance to using the computer system persisted long after in the shape of attempts to put off or 'minimise' their use, thereby emphasising the importance of studying both the adoption and assimilation process.

Wainwright & Waring (2007) studied innovations in information systems in general medical practice in the NHS by means of semi-structured interviews with a core set of staff (GP, practice manager and practice nurse) in five general practices in the north of England. A particular focus - of relevance to this review - was on the political processes relating to ICT adoption and assimilation within the contemporary NHS context. The study explicitly tested four adaptations of diffusion of innovations (DOI) theory[39] in order to identify a pragmatic, relevant and rigorous conceptual framework that may be used to explain the complex issues arising from the adoption and assimilation of IS within small healthcare practices. Of the four adaptations the most interesting for this review is that of Gallivan (2001) as it specifically focused on the 'organisational adoption and assimilation' of (IT) innovations. Developed specifically to be used in the context where initial organisational adoption is driven by management mandate, this model explores both the role of primary authority (the mandate) and secondary (user) adoption decisions (see figure 12). Overall, the findings from retrospectively applying the four models to the case study of IS innovations in the English primary care setting once again highlight the high level of politics influencing the adoption and diffusion process. The

[39] These were: (1) Kautz & Larsen's (2000) adaptation of the original DOI framework by Rogers (1995); (2) Baskerville & Pries-Heje's (2001) application of three innovation diffusion models (the interactive model; the linked-chain model; and the emergent model); (3) Gallivan's (2001) development of a new framework based on traditional individual adoption frameworks combined with process and stage models; and (4) Mustonen-Ollila & Lyytinen's (2003) identification of 28 attributes impacting on the likelihood of adopting an innovation, incorporating 9 'organisational' factors (interpersonal networks; peer networks; informal communication; technological experience; working teams; opinion leaders and change agents; interdependence from others; adopter type; and management hierarchy).

authors suggest that Gallivan's (2001) detailed model (figure 13) in particular could provide insights into these power, political, cultural and organisational issues.

Figure 12. The process of contingent authority innovation adoption in organisations (Gallivan, 2001: 53)

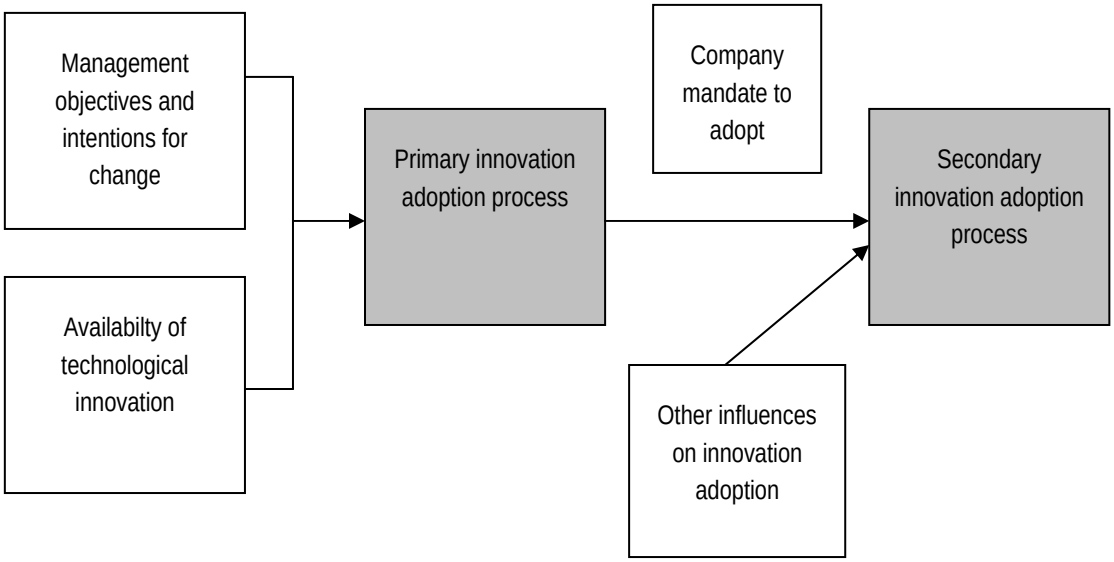
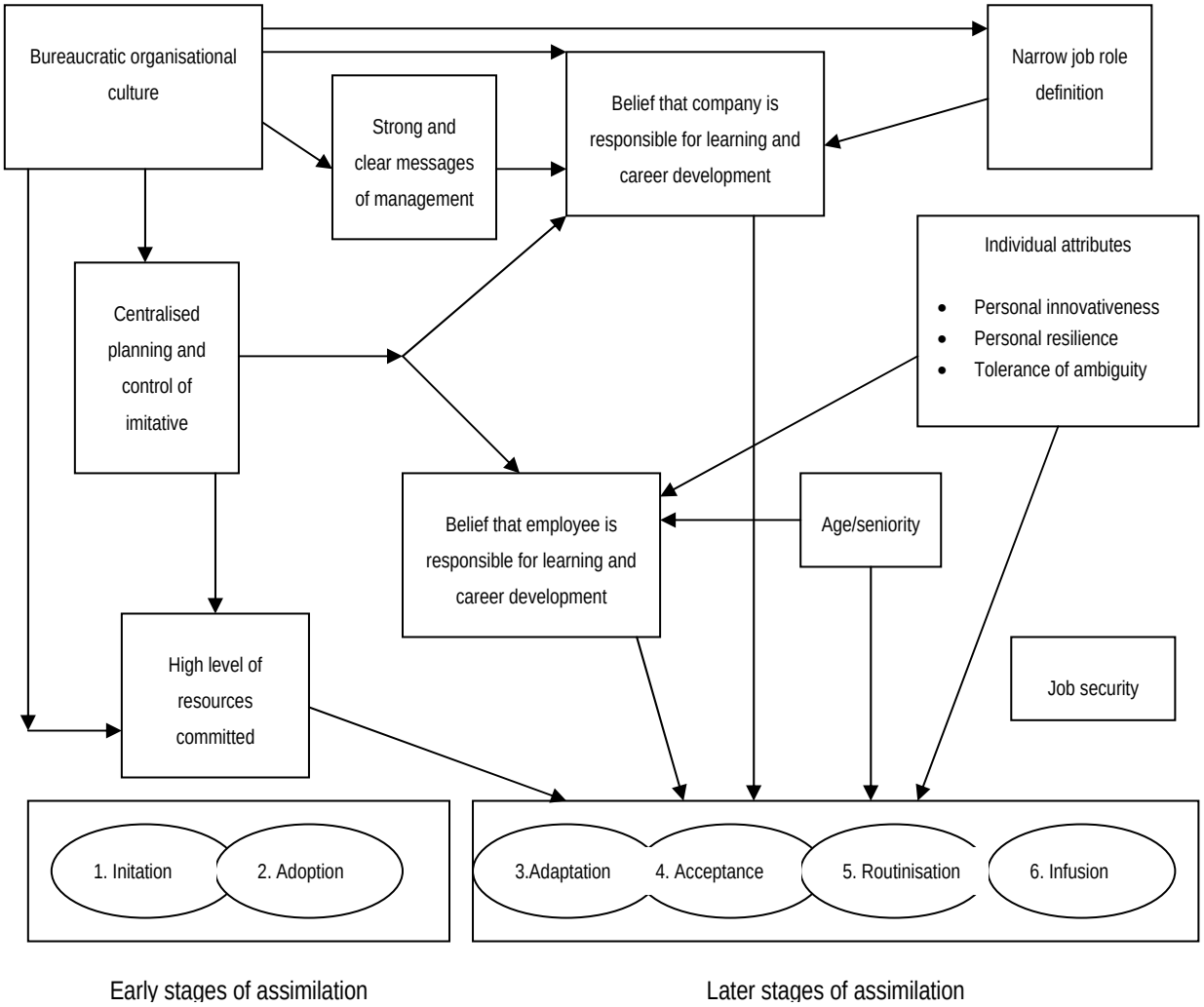


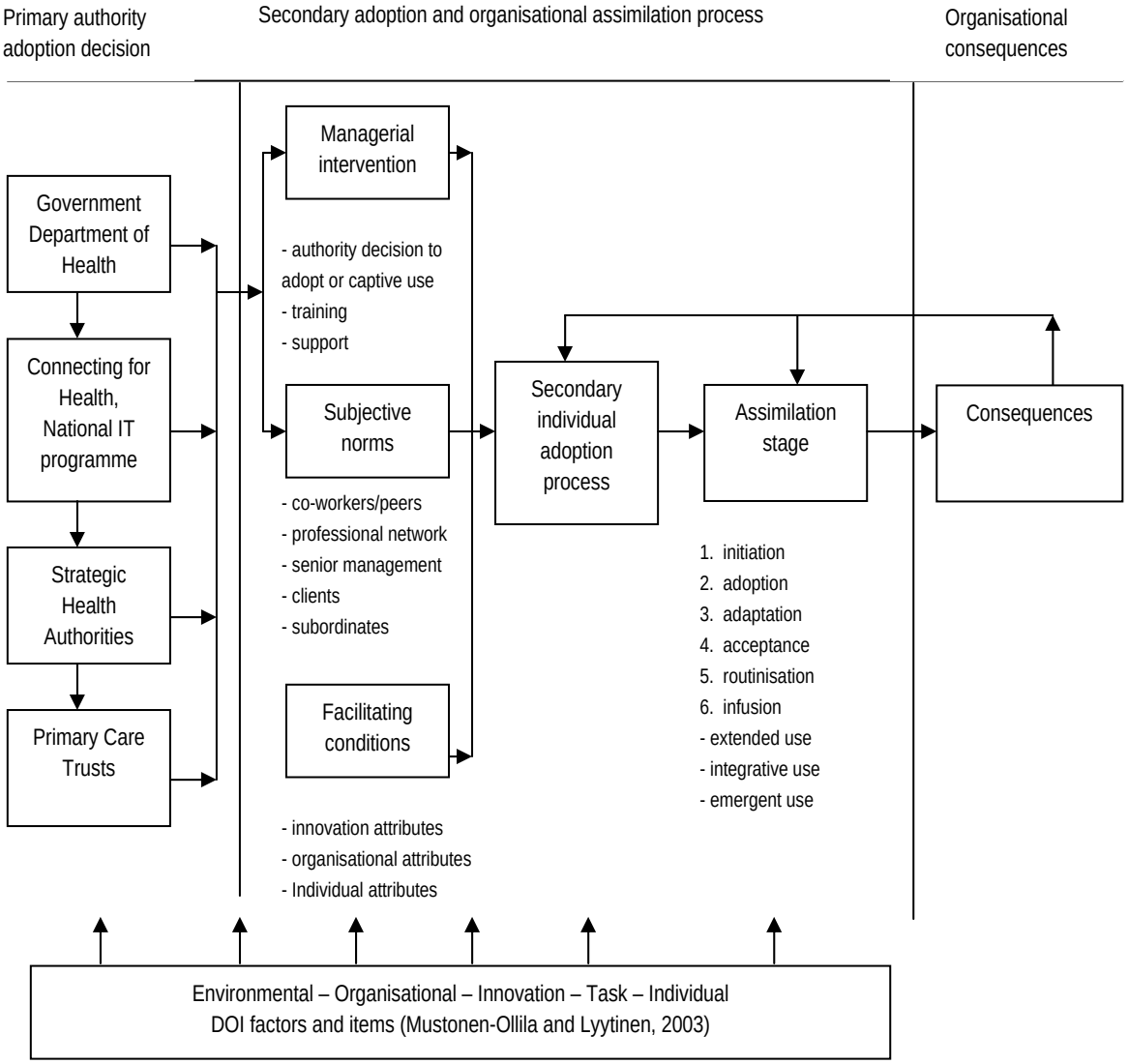
Figure 13. Detailed model (adapted from Gallivan, 2001: 79)



The authors suggest that 'an adapted and contextualised' framework (figure 14) based on a synthesis of Gallivan (2001) and Mustonen-Ollila & Lyytinen (2003) is a useful way of analysing and interpreting complex problems of diffusion where there are strong contingent authority factors present (such as in NHS organisations).

Finally in our review of NHS-based process studies, Waterman et al (2007) studied an information source about practice services ('Guide to General Practice for Patients') designed specifically for patients and members of the public with the purpose of overcoming the known barriers to their engagement with the use of health performance information. The source appeared both in the form of an individual practice booklet and on a Web site in two Primary Care Trusts in England and two Local Health Boards in Wales. Although broadly speaking the study does focus on a 'technological innovation', the study is also of particular interest as it adopted an action research approach.

Figure 14. An adapted and contextualised diffusion of innovation framework (based on Gallivan (2001) and Mustonen and Lyytinen (2003)



As we have argued previously (Greenhalgh et al, 2005) - and Waterman et al explicitly related their study to - features of action research map onto our criteria for much-needed whole systems research into the diffusion of innovations: that is, action research is theory driven, process rather than package oriented, participatory, collaborative and coordinated, addressed using common definitions, and multidisciplinary and multimethod. Using interviews, focus groups, surveys and participant observation, the research team worked with 103 members of the public, practice staff from 19 general practices, and NHS managers from 4 Primary Care Organisations. The authors concluded that action research can be employed to diffuse innovations that need a high level of adaptation in each new setting or where there is a great deal of complexity and mismatch between different groups of people and parts of an organisation, providing there is a need or desire to research the innovation further. They proposed four characteristics of action research important to the diffusion of the innovations that are not commonly discussed in the diffusion literature:

- action research has the potential to be useful in work that requires the participation of patients in the design of health services (and by bringing staff and patients

together can facilitate mutual learning and empowerment, increase understanding of the culture in which the innovation is to be assimilated, and result in more appropriate designs)

- the process and forums of action research help to contextualise the development and diffusion of innovations
- action research has to be well supported in terms of time and human resources
- the symbiotic relationship between participation, research and diffusion of innovation leads to important theoretical and practical insights

As Fitzgerald et al (2002; 1445, citing Van de Ven et al, 1999)) suggest, in a healthcare context characterised by complexity with multiple stakeholders and decision 'points', a far greater importance needs to be placed in the interactions between groups than previous (largely non-healthcare based) literature predicts. For this reason the 10 processual studies reviewed in the preceding section are important to increasing our understanding why and how technological innovations are adopted and assimilated in NHS healthcare organisations. The results of the four related studies reviewed above (Ferlie et al, 2000; 2005; Fitzgerald et al, 2002; 2003) - highlighting the importance of the history, culture and quality of interprofessional relationships - relate closely to the notion of 'absorptive capacity for new knowledge', one of the two components in our original 'non-structural determinant of innovativeness' dimension of the inner context. We draw on the lessons from these studies to refine our initial model in section 5.4.2 of this report. Other key messages from the 10 papers include that:

- there is no single adoption decision (emphasising the importance of studying adoption and assimilation together as opposed to individually)
- the vital role of power and politics (with the medical profession largely dominant in adoption decisions)
- the impact of the characteristics of different decision-making process (decentralised/centralised; formal/informal) and that most decisions appear to be from a short-term perspective (Greer's (1985) 'fiscal-managerial')
- professionalism in healthcare context can be a negative influence on adoption (in stark contrast to conventional thinking as evidenced by studies in other sectors).

Process-based studies from other healthcare systems

We found 23 process studies of technology adoption in healthcare organisations based outside the NHS; of these, 3 (Denis et al, 2002; Edmondson, 2001; Meyer & Goes, 1988) were reviewed in - and 13 were published after - our previous review (Greenhalgh et al, 2005). We review the 10 most informative and relevant to our current review question below (these include the 3 studies included in our previous review), before briefly summarising the remaining 13 studies at the end of this section.

The study by Barley (1986) was not included in our original review as it focuses on technological innovation (rather than an innovation in service delivery and organisation which was the subject of that review) but it is a seminal paper in how studies in the field of technology adoption have moved beyond deterministic approaches. For this reason, we have highlighted this study in the 'Technology-in-practice' section of this report as in our view 'it offers an important and extensively-cited methodology that could be applied to the study of contemporary technological innovations healthcare' (see section 6). Here we therefore only provide a brief overview of the theoretical basis of the study and the

research methods adopted together with a brief summary of the findings. Barley conducted a qualitative comparative case study (using ethnography and interviews) in two US hospital radiology departments, asking why the introduction of the 'same' technology (a CT scanner) played out differently in the two different settings. He found that the embedding of the CT scanner in a radiology department was shaped and constrained by pre-existing social structures via interpretive frames, power and influence, and professional codes of conduct. The technologies offered new opportunities for acting differently, and as a result, new patterns of action and interaction emerged. He therefore concluded that the 'same' technology, when introduced in different contexts, will have different impacts (and be used differently and support different roles) because of complex and subtle differences in historical, contextual and social factors. Black et al (2004) write that since its publication, Barley's study has been widely cited as a convincing rejection of both the technological imperative and more subjective accounts as well as offering several new hypotheses concerning the variety of patterns he observed. Most notably, for Black et al, he concluded his analysis by suggesting that the autonomy of technologists (what he referred to as 'decentralization' of decision making), varied significantly within and across the sites where the new technology was deployed. Although Barley's study is prominent in the organisational studies literature, few researchers have built on his substantive insights to develop a more general account of the relationship between a new technology and behavior in organisations. We discuss this study in more detail therefore in section 6 of this report.

Black et al (2004) sought to extend Barley's original study by incorporating the original data into a systems dynamic modelling approach. The method involved the development of a new approach to analysing interconnections between new technologies and social action and the study sought to develop a theory to explain why the implementation of a new technology often disrupts occupational roles in ways that delay occupational benefits. In doing so, Black et al move beyond Barley's original findings to suggest that it is not necessarily 'decentralisation' of decision-making that leads to realisation of benefits of new technology but the opportunity for different occupational groups to redefine discretion and control through mutual learning. Such a finding supports, for example, Edmondson et als (2001) conclusion (see below) that putting 'teams' of doctors, nurses and technicians through extensive simulated training is one way of realising better the gains a new technology offers. Black et al concluded that practitioners should consider the relative distribution of expertise when implementing a new technology because, when a technology is new, a relative balance in operational knowledge (in this case involving doctors and technologists) leads to greater learning and collaborative change in the roles and relations between actors required to realise its benefits more rapidly.

We reviewed the study by Denis et al, (2002) in detail in our earlier review (Greenhalgh et al, 2005: 109-111) and so provide only brief details here. As part of a large, Canadian government-funded programme on diffusion of innovations in healthcare, Denis *et al.* (2002) used an in-depth ('ethnographic') case study approach to study the adoption of four innovations in Quebec that were selected for their evidence base and rate of adoption; two of these were (non-pharmaceutical) technological innovations (laparoscopic cholecystectomy and multiple-use dialysis filters[40]). The authors used a

[40] In the study, the 'overadoption' of laparoscopic cholecystectomy was attributed to professional fashions along with market pressures on private-practice surgeons to be seen to be using the 'latest techniques'; and to the fact that whereas the benefits of the procedure (shorter hospital stay, smaller scar) were readily observable, the risks (damage to internal organs, need for re-operation) were much less visible. 'Prudence' (the slow adoption of

formal, in-depth cross-case analysis, essentially building a rich picture of each case from an extensive collection of qualitative (63 interviews in total) and quantitative data, and analysing the differences between them in terms of an interpretation of this rich picture. Based on their interpretive data, Denis *et al.* developed a new theoretical model about the adoption of complex healthcare interventions, with three key elements:

- a complex innovation is not a 'thing' with fixed boundaries but comprises a 'hard core' of its irreducible elements (for example, in the case of laparoscopic surgery, the operation itself) plus a 'soft periphery' of the structures and systems that need to be in place to support it. The latter include technologies, skill mix of staff, training and supervision needs, and so on
- the risks and benefits of a complex innovation are not distributed evenly in an organisation or system. Rather, some actors will benefit and others experience unintended or unavoidable consequences. The more the risks and benefits of the innovation map to the interests, values and power of the actors in the adopting system, the easier it will be to build coalitions for spread
- the actors in the adopting system appear to be motivated by interests (such as financial) but also by values (for example, 'academic' doctors feel the need to align with evidence from research trials, while many others are more swayed by norms of practice at what they perceived to be prestigious and trend-setting institutions)

Finally, echoing the conclusion of Meyer and Goes (1988) (see below), Denis and colleagues noted that the adoption process in organisations is not a one-off, all-or-nothing event but a complex (and adaptive) process. Of particular relevance to this review the authors also asked how practitioners (e.g., technology assessment agencies; professional practice regulators, patient advocates) could intervene to promote sensible decision making concerning the adoption of innovations? They suggested some specific practice implications:

- new practices must be analyzed not only in terms of their benefits for patients, but also in terms of their implications for the specific groups of people who need to collaborate in their implementation. Once this analysis has been done, ways may be found to intervene, perhaps by altering the distribution of risks and benefits, or at least by permitting open and frank discussion of personal concerns that may have previously exerted a hidden influence on the dynamics of innovation adoption and diffusion
- there is also scope for bringing patient and citizen concerns directly to the table (see earlier discussion of Waterman et al, 2007, on page 54 and the potential role of action research). Patients often lack power in adoption decisions. However, if better ways were found to intervene on their behalf, perhaps by encouraging participation in discussions of major choices their positions might well be more influential. Neutral groups such as medical colleges, technology assessment groups, and physician advisory bodies could moderate such discussions.

---

multiple-use dialysis filters despite a good evidence base) was attributed to risks and benefits being context-dependent – since re-use requires manual or chemical cleaning of the filters for which there may or may not be overall savings – and to concerns about hidden risks (of rare but fatal infection, for example).

- there may be a number of different ways to achieve effective implementation of useful innovations; negotiation within the soft periphery can render feasible practices that initially appeared destined for failure[41].
- professional regulatory bodies clearly need to consider regulating more seriously these procedures to ensure that those using them have received the necessary training

In summary, this study suggests that those interested in promoting the adoption of beneficial innovations must become deeply aware of the specific ways in which they are likely to interact with their social (i.e. organisational) contexts. Only then can measures be taken to ensure that beneficial innovations receive the support they deserve and that 'risky' ones are treated with circumspection.

We briefly commented on the study by Edmondson et al (2001) in our earlier review (Greenhalgh et al, 2005: 190). This qualitative study of teams in 16 US hospitals implementing an innovative technology for cardiac surgery examined the collective learning process that takes place among interdependent users of a new technology during implementation. The study found that successful implementers underwent a team learning process that was qualitatively different from that experienced by those who were unsuccessful. As we noted, this important study is one of the few that have explored the process of team learning. We have used this study as an example of the application of routinisation theory, which we propose in section 6 (page 91) opens up a new agenda for empirical research in healthcare organisations that links the 'micro' of human action and interaction with the 'macro' of organisational and institutional change.[5]

Greer (1984; 1985) conducted research on technology adoption processes in 25 community hospital in the central US. This large-scale study focused on 12 technological innovations, three from 1976 onwards (CAT scanning, coronary bypass surgery, and phacoemulsification) and nine from 1980 onwards (radioimmunoassy, batch blood analysis, ultrasound, radionuclide scanning, fibreoptic endoscopy, coronary PTA, neonatal intensive care, laser surgery and fetal monitoring). The first paper (1984) of her findings, based on 378 interviews with a stratified sample of community hospital staff (physicians, administrators, board members and nurses) conducted in three waves in 1976, 1977-1979, and 1980, examined the theoretical and empirical bases for hypotheses of professional dominance and the utility of these hypotheses in explaining hospital decisions to adopt new medical technologies. Greer suggests that the appropriate application of professional dominance theory requires specification both of the type of physician exercising influence[42] and of the hospital decision systems within which it is exercised. This is a seminal paper that emphasises the non-unitary nature both of professionals in healthcare and of hospitals and led on to Greer's (1985) classification of 3 discrete decision systems within hospitals (see below).

Greer's (1984) study of decisions on technology adoption identified three different systems operating in the central US community hospitals, upon which she elaborated in a 1985 paper. The three systems were:

---

[41] However, the authors caution that there may be risks in this due to the potential for diluting the active features of the innovation through compromise, or of dispersing the benefits in ways that do not necessarily improve patient care.

[42] Greer (1984) identified four categories of physician: community generalists, community specialists, referral specialists and hospital-based specialists.

- *medical individualistic* - seen within the clinical consultation and dominant in evaluations of new clinical tools; primary objective were the promotion of patient welfare and reduction of risk
- *fiscal-managerial* - seen at departmental level and applies to replacement and accretion of technologies used in hospital departments; focused on the impact of a technology on the efficient running of the hospital
- *strategic-institutional* – seen in evaluation of innovation proposals that imply substantial changes in the nature or future of a hospital; primary objective was to maintain a hospitals status and competitiveness

In the 1985 paper Greer specifies in more detail - based on the empirical findings from her study of the 12 technologies listed above in 25 hospitals (and the resulting 250 potential adoptions) - the dimensions that differentiate between the 3 decision systems she identified (building on Daft & Becker's (1978) similar analysis of decision systems in schools as they related to educational innovations):

Table 9. Hospital decision-making systems

Dimension	Medical-individualistic	Fiscal-managerial	Strategic-institutional
Prominent actors	Physicians, especially community specialists	Chief executives, fiscal officers, employed department heads, hospital-based physicians	Governing boards and chief executives
Espoused ideologies and values	Maximising patient welfare, avoiding risk	Rationality, predictability, financial viability, 'profitability'	Formulating and realising viable institutional missions, securing and protecting future options
Bases of influence	Professional training, clinical experience, colleagues' respect	Reputation for financial, computational and marketing ability	Authority, credibility, and charisma
Typical structuring of decisions	Professional collegia, medical staff committees	Embodied in standardized procedures and analytical programs	Long-range planning and policymaking bodies
Typical decision processes	Assessing clinical effects consensually, tempered by norms of professional deference	Conducting cost-benefit analyses, discounted cash flows, etc.	Forecasting impending threats and opportunities, constructing alternative scenarios
Information gathering and utilisation	Information obtained through personal experience, professional media and short courses of developers/advocates	Systematic search, quantitative evaluation	Information gleaned from diffuse sources combined and extrapolated holistically
Examples of technologies considered	Fibreoptic endosocpe, electronic fetal monitor, laser surgery, phacoemulsification	Automated blood analysis, radio immunoassay, radionuclide scanning ultrasound, CAT scanning	Neonatal intensive care, open heart surgery
Applicable literature		Financial management, accounting, marketing	Organisational change, policy formation, theory of the firm

Whilst undoubtedly a helpful attempt at a classification of decision-making systems relating to technology adoption, Greer herself notes (as long ago as 1985) that whilst at the time of the research it was 'relatively easy to assign a technology to one system or another and anticipate what would follow … the circumstances which allowed the subsystems' independence between 1976 and 1980 … are rapidly vanishing'. In short, this analysis of decision-making systems is very relevant to our review question but is based on empirical data from US hospitals that is, for the most part, almost 30 years old, and the continuing validity of the findings were questioned by the author of the study even at the time they were first proposed. Nonetheless, Greer highlights one key policy implications which is still of relevance (or at least highlight issues to consider) today, that attempts to influence the diffusion of medical technology will be more successful if they are directed to the decision systems that are most critical to adoption of specific technologies (as each system is composed of particular actors and have distinctive internal logics)[43].

Koch et al (1996), drawing on the same dataset as Greer (1984) (i.e. data on 12 technology-adoption processes in 25 US community hospitals were collected over a six-year period using multiple methods including structured interviews with 378 participants), conducted multivariate and discriminant analyses of the potential adoptions studied. Conceptualising hospitals' adoption of medical technology in terms of discrete stages (building on and testing Meyer & Goes (1988) model: knowledge-awareness; evaluation-choice; and adoption-implementation, see below), the authors found that the process through which hospitals adopt medical technology is partitioned into three distinct stages by (1) the request for capital allocation, and (2) the initial acquisition of equipment. Their results also suggested that the support or opposition of an organisations CEO substantially shapes the outcome of an innovation proposal (in both stage 1 and 2). Upon acquisition (stage 3) strategic factors emerged as most potent predictors of utilisation and readoption; which implies that in hospitals many technological innovations are acquired with little consideration given to the levels of demand for the innovation existing in the organisations environment. Overall, Koch et al concluded, unsurprisingly given Greer's previous analysis, that multiple rationalities shape hospitals' adoption decisions and that those studying adoption and assimilation processes need to use multiple lenses to characterise, filter and make sense of confusing and puzzling events in organisations.

The study by Meyer and Goes (1988)[44] was included in our earlier review (Greenhalgh et al, 2005: 106-108) and remains a key source for this review, helping to inform our thinking particularly in relation to the importance of both the adoption AND assimilation of innovations (rather than just the former):

'If adoption in individuals is a complex process, adoption of an innovation by an organisation is necessarily more complex still. Indeed, the term 'adoption' is probably misleading, and we prefer Meyer and Goes's term 'assimilation' (see table 10 below) because it better reflects the complex adjustments that are often needed in the organisational setting.' (106)

---

[43] Greer suggests that, for example, in the US 'fiscal approaches' are relatively weak tools when used as indirect attacks on decisions made within the medical-individualistic or strategic-institutional systems

[44] The basis of their analysis was the conversion of categories and themes (independently coded by two researchers) to numerical scales (for example, assessment of the stage of assimilation on the nine-point scale shown in table 10). These numerical values were fed into both linear and multivariate regression analyses.

To summarise our earlier review of this study, which was again based on the same dataset as that used by Greer (1984; 1985) and Koch et al (1996), Meyer and Goes (1988) forward the notion of 'assimilation' as a 9-stage process (table 10) rather than an all-or-none event, representing a potentially more useful framework for studying *organisational* adoption (albeit with the usual reservations about perceiving adoption as a rational, linear process), and one that has been incorporated into a number of later studies we have reviewed here. As we noted previously (Greenhalgh et al, 2005: 108), 'The raw results of the Meyer and Goes study are impressive in terms of strength of association but otherwise largely unsurprising, and confirm much that was known already about attributes of innovations … and organisational context.' The findings do however highlight that complex and risky innovations that require specialist skill and expertise are not easily adopted into organisations whatever the antecedent capacity.

Table 10. Decision making stages in the assimilation of medical technologies (adapted from Meyer & Goes, 1988; Koch et al, 1996)

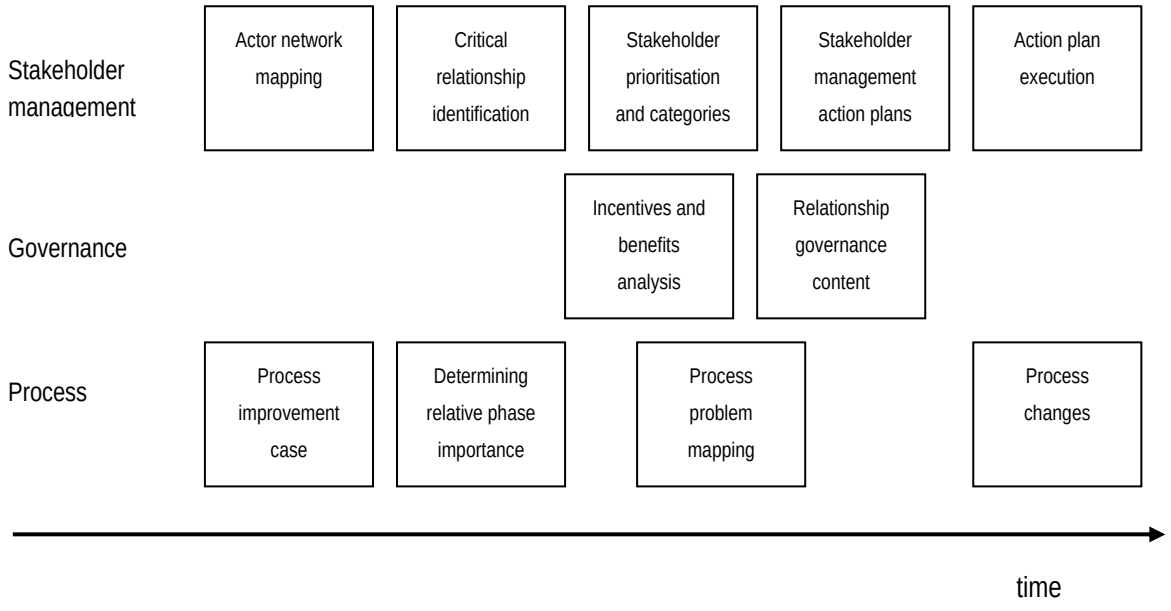
Decision-making stage		Characterised by	Dominant rationality	Eventual adoption positively associated with
Knowledge-Awareness	1 Apprehension: individuals learn of the innovation's existence 2 Consideration: individuals consider the innovation's suitability for their organisation 3 Discussion: individuals engage in conversations concerning adoption	Submission of a formal, written request for the allocation of capital funds to purchase given technology Informal information gathering, evaluation and choice among individual participants (primarily physicians)	Clinical	Good fit between technology and interests/abilities of physicians High observability of impact on patient care
Evaluation-Choice	4 Acquisition proposal: it is formally proposed to purchase the equipment that embodies the innovation 5 Medical–fiscal evaluation: medical and financial costs and benefits are weighed up 6 Political–strategic evaluation: political and strategic costs and benefits are weighed up	Programmed organisational decision-making Bureaucratic decision-making	Fiscal; political	Low capital budgetary complexity Decentralised capital budgeting Less rigorous financial analysis Less pluralistic forums (i.e. a less political process) Long CEO tenure, high CEO educational level and high CEO support Younger medical staff Higher specialisation in medical staff
Adoption-Implementation	7 Trial: the equipment is purchased but still under trial evaluation 8 Acceptance: the equipment becomes well accepted and frequently used 9 Expansion: the equipment is expanded or upgraded	Equipments actual arrival in organisation	Strategic	Larger hospitals Urban hospitals Serving higher socio-demographic population

Parvinen and Tolkki (2007) studied the adoption of picture archiving and communicating systems (PACS) in an imaging centre in Finland with the aim of investigating different stakeholder management settings in four different phases of technology adoption: introduction, acquisition, implementation and utilisation. Using stakeholder analysis[45], 30 structured interviews with stakeholders in the centre concerning the PACS adoption process, and linking the data to a governance analysis of the centre the authors suggest that the governance of healthcare technology adoption operates in three different domains:

- stakeholder management (serving and satisfying the various active parties of healthcare service delivery);
- governance (incentives, ownership, and information in the contractual relations of the stakeholder); and
- micro-process level management issues (the extensive utilisation of the technology where all the advantages and benefits materialise)

However, they found that there was no control over the overall adoption process (in part due to the fragmented structure of healthcare organisations) which caused an asymmetry of information between different process phases. On the basis of their findings, the authors propose a tentative schedule for the co-evolutionary development of the three identified domains, arguing that addressing the tasks within all three domains needs to occur in parallel:

Figure 15. A tentative schedule for governance, stakeholder management and process management tasks along the technology adoption process



Consequently, the authors identified two main challenges for successful technology adoption process (from a stakeholder governance perspective):

[45] Stakeholders are constituted as individuals, groups or organisations which have a stake in the decisions and actions of an organisation, and which attempt to influence those decisions and actions (Freeman, 1999).

- the stakeholder relationships and governance must be matched with the process understanding to enable efficient adoption and introduction of useful technologies; and
- general control over the entire adoption process must be managed.

Weiner et al (2004) studied the adoption and implementation of clinical information systems in a much larger study of 5 US healthcare organisations (in this case, Integrated Delivery Systems) using a multiple, embedded case study design. The research method included a 2-day site visits to each of the 5 organisations (including a total of 81 key informant interviews, 9 focus groups and the collation of archival data), and a postal survey exploring the time since implementation, breadth of application, extent of use and perceived value (actual or expected) of the technology. The theoretical basis[46] for the study was that organisational learning culture follows an S-shaped curve that conceptually can be divided into four developmental stages: emergence, growth, maturity, and critical crossroads. Consequently, organisations in different stages of this life cycle vary in terms of their experience and expertise with innovation, their readiness and tolerance for change, and their ability to generate and make use (i.e., learn from) new knowledge. Based on this model, the authors proposed a number of hypotheses:

- that later-stage organisations would take a more strategic, system-level perspective in clinical IT decision-making than would earlier-stage organisations (given the greater emphasis on systems thinking, the stronger common values, the higher level of interdependence, and the more salient need for coordination found in later-stage organisations)
- that later-stage organisations would employ a more centralised IT decision-making process that emphasised system-wide clinical IT needs, placed clinical IT decisions in a strategic context, and employed generally agreed upon criteria for evaluating clinical IT priorities
- that later-stage hospitals would show more routine clinical involvement in IT decision-making processes generally and in clinical IT adoption and design decisions particularly (as they anticipated that later-stage organisations, possessing more experience with innovation of both the successful and unsuccessful variety, would value more highly the organisational learning that results from early end-user involvement in needs identification, priority setting, and design specification)
- that later-stage organisations would show a greater propensity to make, rather than buy, clinical IT systems because they have more sophisticated clinical IT needs than earlier stage organisations and require more functional, reliable, and customised solutions than IT vendors can deliver

[46] Adapted from the work of Savitz, Kaluzny, and Kelly, 2000, the integration life cycle model posits that integration and organisational learning demonstrate a recursive relationship. Higher levels of integration imply higher levels of interdependence, which in turn demands more coordination. For most healthcare systems, achieving higher levels of coordination requires innovation such as implementing new organisational structures, acquiring new organisational capabilities, and redesigning clinical processes. As the healthcare system gains experience with innovation, particularly successful experience, a learning culture develops wherein people value creating, acquiring, and transferring knowledge, become adept at modifying behavior to reflect new knowledge, and demonstrate greater tolerance for change, ambiguity, and experimentation.

- that adoption and implementation processes would differ for two classes of clinical information systems: individual level[47] and population level[48] (for example, physicians and other clinical staff would participate extensively in adoption decisions and implementation processes for individual-level systems because they are the primary targeted users of such systems)

Four general themes emerged in this study. First, the organisations showed substantial clinical involvement, at both the system level and the local level, in clinical IT adoption decisions and implementation processes. However, lower levels of clinical involvement for population- level IT systems may have contributed to lower use levels and greater resistance among clinicians with respect to these systems. Study results point to the importance of early end-user involvement in needs identification, priority setting, and design of population-level IT systems. Second, system-level senior managers generally did not provide leadership in terms of setting the agenda for decision-making about clinical information systems. In most cases, enterprising CIOs or small groups of clinicians identified the need or saw the opportunity for the system, developed the system or assessed the existing products in the market, and then persuaded senior managers to make the adoption decision. However, senior managers at later-stage organisations increasingly recognised that they must provide leadership to ensure that system-level priorities and business problems drive IT decision-making. Third, healthcare organisations generally take a phased approach to implementation that involves both sequential installation of across care delivery sites and maintenance of parallel data entry, storage, and retrieval systems. This implementation approach has advantages and disadvantages[49]. Finally, organisations at later stages in the integration life cycle differed systematically from those in the earlier stages in terms of the types of clinical information systems they implemented, the propensity to develop clinical information systems internally, and the structures and processes they employed in making adoption decisions. Differences in implementation processes, however, seemed more related to the characteristics of the IT system than to the location of the organisations in the integration life cycle. Despite greater experience with innovation and greater organisational tolerance for change, later-stage organisation leaders grappled as much as earlier-stage organisation leaders with the challenges of managing the pace, scope, and intensity of change associated with clinical information systems implementation. The

[47] Individual-level systems focus on the delivery of care at the patient level and include such applications as clinical workstations, physician order entry systems, clinical decision support systems, and automated drug dispensing systems.

[48] population-level systems focus on the delivery of care from a population perspective and include such applications as pharmaceutical surveillance systems, clinical registries, clinical benchmarking systems, and data warehouses

[49] By phasing installation across care delivery sites, organisations gain opportunities to incorporate later installations the lessons learned in earlier installations. Further, by maintaining parallel systems, organisations can mitigate their operational dependence on new systems whose functionality, speed, and robustness may not be proven while simultaneously easing the transition for targeted users. However, phasing installation across care delivery sites may delay the realization of the system's intended benefits if those benefits depend on reaching a threshold number of users. Likewise, maintaining parallel systems introduces a host of problems, not the least of which is weaning targeted users from the legacy systems and processes with which they are familiar, competent, and efficient users. Those organisations that developed a transition plan, provided appropriate incentives, and instituted supporting policies experienced more rapid migration to new systems.

authors offered some (very common) 'lessons learned' for managers in terms of adopting and implementing clinical information systems:

- involving targeted users early on in the process
- rigourously pilot testing new systems
- performing detailed analysis to avoid automating existing workflow
- planning for the technical and human transition from legacy systems
- budgeting and allocating adequate resources for ongoing training, support and maintenance

For a variety of reasons, we have given relatively less weight to the remaining 13 process studies based in other healthcare systems. Some were very small-scale case studies (for example, Danjoux et al, (2007) and Sharma et al, (2006) interviewed just 5 and 6 informants respectively); some, although taking a process perspective, were largely survey-based (Armer, 2004; Pare, 2006); and others explored specific elements of the 'inner context' without relating their findings to the broader impact of organisational factors on adoption and assimilation (McGregor, 2005). However, each of the 13 studies offer a particular insight or perspective on the review question and so we briefly summarise them below.

Armer (2004) conducted an in-depth study in one rural nursing home in the US to examine how the adoption of telemedicine would affect communication between and among community health professionals. The findings from this largely survey-based study (drawing on the 'Concerns-Based Adoption Model') provided feedback for the implementation and training phases of the project. For example, it was found that technical assistance on the nursing units during the initial stages of using the telemedicine technology (largely e-mail and Internet searches) built confidence and facilitated utilization. The study is an example of an educational/learning-based perspective on the adoption process.

Crosson (2008) undertook a multi-method qualitative case study of ambulatory medical practices in the US before and after e-prescribing implementation. The study aimed to develop new insights into factors that influence the effective implementation and use of e-prescribing in typical ambulatory care settings. Compared to practice members in other groups, members of successful practices exhibited greater familiarity with the capabilities of health information technologies and had more modest expectations about the benefits likely to accrue from e-prescribing. Members of unsuccessful practices reported limited understanding of e-prescribing capabilities, expected that the program would increase the speed of clinical care and reported difficulties with technical aspects of the implementation and insufficient technical support. The overall findings support the view that 'adoption' cannot be studied as a discrete event and that to understand how and why innovations are successfully implemented and assimilated, researchers need to study adoption as a broader process than is usually the case.

Danjoux et al (2007) studied the adoption of a new technology for the repair of abdominal aortic aneurysms - endovascular aneurysm repair (EVAR) - in a single academic health sciences centre in Canada. This qualitative case study was conducted using analysis of documents and semi-structured interviews conducted with individuals identified to have the most involvement with the innovation (3 vascular surgeons, 1 hospital decision-maker, and 1 radiologist). As decision-making processes for the adoption of surgical innovations have not been well studied, and a standard process for the introduction of surgical innovations in hospitals does not exist, the authors proposed

that the results from the study would contribute to the development of guidelines to help decision-makers in relation to future surgical innovations in Canadian hospitals. 'Accountability for Reasonableness' was used as a conceptual framework for fairness in priority setting processes in healthcare organisations[50]. They found that there were two key decisions regarding EVAR: the decision to adopt the new technology in the hospital and the decision to stop hospital funding. By applying their conceptual framework, the authors suggest that the decision to adopt EVAR was based on perceived improved patient outcomes, safety, and the surgeons' desire to innovate but that this decision involved very few stakeholders; there was only limited internal communications prior to adopting the technology. In contrast, the decision to stop funding of EVAR involved all key players and was based on criteria apparent to all those involved, including cost, evidence and hospital priorities. Throughout the adoption (and de-adoption) process, there was no formal means to appeal the decisions made.

Lang (2005) conducted a qualitative analysis of key informant interviews with 15 physicians, including four internationally renowned key opinion leaders, representing five medical centres with differing professional experience of adopting carotid artery stenting (CAS). Although not explicitly about the adoption of such a technological innovation in an organisational context, the study does offer interesting insights into some of the power and politics issues raised in other studies. The study found that variation in beliefs about the safety and efficacy of CAS within specialties was overshadowed by variation across the specialties examined, and concluded that local collaboration of individual physicians and the departments and professional organisations they comprise, would have an important impact on how this technology was adopted.

McGregor (2005) provides a case study description of a mechanism in a large Canadian teaching hospital to increase the influence of health technology assessments (HTAs) on hospital decisions regarding adoption of technologies. The study concluded that the local in-house HTA has had a major impact on the adoption of new technology and that it's success was due to (a) relevance (by incorporating local data and reflecting local needs), (b) timeliness, and (c) the formulation of policy reflecting community values by a local representative committee. The authors suggest that small HTA units in close proximity to local decision-makers can influence the process of adoption.

Mike (1996) provides an external perspective on the adoption of transcutaneous oxygen monitoring in neonatal intensive care units in the US, by drawing on 26 interviews with industry professionals and 10 interviews with biomedical investigators. The study explored the development and adoption of medical technology, including how ideas for new products arise and reach stages of development and marketing, and to describe the nature of the interaction with the medical community. The overarching theme of the findings was one of complexity and uncertainty, and of the doctor as a pivotal player in the introduction and diffusion of medical technology.

Pare (2007) undertook a retrospective, multiple case study of the implementation process for Picture Archiving and Communication Systems (PACS) at two Canadian hospitals. The aim of the study was to better understand the nature of the challenges faced in adopting and implementing PACS, the conditions for success and strategies that can be implemented in order to maximise the benefits that can be derived from PACS.

---

[50] 'Accountability for Reasonableness' is a framework for analysing priority setting (Daniels & Sabin, 2002) that specifies that an organisations priority setting decisions may be considered fair if they satisfy four conditions: relevance, publicity, appeals and enforcement.

Drawing on Rogers classical theory of diffusion and on theory of barriers to innovation (knowledge barriers), the study found that it is crucial to anticipate and address organisational and behavioural challenges from the very first phase of the innovation process, in order to ensure all participants will be committed to the project. The three main conclusions (and the related 'lessons learned for practitioners) are as shown in table 11:

Table 11. Summary of conclusions and lessons learned for practitioners

Main conclusions	Lessons learned for practitioners
Merely deciding to adopt PACs does not guarantee success; effective PACS implementation is also necessary	To demonstrate the financial viability of the project is a necessary, but not sufficient condition for success Share the project vision with all the concerned authorities and parties Conduct an early assessment of the project context and derive a substantive plan describing potential key challenges
A planned and rational implementation strategy centred on technological considerations, with a relative exclusion of wider organisational and human concerns, is most likely to lead to project failure	Treat any PACS deployment not simply as a rollout of new technology but as a project that will transform the organisation Do not believe in 'magic thinking' Rather, adopt a proactive strategy that takes into consideration all the technical, economic, organisational and human factors and that does so from the very first phase of the innovation process
The quality of the implementation strategy can be largely predicted by the key actors involved in the process, given their backgrounds, commitment and levels of motivation	The active and sustained involvement of highly motivated actors with complementary skills and interests is likely to favour project success Key actors must exert enough decision-making power to oversee the PACS acquisition process

Pare (2006) also studied the adoption behaviour of physician users of a physician order entry (POE) system in Quebec, Canada by means of postal questionnaire. The authors hypothesised that feelings of ownership towards a CIS may be developed through active physician involvement and participation in the system implementation process. They found that psychological ownership of a POE system is positively associated with physicians' perceptions of system utility and system user friendliness. Through their active involvement and participation, physicians feel they have greater influence on the development process, thereby developing feelings of ownership toward the clinical system.

Randeree (2007) used an interview approach (CIO or practice manager) to study the adoption of electronic medical records (EMRs) in US small group practices. The paper documents the implementation of EMRs in small practices and provides a roadmap for others to follow. Results show that planning was a key common variable missing; the anticipated downtime was longer than expected and the workflow disruption and maintenance costs were underestimated. The authors suggest that EMR adoption can be encouraged through higher reimbursements for physicians that adopt EMRs.

Roback (2007) sought to investigate the process leading to the adoption or rejection of medical devices in neonatal intensive care units (NICUs) in Sweden. In an interview-based study, 24 respondents were recruited at 10 selected NICUs. The research questions focused on: (1) managerial and organisational characteristics and contexts; (2) innovation and adopter characteristics; (3) information sources and communication channels; (4) influences on adoption and diffusion; and (5) assimilation of innovations leading to technological change. Adoption was found to be primarily initiated by vendor activities, but professionals often sought information about functionality from close colleagues. Full integration of the selected devices was sometimes not achieved, and even though the adopting units had good 'introduction' routines, there was no systematic follow-up of how adopted devices had been integrated into work practices. Overall, three factors were found to be the major explanatory variables of the adoption of medical devices:

- the subjective expected value of the device; i.e. the perceived healthcare benefit
- information and learning; the process of knowledge accumulation
- the innovativeness of the adopting unit; the adopter's willingness to try new alternative solutions and the ability to implement change.

Sharma et al (2006) studied the introduction of advanced laparoscopic surgical procedures[51] in a small-scale study in a single community hospital in Canada by means of semi-structured interviews with just 6 key informants. As with Danjoux et al (2007) - see above - the authors (who included Danjoux) sought to study priority setting in the context of surgical innovations by again analyzing the decision-making process the Accountability for Reasonableness. They found that there was no structured, explicit process for making decisions about introducing new surgical technologies in the hospital, and that there was no systematic structure in place to oversee publicity, appeals, or enforcement. In summary, the decision to adopt advanced laparoscopic surgery at a community hospital in Toronto, Canada, was made primarily on the basis of its relevance to patient care and the role of the hospital board was not well-defined.

Southon (1997) studied the failed implementation of a Patient Information System (PAS) clinical system in New South Wales, Australia, through interviews involving over 60 staff at all levels. The authors propose that there are two major conceptual approaches to the study of technology transfer relevant to their study: innovation/diffusion theory and configurational theories of IT-organisational fit. They explain that theories of IT-organizational fit have been developed to provide a better understanding of the full range of organisational factors affecting the strategic application of IT. Consequently, they used 'IT-organisational fit' as their analytical framework. The diffusion process experienced problems because of the lack of fit in the strategy–structure, strategy–structure–management processes, and strategy–structure–role relationships, and the authors argue that there is a need to take a more sophisticated approach to understanding the complexities of organisational factors than has traditionally been the case: 'these were not problems of diffusion but organisational problems requiring organisational solutions.' (122)

[51] The advanced laparoscopic procedures introduced at the hospital between 2000 and 2005 were laparoscopic colon resection, laparoscopic adrenalectomy, laparoscopic rectal prolapse repair, and laparoscopic repair of abdominal wall hernia.

Stricklin (2003) used a survey approach to identify the key factors influencing nurses' acceptance and use of Point of Care (POC) technology in clinical work (in a home health agency in the US). The study sought to evaluate a 'Values Approach' (Lewin forcefield analysis) plus a socio-technical approach to the POC implementation and found that the 'decision to approach the POC implementation with a research-based design and employ a sociotechnical model' was supported. The authors suggested four guiding principles for successful POC implementation:

- training; a training curriculum that integrated nurse end user needs and clinical practice patterns
- system functionality; ongoing implementation support and troubleshooting
- implementation; there is no 'post-implementation'; the investment in people and technology never ceases
- user satisfaction: (a) involve clinical end users and management staff through training, and (b) make onsite adjustments to software and undertake work redesign so that the technology enhances clinical practice.

Although not undertaken in the contemporary NHS context, these 23 process studies from other healthcare systems (largely in the US) do nonetheless provide rich insights into key elements shaping the adoption and assimilation of technological innovations in healthcare organisations.

5.3.4 Deterministic studies

Finally, we have summarised in appendices 8 and 9 the 54 deterministic studies (2 in the NHS and 52 from other healthcare systems) that were retrieved by our literature review. Several of these studies are key papers from the early research of innovation adoption in (usually US) healthcare organisations from the 1960s and 1970s which have influenced later work (for example, Mohr, 1969; Kaluzny, 1974).

Deterministic studies in the NHS

As noted we found only two deterministic studies of technological innovation adoption and assimilation in healthcare organisations based in the NHS. The first of these by Booth-Clibborn et al (2000) was a small, retrospective study using questionnaires to twenty-four acute hospital trusts which contained eight true/false statements about the influence of different factors on the adoption of health technologies in the West Midlands region of England: namely, coronary stents and MRI. [52] The principal influences of the adoption of coronary stents were reported to be an enthusiastic individual supporting their use and the development of local guidelines; the principal influence on the adoption of MRI scanners was the cost (a deterrent) and the presence of national and local guidelines, and, again, an enthusiastic local individual. These findings for stents and MRI were based on only four and eight questionnaire responses, respectively, but the authors concluded that the 'influences on adoption ... are very different for different health technologies.'

[52] The statements related to: the cost of the technology; use of national guidelines; use of hospital guidelines; role of enthusiastic individuals; pressure from purchasers; pressure from patients/ patient groups; clinical research in responding hospital; and direct promotion in the responding hospital by the pharmaceutical/marketing companies. The study also included primary care prescribing data relating to the level of use of statins and factors effecting the diffusion of this pharmaceutical technology.

Higgs et al (2005) used a mixed-methods approach (postal questionnaire and semi-structured interviews) to explore the importance of behavioural, cultural and organisational factors on the diffusion of Geographical Information Systems in health authorities/health boards in England, Scotland, Northern Ireland and Wales[53]. The study focused on identifying 'barriers to wider implementation within NHS organisations'. The overall response rate to the questionnaire survey to health authorities/boards was 65% (n=80). Semi-structured interviews were conducted with 20 NHS personnel in 12 localities in order to gain a deeper understanding of some of the key issues identified in the questionnaire survey. The survey and interview findings highlighted both organisational barriers (work time constraints, insufficient staff and financial resources) to fully implement systems as well as the lack of training/guidance in the use of GIS-based techniques. The authors concluded that there are difficulties in reconciling 'bottom up' and 'top down' modes of technology adoption and suggested that further research into 'methods by which users, designers and policy makers might interact to ensure more effective implementation' is needed.

Deterministic studies in other healthcare systems

We have noted elsewhere the limitations of deterministic studies of adoption and assimilation processes in healthcare organisations, and particularly the limitations of extrapolating - and seeking to learn from - the results of such studies undertaken in other healthcare systems into the contemporary NHS. In order to illustrate the typical methods used and range of research hypotheses tested in such studies, we summarise below 11 of the 52 studies we found; of course, these typical approaches and hypotheses are also reflected in the results of the meta-analyses we reviewed earlier (in section 5.3.1). Summary details of each of the 52 studies are provided in appendix 9.

Friedman et al (1996) used a postal questionnaire to explore factors affecting the acquisition of nine technologies (auto analyzer; cardiac ultrasound; CT scanners; ESWL; haemodialysis; MRI; NICU; PET; quantitative EEG) at 126 hospitals in southern California[54]. The response rate was 17.8% (n=95) and the survey sought to learn about the 'behavioural factors' affecting technology acquisition decisions (for example, is technology adoption a well thought out and rational process or is it more affected by political pressure and organisational dynamics?). The survey found that senior physicians had the highest level of influence on the decision to acquire a technology (amongst six pre-defined categories of decision-makers[55]) in the case of all nine of the technologies (table 12). Chief financial officers had a greater level of influence in those hospitals which were early adopters of the four 'radical' technologies (ESWL, MRI, PET and quantitative EEG) relative to the five 'routine' technologies (automated chemistry analyzers, cardiac ultrasound, CT, hemodialysis and NICU). In response to questions regarding the effects of the various choice criteria[56], maximisation of patient welfare was reported to be the most important criterion, with a positive cost/benefit analysis appearing to be the next

[53] The survey also included all 469 NHS health trusts but the response rate of 26% was low and results not reported.

[54] The survey employed a scoring system whereby a score of 1 was assigned to the highest preferred alternative and decreased sequentially with a 6 given to the least preferred alternative.

[55] The six categories were: staff physicians (defined as regular members of the medical staff), senior physicians (defined as department heads or chiefs of staff), Chief executive officer, Chief operating officer, Chief financial officer and the governing board.

[56] The six criteria were: mission (concurrence with the hospital's mission), success (successful use of other new devices), cost/benefit (positive cost/benefit analysis), mktg (favourable marketing potential), ease (ease of use of the technology) and pt wel (maximisation of patient welfare).

most important consideration in the adoption decision (table 13). Overall, ease of use was one of the least important criteria (albeit slightly more important in the adoption of routine technologies).

Table 12. Perceived influence of six key decision-makers: mean preference score results (n=95)

Time of adoption/nature of technology	Staff MD	Senior MD	CEO	COO	CFO	Board
Early/routine	2.68	1.91	2.79	3.70	4.45	5.30
Late/routine	2.80	2.03	2.63	3.68	4.41	5.15
Early/radical	2.95	1.79	2.66	4.30	4.20	5.06
Late/radical	2.79	2.14	2.35	4.05	4.40	5.14

Table 13. Decision criteria: mean preference scores (n=95)

Time of adoption/nature of technology	Mission	Success	Cost/B	Mktg	Ease	Pt. wel
Early/routine	3.23	4.16	3.17	4.10	4.20	2.06
Late/routine	3.59	4.38	2.85	3.96	4.12	2.06
Early/radical	3.27	4.13	2.72	3.70	4.88	2.25
Late/radical	4.31	4.09	2.80	3.18	4.16	2.35

Amongst six defined 'decision considerations and influences' (those factors which express the basic values and culture of the organisation)[57], input from the medical staff was reported to be the most important variable (table 14):

Table 14. Decision consideration and influences: mean preference score (n=95)

Time of adoption/nature of technology	MD input	Exper	Capital	Strat	Market	Fin Ana
Early/routine	1.73	3.42	3.40	3.84	4.93	3.62
Late/routine	2.04	3.53	3.36	3.52	4.79	3.60
Early/radical	1.79	4.19	3.44	3.13	4.93	3.48
Late/radical	1.67	3.17	3.66	4.09	4.73	3.62

[57] The six 'considerations and influences' were: MD input (input from the medical staff), exper (experience of other hospitals with the same device), capital (fit with the hospital's capital budget), strat (results of the strategic planning process), market (coordination with marketing plans), and fin ana (results of standardised financial analysis programs).

Overall, the authors concluded that technology acquisition appears to be a physician centred activity with less consideration given to strategic or economic factors. Although the low response rate may undermine the generalisability of the findings, the reported results highlight the influence of medical staff as one of the most significant forces in decision-making processes related to acquisition of technologies. As the authors note one factor not measured is that of 'political pressure' (the extent to which physicians exert pressure on technology adoption decisions based on their stature, reputation or patient referral potential); this is a theme we return today later in this review.

Gagnon et al (2005) developed a framework of the organisational factors that could influence telehealth adoption based on a synthesis of the literature on the adoption of innovations by hospitals. Six structural variables (horizontal specialisation; functional differentiation; size of units; planning and control systems; internal communications; and decentralisation of power) were identified and associated research hypotheses (table 15) were then tested by means of a telephone-based questionnaire to 32 hospitals in Canada[58], followed by nine case studies based on 24 face-to-face interviews with principal actors involved in telehealth.

Table 15. Structural variables and research hypotheses

Variable	Description	Hypothesis
Horizontal specialisation	The division of work is negotiated between the various specialities rather than on a hierarchical basis	Horizontal specialisation has a negative influence on telehealth adoption
Functional differentiation	Differentiation, that is how the work is divided, is based on production units, or fields of expertise	The influence of functional differentiation on telehealth adoption depends on groups' values towards the system
Size of units	The size of units depends on the clientele size because professionals are grouped together according to their expertise	The size of units has an undetermined influence on telehealth adoption
Planning and control systems	Professionals try to exert a collective power on administrative decisions. For this reason, physicians often hold administrative positions in hospitals and central control is thus limited	Few planning and control systems have a negative influence on telehealth adoption
Internal communications	Information exchanges are mostly inofmral and the use of formal communication mechanisms is limited in the operational core. Permanent committees and taskforce groups represent a form of communication mechanism	Internal communications mechanisms have a variable influence on telehealth adoption
Decentralisation of power	Informal power is both vertically and horizontally decentralised. Power is dispersed towards the bottom of the hierarchical chain and professionals exert a control over decision processes	Decentralisation of power has a variable influence on telehealth adoption, depending on physicians' values towards the technology.

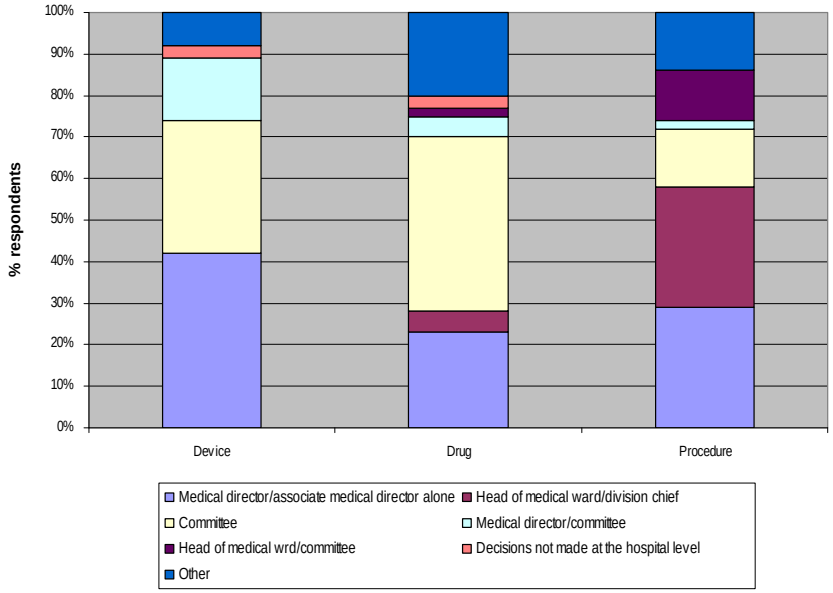
The study found that a smaller number of sub-units (functional differentiation) was positively associated with telehealth adoption, whereas the number of physicians in administrative positions (planning and control) and the participation of physicians in telehealth decision making (decentralisation) are negatively associated with telehealth adoption. The authors suggest that 'telehealth applications in larger hospitals may be inconsistent with physicians' interests … where physicians can exert directly their power by holding strategic positions … resistance to telehealth might be harder to overcome'

[58] The questionnaire also explored five contextual variables and research hypotheses relating to age of the hospitals, size of the hospital, level of competition, localisation and interorganisational relationships.

(50). Smaller hospitals and hospitals with less than 10,000 annual admissions (size) were more likely to adopt telehealth; this was an unexpected finding as most previous research predicted that a size variable would have provided a statistically significant impact. However, the overall findings from the study are a good example of how the specific nature and type of a technology can lead to (seemingly) contradictory findings.

Greenberg et al (2005) administered a questionnaire survey to 132 hospital executives in 24 Israeli hospitals which asked about decision-making responsibilities (as related to new technology assessment and adoption) of different members of hospital management, and their opinions as to preferred decision-making mechanisms. The results (figure 16) from the 61 responses (46%) suggested that final decision-making responsibility varies among technologies; for instance, the medical director frequently made the final decision when a new device was involved, but this responsibility decreased when a new drug or a new procedure was considered, findings that suggest support for the 'medical individualistic theory' forwarded by Greer (1985). The majority of respondents stated that - regardless of the type of technology - the final decision should be the responsibility of the medical director or a committee. The findings also suggest that different decision-makers may use different sources of information and processes when making their decisions. The authors concluded that further research is needed to highlight the influence of medical department heads on technology adoption and utilisation decisions (which appeared to be particularly strong in relation to innovative procedures).

Figure 16. Actual responsibilities for final technology adoption decisions



In a much earlier (and larger) study, again based on a questionnaire survey, Moch (1976) tested several hypotheses in relation to twelve technologies in the area of diagnosis, treatment or prevention of respiratory disease: namely, that larger - and consequently more specialised, differentiated and decentralised - organisations are more likely to adopt technical innovations. The survey was sent to approximately 1.000 hospitals in the US (and completed by hospital administrators and chief medical officers); the response rate was 67% amongst the medical officers and 68% amongst the administrative officers. In total, 489 (49%) of the hospitals responded to both questionnaires. The results suggest that attributes thought to characterise the generally innovative organisation - specialisation, differentiation and decentralisation - do successfully predict the frequency of adoption of innovations *compatible* with the

interests or perspectives of lower-level decision-makers. However, centralisation and the interaction between size and centralisation do not appear to affect the adoption of innovations which are *incompatible* with the interest of lower-level decision-makers. Therefore, innovations compatible with the interests of specialists and department heads will occur to the extent that the organisations are large, specialised, functionally differentiated and decentralised, but less compatible innovations (i.e. those which facilitate coordination and control) are likely to be adopted by large and functionally differentiated organisations. In seeking to explain these findings, Moch (1976) notes that the process of structural development that attends increases in size enables organisations to realise benefits which accrue from the division of labour and from increasing expertise. However, such development also introduces constraints on the patterns of resource allocation. Whilst specialists and heads of departments are responsible for successfully attaining the intermediate goals of the organisation, they may not be so concerned with the effective and efficient operation of the organisation as a whole. While diverging in particulars, these individuals are likely to be unified in their support for task-related, often technological, allocations and in their opposition to allocations proposed in the interests of coordination and control. Taken as a whole, the study findings suggests that research on large, complex organisations is likely to benefit from including political as well as rational factors in theory construction.

Kimberley (1978), drawing on the same large survey-based dataset as above (Moch 1976; 1977), suggest that the observed variability in hospital adoption of innovation can be accounted for, at least in part, by variability in the development of structural mechanisms (extra-organisational mechanisms; internal mechanisms; joint mechanisms) which provide access to information about change in the environment (i.e. the number and extensiveness of various mechanisms which appear to increase the likelihood that information about medical technology in general and respiratory disease in particular would enter the organisation). This hypothesis regarding the relationship between amount of innovation and hospital integration into technical informational environments received respectable statistical support (indicators such as research activity and hospital allocation of resources to bring in outside speakers and send physicians to meetings proved to be good predictors). Hospitals with a structurally differentiated, formal commitment in the area of respiratory disease are clearly more likely to adopt innovations in this area than those which do not; this suggests that the influence of characteristics of the potential adopting system (for example, centralisation) on adoption may be mediated by the relationship between the nature of the innovation and the adopting system. Furthermore, the relationship between those structures and/or activities which serve to integrate the organisation into its informational environment, and the internal dynamics of the decision process, result in a decision to adopt an innovation or set of innovations (or not).

Nathanson (1980) studied twenty innovations (ten ‘technological’ and ten ‘social) in obstetrics in US hospitals by means of 254 interviews with key informants in twelve US hospitals in the same metropolitan area. The interviews covered 34 issues divided into six areas: long-range planning, major changes in allocation of the hospital budget, introduction/elimination of hospital programmes and services, organisation of hospital departments and personnel, hospital/physician relationships, and miscellaneous policy issues. A questionnaire to interviewees also asked them to rate the amount of influence exercised by individuals in key hospital positions on different types of decisions. Although the main focus of the paper is on social innovations, an additional implicit hypothesis was that the conditions for social and technological innovation would differ. This expectation was supported; the only variable significantly associated with the

adoption of innovations high in 'technology/cost' is the presence of an influential chairman of the hospital's board of trustees (which was not a significant variable for social innovations). Although focusing on social rather than technological innovations, the study does draw comparisons between the two and overall suggests that the findings lend considerable support to the hypothesis that different patterns of innovation are associated with different sets of structural and normative conditions. The implication is that knowledge of these conditions is essential if existing patterns of innovation are to be changed or new patterns introduced.

Robertson (1983) in a secondary analysis of data collected for an earlier study, suggest that the study of decision-making relating to innovation adoption needs to take in to account coalition formation and other negotiative tactics among members of a hospital, and that it is necessary to include both the bureaucratic and professional perspectives within an organisation. This suggestion was based on the findings of the original questionnaire survey of 209 hospitals which explored the adoption of seven new medical instruments for radiology departments in the US[59]. For each hospital, respondents were the administrator, the chief radiologist and at least one staff radiologist. The analysis took into account three sets of variable types: (1) organisational demographic variables, (2) psychographic variables[60], and (3) consensus measures between the radiologist and administrator members of the 'buying centre'. The results of the multiple regression analysis suggest that the inclusion of organisational psychographic characteristics improved the predictive efficacy of 'organisational innovativeness', as predicting the hospital's level of innovation was improved by redefining organisational cosmopolitanism as the *pattern* of cosmopolitanism among relevant members of the 'buying' centre (and not on a single organisational respondent). Further improvement in predictive ability was achieved when the degree of consensus is added. The authors argue that organisational innovativeness has focused almost exclusively on organisational demographic variables (for example, size) but suggests that psychographics should be viewed as complementary to demographics (although the paper notes that the improvement in explained variance is 'modest') , as the use of a typology of organisational cosmopolitanism, combining the administrative and professional cosmopolitanism levels, would seem to have value for research on organisational innovativeness.

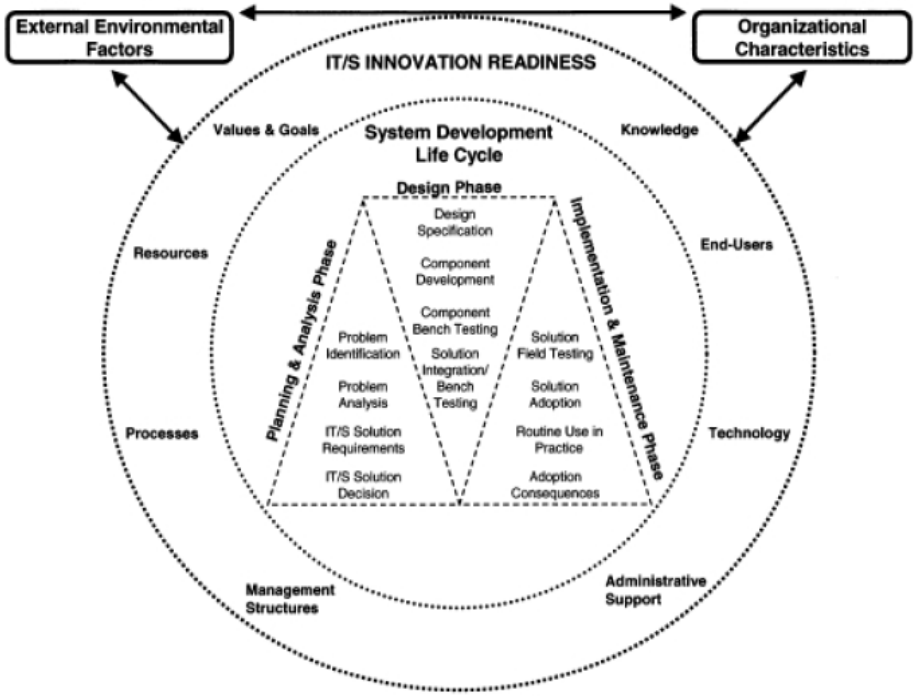
Snyder-Halpern's (2001) study focused on healthcare 'organisational readiness' - one of the components of the inner context identified in our original review - for clinical IT/IS innovations. The study was part of a multi-phased research program that had begun in 1996 and had previously developed a 'heuristic organisational information technology/systems innovation model' (OITIM). The intended purpose of the OITIM was 'to provide healthcare clinical IT/IS decision makers with a conceptual assessment framework to guide their decision-making processes' (181). By means of a two round Delphi study with 34 experts from US-based healthcare organisations with direct involvement with clinical information systems and applications, the study aimed to achieve consensus on (a) the dimensions of organisational readiness for innovation previously identified in the OITIM, and (b) indicators for assessing these dimensions. The Delphi study identified eight innovation readiness sub-dimensions: resources, staffing

[59] The analysis was based on a subset of 182 hospitals with complete data on all variables in question.

[60] By means of a quantitative research tool intended to place 'consumers' on psychological – as distinguished from demographic – dimensions in order to help assess the incremental contribution of organisational psychographics to the explanation of organisational innovativeness (the number of medical innovations adopted by the hospital).

and skills, technology, knowledge, processes, values and goals, and operations (figure 17); 316 indicators were identified for these sub-dimensions[61].

Figure 17. Validated Organisational Innovation Technology Innovation Model (OITIM)



The results of the study informed the development of an Organisational Information Technology/Systems Innovation Readiness Scale (OITIRS)[62], a potential tool for using as an operational measure of organisational innovation readiness (albeit designed explicitly for IT/IS innovations but with potential for adaptation).

The findings from Tabak et als (1999) cross-sectional survey of top managers 'intention to adopt' suggest that top managers who perceive their organisations with (a) 'domain offense' strategies (a measure of risk acceptance and complexity), (b) a dynamic and interactive team, and (c) slack financial and human resources tend to view potential innovations more positively[63]. These findings were based on a postal questionnaire to 4,625 CEOs, CFOs, COOs and VPs of non-federally owned hospitals exploring their 'intent to adopt' three specific 'radical' technological innovations (digital radiography,

[61] For example, under the 'processes' sub-dimension, 31 indicators were identified including: 'adequacy of organisational communication pathways, types of IT/S budget management processes used by the organisation and availability of an executive-leveel IT/S steering committee.

[62] 'The OITIRS has been designed as an 48-item, Likert-type scale designed for us with a variety of end users in healthcare organisations experiencing clinical IT/S innovation' (Snyder-Halpern, 2001: 202). Various papers are available reporting on the further piloting and deployment of the OITIRS (for example, Snyder and Fields, 2006).

[63] The stated rationale for this finding is that ''domain offense' strategies demand prospective, proactive and innovative organisational behaviour which aligns with an interactive top management team with low formalisation in decision-making. Awareness of organisational resource availability reinforces the perceptions of affordability of experimentation with innovations. Further, resource availability secures congruence with a domain offense strategy, characterised by diversity and change in products and services offered' (p. 265).

stereotactic breast biopsy, and spiral acquisition computed tomography) in US hospitals of 100-199 beds. The response rate was 24% (n=1,096). The results did not support one of the author's hypotheses that hospital specialization would be positively related to intentions to adopt but it is important to note that the survey was limited to hospitals with 100-199 beds (the findings may have been different in larger hospitals where resource availability was not as big a constraint). Finally, the findings should be treated with some caution as the focus of the study was on 'intention to adopt' and not 'actual' adoption.

Teplensky (1995) reported that a hospital's adoption behaviour is strongly linked to its strategic orientation on the basis of a study of MRI adoption in 637 US hospitals. Two telephone surveys were undertaken: one of 507 hospitals with MRI plus a second with a stratified sample of non-adopters. The first survey was of members of radiology departments relating to the technology itself and then second survey was of hospital CEOs asking about the organisations decision-making process. In the second survey non-adopters were asked about factors that might cause them to consider adoption of an MRI. In the study, a composite model incorporating three common explanations for medical technology adoption (profit maximisation, technological pre-eminence and clinical excellence) was tested. Findings suggest that the importance a hospital attached to being a technological leader, together with an emphasis on clinical services that required MRI and the change in revenues it believed to be associated with the adoption of MRI, were the major determinants of adoption behaviour. Changing the level of medical staff involvement in the decision-making to above the median also increased the odds of adoption. Larger hospitals were more likely to adopt MRI early but teaching hospitals were not more likely to adopt. These findings suggest that the importance of being a technological leader is one of the strongest determinants of hospital adoption behaviour but should be treated with caution as they are derived from interviews with just one respondent from each organisation.

In his study to describe decision-making regarding the acquisition of 'advanced medical equipment' in 12 academic medical centres in the US - including the clinical, economic and strategic considerations that informed the decision - Weingart (1993) undertook 16 open-ended interviews with self-selecting respondents. The study found that most of the centres had no distinct and recognisable technology assessment process in place; decisions about the acquisition of technology were often described as 'political', 'informal', or 'ad hoc'; the capital budgeting process was the primary vehicle at most centres for rationalising technology acquisition; and, uniformly, proposals for new technology percolate up from the clinical departments. Weingart notes that while financial considerations are critical to technology acquisition, the technology assessment process in large medical centres is highly political and variable with physicians, administrators and others vying for influence over the speed and scale of adoption (Friedman, 2000: 318). Weingart suggests that 'from the administrators perspective, the preparation of proposals [for new technology acquisition] and the demonstration of their merit as a clinical or research tool is a 'black box' that occurs within the clinical department' (535). He noted that many of the academic medical centres he studied used the capital budgeting process or an existing committee system as a vehicle for assessing technology. Overall, the study highlights the informal and political nature of technology adoption decision-making processes (albeit in the US in the early 1990s). However, it does not provide any assessment of the quality of these decision-making processes and the findings are of course not generalisable to how contemporary NHS organisations make such decisions.

The 11 deterministic studies summarised above were undertaken outside the NHS and are representative of the most common type of studies that we retrieved in our review. Typically, such studies undertake a large scale (usually postal) questionnaire survey of 2-4 key decision-makers in healthcare organisations (although some only survey one respondent from each specific organisation), which can then be supplemented by further qualitative interviews with a sample of the survey respondents. Mostly, the surveys will identify a number of particular innovations and ask respondents a series of Likert-type questions relating to these. Often the response rates to the surveys are relatively low (around 20-25%). The focus of the studies varies but is most commonly placed on establishing which organisational factors influence adoption (for example, size or extent of decentralisation of decision-making), although a minority take a more practice-oriented perspective and seek to develop tools and frameworks for practitioners to apply in their organisational settings (for example, Snyder-Halpern (2001)). Of those studies that have explored the nature of decision-making processes as they relate to innovation adoption in healthcare organisations, it is clear that senior physicians are key decision-makers (for example, see Friedman et al, 1996, and Greenberg et al, 2005) although – as Gagnon et al (2005) highlight in the case of telehealth – such centrality should not necessarily assume a positive association with the adoption of different types of technologies. Nonetheless, broadly speaking these types of studies support Greer's emphasis on the importance of the 'medical-individualistic' system of decision-making, along with the political nature of these processes (for example, Robertson, 1983; Moch, 1976; Weingart, 1993). Another of Greer's systems - 'strategic-institutional' - is also found to be important (Tabak et al, 1999; Teplensky, 1995), albeit with reservations about the sampling of respondents in such studies and the use of 'intention to adopt' responses as a proxy for actual adoption decisions. Finally, and again in relation to innovation adoption decisions, other deterministic studies focus on the dynamics between the internal decision-making structures of an organisation and it's relationships with it's external environment (for example, Kimberly, 1978).

5.4 Summary of overall findings and a revised model of technological adoption and assimilation in healthcare organisations

This summary section brings together our interpretation of the findings from the 99 primary and secondary studies reviewed and summarised above. The vast majority of these studies were not included in our original review either because they relate to technological innovations, rather than innovations in service delivery and organisation, or were published subsequent to our review being completed in 2004. We discuss below (section 5.4.1) how these findings relate to our original conceptualisation of the key components of the 'inner (organisational) context' as they impact upon the adoption and assimilation of innovations. We then present (section 5.4.2) a refined model that seeks to represent the organisational factors and processes which influence the adoption and assimilation of technological innovations in the healthcare setting (the specific focus of this review). The remainder of the report then presents:

- three particular perspectives on innovation studies which we believe may offer further insights into the process of innovation adoption and assimilation (section 6)
- a set of case studies against which we test the utility and validity of our refined concepts and model (section 7), and
- recommendations for policy makers, practitioners and researchers (section 8).

5.4.1 Summary of findings

As part of our original, broader, review of the diffusion of innovations literature (Greenhalgh et al, 2005) we identified two broad categories of factors and processes within the 'inner (organisational) context' of healthcare organisations that impacted upon the adoption of innovations in service delivery and organisation. The categories were:

- organisational antecedents for innovation in general (comprising both structural and non-structural determinants), and
- organisational readiness for a specific innovation

These were further broken down into several components as described in the relevant sections below which identify the key findings from this more specific review of technological adoption and assimilation as they relate to each of these categories.

Organisational antecedents for innovation in general

Our original review identified 'organisational (user system) antecedents' as a key determinant of innovation adoption and suggested there were two key groups of components within this determinant: structural and non-structural. The findings of our earlier review suggested that *structural* determinants which were associated with whether an organisation will assimilate innovations more readily included if:

- it is large (organisational size is almost certainly a proxy for other determinants including slack resources and functional differentiation) and mature
- it is functionally differentiated (that is, divided into semi-autonomous departments and units)
- it is specialised
- it has decentralised decision-making structures
- it has slack resources available to be channelled into new projects.

As we reported, in general, these structural determinants are significantly, positively and consistently associated with organisational innovativeness, but together they account for only a small proportion of the variation between comparable organisations. In this review we have found that such broad determinants are equally applicable to the adoption and assimilation of technological innovations as they are to innovations in service delivery and organisation (and, for the most part, with similar positive associations - see Camisón-Zornosa et al (2004); Fleuren et al (2004); Rye & Kimberly (2007)). However, interestingly, Ferlie et al (2002) argue that 'professionalisation' (closely related to the notion of specialisation) acts as a barrier to the spread of innovations in the healthcare context; a finding in direct contrast to conventional theory (in terms both of empirical studies outside the healthcare context and Rye & Kimberly's (2007) review of studies in the healthcare context) in which professionalisation is seen as enhancing innovation spread. We also found much greater relative emphasis placed upon the impact of (a) different formal decision-making structures, and (b) the nature of decision-making processes and criteria in determining the successful adoption and assimilation of technological innovations in healthcare organisations (see for example, Rosen & Mays, 1988; Fitzgerald et al, 2002; and, importantly, Greer, 1985). In this regard, Wainwright & Waring (2007) also highlight the distinction between the adoption decisions of (a) an organisation and (b) the individual users of the technology within that organisation.

In terms of the *non-structural* determinants of innovativeness (or what Barley (1986) termed the 'historical, contextual and social factors') we argued in our earlier review that the construction, interpretation, distribution and utilisation of knowledge within the organisation is also a crucial aspect. The ability to absorb new knowledge depends critically on what knowledge the organisation already has - and how this is used and exchanged among its members. We categorised factors relating to this determinant under the heading 'absorptive capacity for new knowledge' and identified four specific factors to be important:

- existing knowledge and skills base
- pre-existing related technologies
- a 'learning organisational' culture
- proactive leadership to enable sharing of knowledge both internally and externally

In the findings of this review, both Black et al (2004) and Edmondson et al (2001) place an emphasis on the importance of individual and team (collective) learning when implementing a new technology; they both highlight the beneficial role of mutual learning amongst different occupational groups, which Black et al argue is shaped by how expertise is distributed in the organisation prior to the technology's adoption. Edmondson et al conclude that training simulations involving the different groups responsible for implementing a technology leads to fuller realisation of the technology's benefits for the adopting organisation. Ferlie et al (2002) also highlight the importance of the 'learning and change capability of local clinical groups' and argue that this is 'shaped by prior history and pattern of roles and relationships'. The narrative review by Williams et al (2008) recommended several interventions to increase the absorptive capacity for new knowledge. Weiner et al (2004) suggest that organisations at different stages of their life-cycle will have a different organisational learning culture characterised by differences in terms of their experience and expertise with innovation, their readiness and tolerance for change, and their ability to generate and make use of new knowledge. Similarly, Rye & Kimberly (2007) suggest that 'organisational age' is positively associated with 'innovative behaviour'. The findings of this current review also suggest that there are some important processual features within healthcare organisations that bridge these structural and non-structural components. For example, what are the formal committee and governance structures for decision-making relating to technological innovations (structural), and do these maximise best use of the existing knowledge and skills base within the organisation (non-structural)? Similarly, how well do semi-autonomous departments and units (structural) share their experiences of working with pre-existing related technologies (non-structural)?

Our final component within the organisational antecedents category - 'receptive context for change'- clearly includes some elements of absorptive capacity (including the learning organisation culture) but takes a broader view of non-structural organisational antecedents to include general features associated with receptivity to change more generally which means that an organisation will be better able to assimilate innovations. These features include:

- strong leadership
- clear strategic vision
- good managerial relations
- visionary staff in key positions

- a climate conducive to experimentation and risk-taking, and
- effective monitoring and feedback systems that are able to capture and process high-quality data.

The narrative and systematic reviews included in this review drew particular attention to leadership and cultural factors (see for example Lansisalmi, 2006) as did a number of the primary studies (see Koch et al, (1996) on the importance of CEO support) but one feature that was particularly prominent in the primary and secondary studies we reviewed was the role of strategy and strategic positioning (Rye & Kimberly, 2007; Koch et al, 1996); this factor was seen as being positively associated with innovative behaviour if, for example, the organisation wish to be perceived as a 'technology leader'.

Organisational readiness for a specific innovation

An organisation may be amenable to innovation in general (because of the structural and non-structural determinants described above) but not ready or willing to assimilate a particular innovation. The elements of system readiness for a specific innovation as identified in our original review are listed below:

- tension for change
- innovation–system fit
- power balances (supporters versus opponents)
- assessment of implications
- support and advocacy
- dedicated time and resources
- capacity to evaluate the innovation

As noted, many of the determinants identified through Fleuren et al's (2004) systematic review - and included within their 'facilities needed to implement' category - map onto the elements above. Relative to our earlier review, much greater emphasis was placed by the studies we reviewed here firstly on the role of power in determining the success or otherwise of technology adoption and assimilation; an aspect that is particularly pertinent in the healthcare context given that - as Greer (1981) – argued 'no other organisation [than a hospital] exhibits such a striking division in authority and control'. Barley (1986) highlighted power and influence as one of three factors shaping the outcomes of the introduction of a CT scanner into radiology department. Greer (1984) distinguished between different types of physicians and the hospital decision-systems in which they exercised their influence as part of her argument that attempts to influence technology adoption would be more successful if they were directed to the decision systems (comprised of different actors and logics) that are most critical to the adoption of specific technologies. Whilst concluding that the nature of diffusion is highly interactive and influenced by the interplay of a number of factors, Fitzgerald et al (2002) noted that the one common theme in their study was the 'prime influence exercised by the medical profession' in relation to local adoption decisions; a finding echoed by Rosen & Mays (1998) in a second NHS-based study. Denis et al (2002) found that the more the risks and benefits of an innovation map to the interests, value and power of the actors in the adopting system, the easier it is to build coalitions for 'spread'. May et al (2003) draw attention to the need to 'negotiate' functions and roles between heterogenous actors when seeking to normalise telemedicine systems in clinical practice. Wainwright & Waring's (2007) study further emphasises the high level of 'politics' influencing the

adoption and assimilation process. Secondly, the participation of key stakeholders (particularly clinicians) in the adoption and assimilation process - through facilitated networks or formal dissemination programmes together with dedicated time for training - was another common theme in both the primary (Waterman et al, 2007; Weiner et al, 2004) and secondary studies we reviewed (Karsh, 2004; Lansisalmi et al, 2006; Williams et al, 2008).

As with the interrelationships between the structural and non-structural determinants described above, so there are numerous potential links between factors associated with 'oragnisational readiness for a specific innovation' and 'organisational antecedents for innovation in general'; for example, how does the 'assessment of implications' of a specific technology and an organisation's 'capacity to evaluate the innovation' feed into the established, existing decision-making systems (an organisational antecedent)?

5.4.2 A revised model of technological adoption and assimilation in healthcare organisations

There are two key messages to take from the findings of both our original and this latest review. The first is to emphasise once again that the different determinants discussed interact in a complex way with one another, and that these nature and importance of these interactions are likely to vary depending upon:

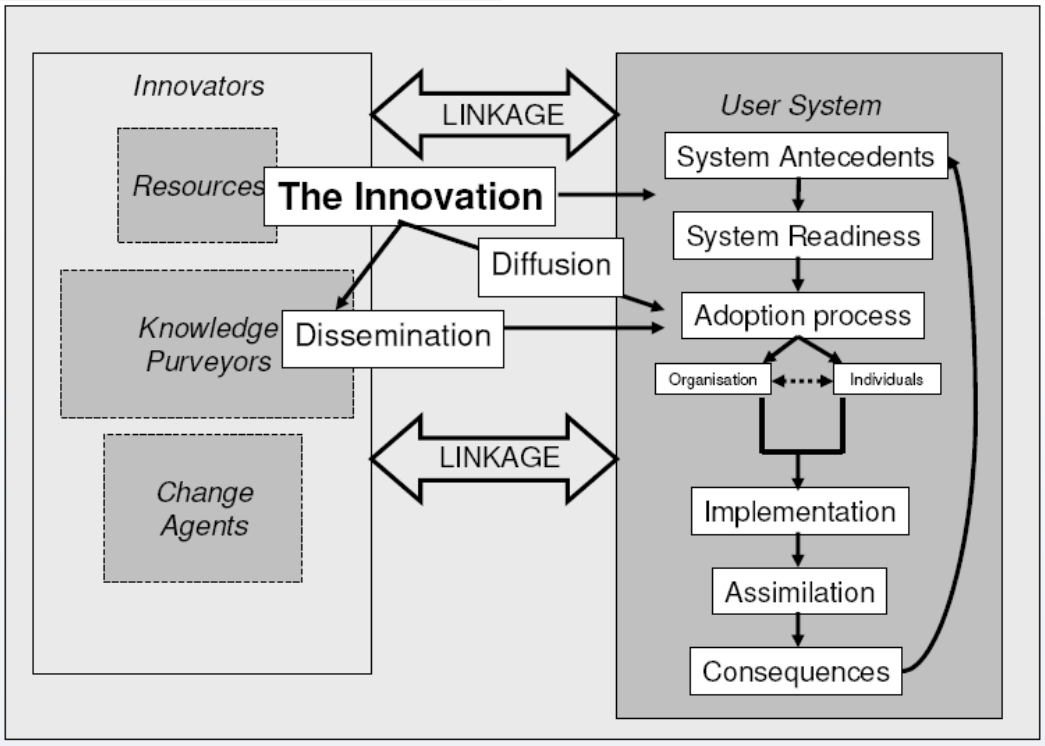
- the specific innovation concerned
- the different actors involved in the various stages of an innovation's adoption, implementation and assimilation into routine clinical practice, and
- the particular organisational context, systems and processes in which 'formal' and 'informal' adoption decisions are made and in which, ultimately, the innovation is to be assimilated.

As Rye & Kimberly (2007) noted, and our review confirms, 'it is unfortunate that so few studies have taken this complexity into account.' A small number of exemplar studies have sought to acknowledge and address this complexity (for example, Ferlie et al, 2002; Denis et al, 2002) but they are very much in the minority. Our 'research recommendations' section at the end of this report takes up this point.

The second key message is - if we seek to further our understanding of how to increase the speed and scale of the realisation of benefits from technological innovations - we have to stress the crucial importance of seeing 'adoption' as a process rather than a discrete event. Timmons (2001) study of 'resistive compliance' amongst nurses towards a new technology that had been successfully adopted and implemented in the eyes of their managers illustrates this point neatly. In our original review we represented this process as moving from 'adoption/assimilation' through to 'implementation within the system' and, whilst acknowledging the distinction between individual and organisational decisions to adopt, represented 'adoption' graphically as one 'stage' in the process. Furthermore, whilst noting that Meyer & Goes's (1988) term 'assimilation' was our preferred conceptualisation of the 'complex adjustments that are often needed in the organisational setting' when a technology is first adopted and then implemented, we represented 'assimilation' as occurring between 'adoption' and 'implementation'. Based on the findings from this review of studies of technological adoption - summarised in section 5.4.1 above - we now present a revised conceptual model (figure 18) that clearly distinguishes between processes of individual and organisational adoption (whilst

acknowledging the interactions between them) and sees assimilation as the end point of the adoption process (and one that follows implementation rather than leading to it):

Figure 18. Revised conceptual model for considering the determinants of the [illegible] assimilation of technological innovations in



In terms of specific refinements to the detailed components of our original model, the implications of our findings suggest greater attention needs to be paid to the following determinants of the adoption and assimilation of technological innovations in healthcare organisations:

- the impact of professionalisation (particularly following Ferlie et al, 2005)
- the relative influence of established organisational decision-making systems and processes (formal and informal; actors and criteria)
- the role of individual and team learning in determining the realisation of benefits from technological innovations
- the strategy and strategic positioning of the organisation
- the nature of power relations and 'politics' of change
- the nature and extent of the participation of key stakeholders in the adoption decision, implementation and assimilation of the technology into routine clinical practice

Of course many of the suggested interventions to increase the 'organisational readiness for innovation' are related to the 'organisational antecedents' (for example, the provision of dedicated time and resources to support the adoption and assimilation of a specific innovation, and the general organisational antecedent of 'slack resources'; similarly 'support and advocacy' and 'leadership and vision'). The following section provides three

particular perspectives on innovation studies which we believe may offer further insights into the process of innovation adoption and assimilation as well as highlighting several of the findings summarised above. In section 7 we then apply our revised determinants to a series of case studies of technological innovations.

6 Technology-in-practice perspectives on innovation adoption and assimilation

Key points

1 Recognising the limitations of much of the existing empirical literature for making recommendations to practitioners, we note the promising but as yet, relatively untested, Normalisation Process Model (May et al, 2006; 2007), which is closely related to the concept of 'assimilation' used in this review. This model comprises four components: interactional workability (which in terms of this review asks: does the innovation fit with the micro-environment of the clinical encounter?); relational integration (does it fit with the network of relationships within which the clinical encounter sits, and especially, how does it impact on issues such as interpersonal trust?); skill set workability (does it fit with the formal and informal division of labour between staff?) and contextual integration (does the organisation understand the innovation and agree to allocate material and human resources to its implementation?).

2. We also offer three examples of the 'technology-in-practice' perspective which if applied in future innovation studies could also potentially offer further insights into the process of innovation adoption and assimilation in healthcare organisations:

   - routinisation theory
   - technology structuration theory
   - actor-network theory

2. Routinisation theory offers a relatively new way of thinking about the embedding of innovation; whilst the empirical literature on its application in healthcare is very sparse, Edmondson et als study of the introduction of minimally invasive cardiac surgery by 16 teams in US hospitals offers a good example of how this theoretical perspective can link the 'micro-level' of human action and interaction with 'macro-level' issues of organisational and institutional change. This theory could help with questions such as: how do collaborative routines emerge in healthcare organisations, and how does their emergence link to the adoption and assimilation of complex innovations?

3. The use of technology structuration theory was developed for Barley's study of the adoption and use of CT scanners which found that introducing the same technological innovation into two different US hospitals had very different impacts (in terms of the patterns of interaction between clinicians and technicians – and hence in the social order (structure) of the two departments. This was due to the complex and subtle differences in historical, contextual and social factors in the two organisations. Using a technology structuration perspective could help explore issues such as: how do teams collaborating around common tasks (e.g. multi-disciplinary care of a patient) negotiate how their respective roles and practices will be shaped and aligned, and how do the material properties and constraints of the technologies impact on this in different settings?

4. Actor-network theory views 'networks' as made up of both people and things (or technological innovations, in the context of this review). The contributions of this theoretical perspective to the literature on technological innovation are likely to lie, firstly, in helping to explain why innovations appear to 'behave' differently in different settings or at different times and, secondly, drawing attention to the unintended consequences of innovation adoption and assimilation (as well as the anticipated outcomes). Novek's study of a networked drug distribution system in a long stay care facility in Canada found that this innovation was never assimilated into routine practice because the abstracted roles and rigid time-bound procedures that had been built into the technology aligned so poorly with the reality of front-line nursing work; the nurses simply reverted to previous ways of working. Typical research questions that might usefully be explored from an actor-network theory perspective include: what are the actor-networks within which particular technologies are embedded, and how do these shape and constrain the use of these technologies?

In our original systematic review of diffusion of service-level innovations in healthcare organisations, published in 2004 (Greenhalgh et al, 2004), we commented that 'routinisation' (what we term here 'assimilation') - the process of embedding innovations so they become 'business as usual' - was an important but under-researched area of enquiry. We also recommended a shift in emphasis in healthcare innovation research, which we felt was over-focused on quantitative research couched in deterministic terms and oriented to producing normative and context-free statements about impacts and outcomes (e.g. 'what is the impact of innovation X on outcome Y?').

Whilst we recognised that determinist studies had already made an important contribution to the knowledge base, we felt that there was a need for in-depth, naturalistic (i.e. real-world rather than experimental) research using mostly qualitative methods and oriented to understanding the micro-detail of work in context; illuminating key processes and interactions; and developing theory. Other authors in healthcare organisation and management research have echoed our call to shift the goal from prescribing what organisational members *should* do (and measuring whether they do it) to studying in detail what they *actually* do (Braithwaite, 2004).

This call recognises that even when a technological innovation has all the attributes of likely 'success' (for example, it is widely acknowledged to have high relative advantage; it is apparently compatible with the values, norms and perceived needs of those who are expected to adopt it; and it has the potential to be adapted to a range of local requirements) there is no guarantee that it will work as well in practice as anticipated. As we have argued previously (Greenhalgh et al, 2005) it is also necessary to explore very carefully the potential interaction between the innovation, its intended adopters and its context when assessing the likelihood of successful implementation. One recently proposed theoretical model that seeks to explain the processes by which complex interventions become routinely embedded in healthcare practice is the Normalization Process Model (May, 2006; May et al, 2007).

Primarily developed to offer a framework for process evaluations of complex interventions (defined as interventions consisting of multiple behavioural, technological and organisational components), the Normalization Process Model was derived from a re-analysis of empirical studies set in the specific context of chronic disease management in primary care in the NHS (May, 2006) [64]. In contrast to the sponsor's original aims for this review, May (2006) notes that:

'It is important to … note that the model does not offer a set of instructions about how to do normalization. Instead, it offers a conceptual framework for understanding the processes in which complex interventions become embedded in practice, and thus sets out a rational framework for their evaluation.'

The authors define 'normalization' as 'the embedding of a technique, technology or organisational change as a routine and taken-for-granted element of clinical practice'; what we have called 'assimilation' in this review. The model explains the normalization of complex interventions by reference to four factors demonstrated to promote or inhibit the operationalisation and embedding of complex interventions:

[64] The model was derived from formative and summative analyses within 23 qualitative studies undertaken between 1995 and 2005 (see also May et al (2003) which earlier drew together the findings of three separate studies of the 'normalisation' of telehealthcare in the NHS, as reviewed in section 5.3.3). Summative propositions were developed through a series of theory-building activities which included testing the propositions against the known outcomes of telemedicine service evaluations (May, 2006).

- interactional workability: how does a complex intervention affect interactions between people and practices?
- relational integration: how does a complex intervention relate to existing knowledge and relationships?
- skill-set workability: how is the current division of labour affected by a complex intervention?
- contextual integration: how does a complex intervention relate to the organisation in which it is set?

The following sections describe three areas of literature - routinisation theory, technology structuration, and actor-network theory - which all take a similar 'technology-in-practice' approach to the assimilation (or 'normalization') of new technologies. They have in common the use of naturalistic, ethnographic methods to study practice, and an interpretive, reflexive approach to analysis. All originated in the 1980s or early 1990s and have developed rapidly in the past five years. Although others have suggested that these approaches - whilst helpful at engaging with complexity at a systems level - may be limited in terms of accounting for everyday micro-level practice and assisting with practical problem-solving (May, 2006), we believe such approaches should be explored further and adaptations of these used to underpin new programmes of research in the healthcare field. Below, we outline the core principles of routinisation theory, structuration theory, and actor-network theory, and describe some examples of empirical studies on the introduction of new technologies from the perspective of these theories. All these traditions have been widely drawn upon by researchers of electronic patient records, and will be covered in more detail in a separate systematic review.

6.1 Routinisation theory[65]

6.1.1 Theoretical basis

An organisational routine (as opposed to the lay use of the term meaning 'personal habit') is *'a repetitive, recognizable pattern of interdependent actions, involving multiple actors'* (Feldman, 2003). Becker (2004) suggested that 'the routine' may be the most fruitful unit of analysis when researching organisational change, and set out its defining characteristics (Box 1). One purpose of routines in organisations is the reduction of uncertainty (and hence, cognitive dissonance and stress). On our first day in a new job, for example, we experience confusion because we do not 'know the ropes'. Work gradually becomes less stressful as we learn whom to interact with, when, where, and how. Another purpose is governance or control – the presence of a routine shapes and constrains the behaviour of people and makes some actions and processes impossible (Becker, 2004).

The development and delivery of effective routines depends on at least three things: structuring devices, people, and organisational learning. We consider these in turn below.

Organisational life is highly structured (Giddens, 1984). This structuring (a sociological term meaning 'patterning', which is nothing to do with [re]structuring of services) is achieved through a number of devices including time, space, artefacts (e.g. documents

65 This section is based partly on Greenhalgh, T. (2008) 'Towards a theory of collaborative healthcare in organisations: Let's think about routines', *British Medical Journal*, 337: 1269-1271.

or technologies), and roles and responsibilities. Østerlund has summarised the key role of time and space:

'The routines that comprise social practices gain their 'routineness' only in so far as they persist in time and over space. Social practices have beginnings and ends that must be managed by the participants.' (Østerlund, 2002: 30)

Box 1: Organisational routines: key characteristics (summarised form Becker, 2004)

- Routines are recurrent, collective, interactive behaviour patterns
- Routines are specific (they have a history, a local context and a particular set of relations) – hence, there is no such thing as universal best practice
- Routines co-ordinate (they work by enhancing interaction among participants)
- Routines have two main purposes – cognitive (knowledge of what to do) and governance (control)
- Routines, by allowing actors to make many decisions at a subconscious level, conserve cognitive power for non-routine activities
- Routines store and pass on knowledge (especially tacit knowledge)
- The knowledge for executing routines may be distributed (everyone has similar knowledge) or dispersed (everyone knows something different; overlaps are small)
- Routines reduce uncertainty, and hence reduce the complexity of individual decisions
- Routines confer stability while containing the seeds of change (through the individual's response to feedback from previous iterations)
- Routines change in a path-dependent manner (i.e. depending on what has gone before)
- Routines are triggered by actor related factors (e.g. aspiration levels) and by external cues

Consider a new doctor who is told by a colleague, 'We all gather round the notes trolley at 8.30 am for the ward round'. This simple example illustrates how collaborative work is supported by the coming together of people *at particular times* and *in particular places* for an *agreed set of tasks* delivered through *agreed roles and responsibilities*, and that *particular artefacts* may serve as 'itineraries' for such complex, collaborative tasks (Berg, 1999). Pentland (1995) has described this structuring process as a 'grammar' of organisational life which seasoned staff follow largely unconsciously and which new members must actively learn.

Technological artefacts such as the telephone, fax machine, desktop computer and personal digital assistant (PDA) can add to the structuring of routines – and sometimes subtract from them – by allowing communication to become 'placeless'. Østerlund (2004) has shown that health professionals tend to gather in information-dense spaces such as 'by the notes trolley' or 'under the white board' when high levels of collaboration are required. The physical presence of a document with the patient structures key moves in the routine such as the transfer of a patient from one part of the healthcare system to another (e.g. without an 'admission sheet', the patient cannot leave the Accident and Emergency department to go to the ward).

The human action and interaction that make up an organisational routine depend on key personal qualities of individuals. People must be capable of undertaking the role that is expected of them – including communicating with, and handing over to, other individuals. This quality is referred to as 'capability' to highlight the need for flexibility, sensitivity to context and responsiveness to the input of others – which is what

distinguishes it from 'competence' (a relatively static and easily-delineated package of knowledge, skills and attitudes) (Fraser & Greenhalgh, 2001).

Another requirement of individuals is an awareness of how the collaborative work of the whole team contributes to the patient's (or the population's) overall care. This can be thought of in terms of what Epstein called 'mindfulness': critical awareness of one's own performance, limitations and needs in the context of clinical work (Epstein, 1999). In a recent analysis of key determinants of quality in high-performing US hospitals, Bate et al (2008) acknowledged this collaborative element of mindfulness: *'….A culture of 'mindfulness' that keeps staff constantly vigilant and alert as to their personal and group standards and practices – being 'awake' to quality and safety concerns, and avoiding 'automatic' or 'standard cookbook' practice.'*

Braithwaite and colleagues (2007) have extended the concept of mindfulness to what they call theory of mind (the capacity to *'understand others' behaviours, mental states and intentions, and use this knowledge to advantage'* [361]) and Machiavellian intelligence (the capacity to *'solve social problems, including to befriend others for our own purposes, manipulate social situations, benefit from social alliances, and to deceive and outwit when necessary'* [360]). These uniquely human abilities form the basis of positive intangibles in organisations such as trust, team spirit and reciprocity, and negative ones like suspicion, blame and 'covering one's back' – all of which may contribute positively or negatively to the work of routinisation.

Another human element in successful routines is identity – the 'self' that individuals actively construct to present to the world (Goffman, 1969). As Pinder et al (2005) have shown, demarcation of roles and responsibilities is not a simple matter of seeing who is able and available to perform a particular role – it also reflects what that role says about *who they are*. The general practitioner who says that shared electronic templates for chronic disease management have 'reduced me to a data entry clerk' is less likely to contribute enthusiastically to collaborative work than one who feels that the templates have helped her to 'do my bit for interdisciplinary, holistic care throughout the patient journey.'

A final dimension of the individual's contribution to organisational routines is agency. As Feldman (2000: 614) has put it, *'Routines are performed by people who think and feel and care. Their reactions are situated in institutional, organisational and personal contexts. Their actions are motivated by will and intention. All of these forces influence the enactment of organisational routines and create in them a tremendous potential for change'.*

The above quote highlights the theoretical tension between 'routines as the preservation of past practice' and 'routines as embodying scope for change'. Recent work in organisational sociology has emphasised that routines are sustained and evolve through the agency and choice of individual actors, especially in response to failure or in a turbulent or threatening external environment (Feldman, 2003; Howard-Grenville, 2005). The term 'routine' refers to both the abstract understanding of what should happen in the routine ('ostensive' aspects) and also to what people actually do ('performative' aspects) (Feldman, 2003; Feldman & Pentland, 2002). Pentland's (1995) 'organisational grammar' offers a repertoire of choices that *could* be made in particular circumstances, but the final decision of what to do in any *actual* circumstance must be made judiciously by the actor. Importantly, it is here – in the tension between ostensive and performative aspects of the routine – that the scope for incremental change (and hence quality improvement) lies (Feldman, 2003; Orlikowski, 2000). To use a somewhat oversimplified example, if everyone is repeatedly late for the ward round and delivers their allotted

contribution half-heartedly, its start time will slip; some people may not turn up for it at all; and quality of care will fall. If on the other hand, people take it on themselves to be punctual and prepared for the ward round, and to suggest ways of making it work better, it sharpens as a collaborative activity and quality of care is likely to improve.

It is worth noting that whilst routines, by virtue of being enacted by human agents, contain the scope for their own refinement and evolution, they are also heavily susceptible to human resistance and failure (see below).

Routinisation theory links to theories of organisational learning (that is, to the means by which organisations capture knowledge about their own activity, reflect on that knowledge, and adjust their systems and processes accordingly) (Garvin et al, 2008). This principle underpins much quality improvement work in healthcare (Wilson et al, 2003). It links to Epstein's (1999) 'culture of mindfulness' (which emerges when there are opportunities for honest reflection, incentives and rewards for asking questions, and training and performance review), and to Weick's (1995) notion of organisational sensemaking. The latter says that organisational members are active framers, cognitively making sense of the events, processes, objects and issues that make up organisational life in a way that links with their personal and professional identity. In a learning organisation, people's cognitive frames are continually shared and negotiated, enabling them to accommodate the frames of others and allow the organisation to better embrace innovation and change. Conversely, where organisational learning is underdeveloped or suppressed, counterproductive 'defensive' routines become entrenched (Argyris, 1985). Organisational learning is important both for embedding and refining helpful routines and also for negotiating and changing unhelpful ones.

Mapping routines in healthcare has many parallels to process mapping, which has shown considerable promise in quality improvement initiatives (Ben-Tovim et al, 2008; Taylor & Randall, 2007). This is no easy task – nor is it likely to suggest simple or resource-neutral solutions. Routines are almost never performed in a vacuum, but overlap with other routines (Becker, 2004). Overlapping routines are especially hard to align if they occur at different speeds or frequencies (Becker, 2004) or cross organisational boundaries (Gittell & Weiss, 2004).

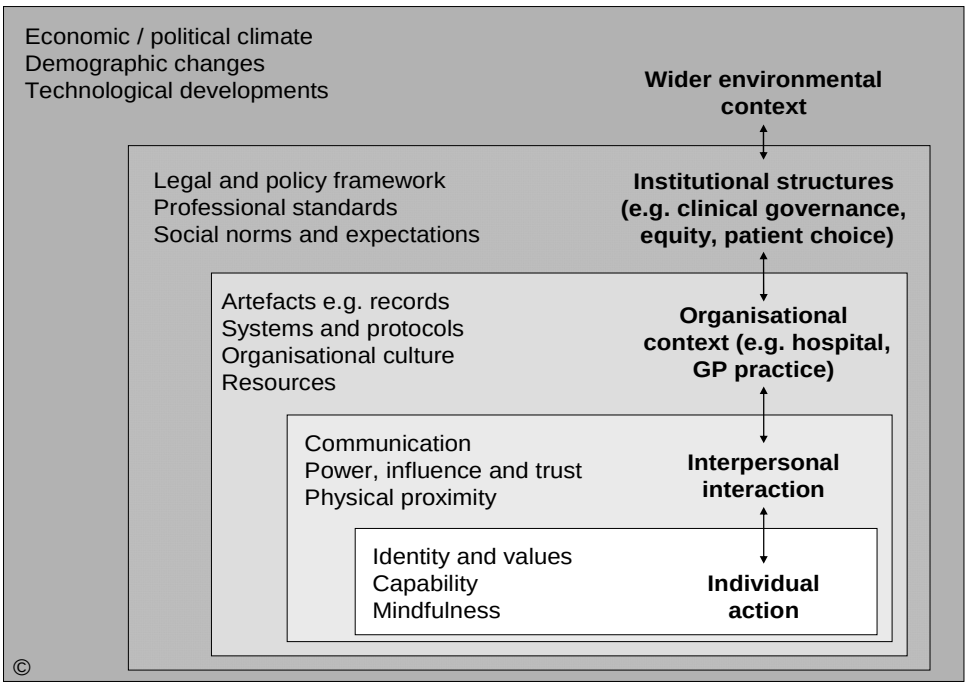
If an innovation is introduced in an organisation, but does not become routinised, this may have a number of explanations at different levels of analysis. At the individual level, people on whom the routine depends may not know what needs to be done or may lack the capability to do it (Fraser & Greenhalgh, 2001). Alternatively, they may know what is required of them but choose not to do it because it does not fit with their identity, values, or goals (Pratt et al, 2006). At the interpersonal level, they may fail to interact effectively with other actors – because they lack 'theory of mind', Machiavellian intelligence or organisational power, or because they do not trust individuals (perhaps due to clashes of professional culture) (Barley, 1986).

At organisational level, there may be a variety of problems (e.g. the routine is under-resourced or poorly coordinated; the technology is inadequate; the new routine conflicts with other more established or critical routines; key actors lack the necessary autonomy, or leaders create a weak or inappropriate 'framing' for the routine and fail to invest in training at the level of the team) (Howard-Grenville, 2005; Edmondson et al, 2001). At the level of institutional structures (for example, professional codes of conduct, legal frameworks, prevailing patient expectations), there may be constraints or drivers such as laws, codes, and expectations of how a 'good clinician' would behave (e.g. clinical governance, equity. choice) (Scott, 2001). Finally, wider environmental forces (such as

economic pressure) may creative incentives or disincentives for particular routines. These are shown in figure 19.

In summary, this section has briefly introduced a rich and complex sociological literature on organisational routines, which offers new ways of thinking about the embedding of innovation in healthcare. The flexible and emergent nature of organisational routines, and the fact that they are always enacted by thinking agents in particular contexts, means that whilst routines should be mapped and understood at an abstract level in an organisation, they should not normally be formalised through detailed written rules. A ward round undertaken under Standard Operating Procedures would surely be a nightmare – but a mindful team that actively seeks to contribute to, make sense of, and learn from, its ward rounds will refine and improve this routine every time it is enacted.

Figure 19. Figure 1: Multiple levels of influence on the routinisation of innovation



6.1.2 Examples of empirical studies that used routinisation theory

The empirical literature on the application of routinisation theory in healthcare is very sparse. Whilst several studies have documented the extent to which routines are disrupted by new technologies, we did not find any that looked at how routines might 'embody scope for change' via the agency and initiative of individual staff (see above) and thus help in the embedding of innovation in an organisation.

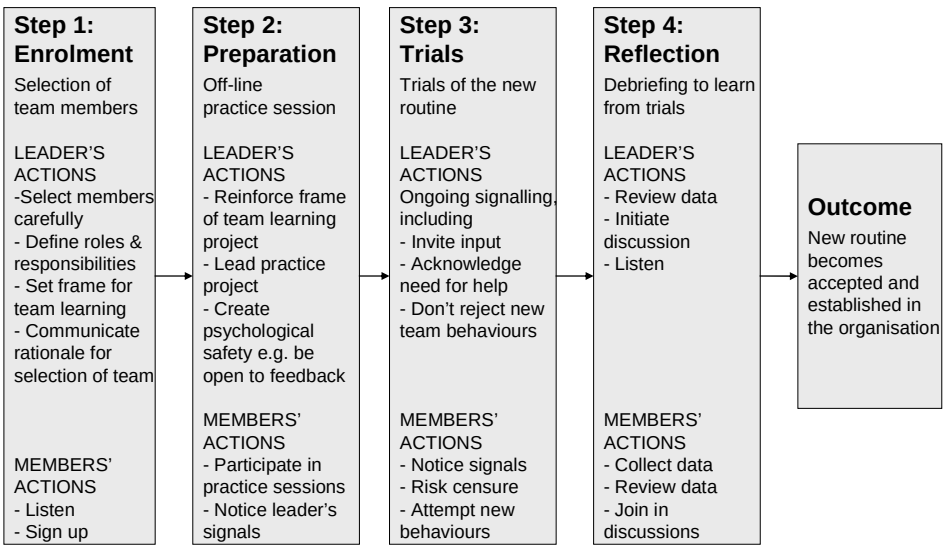
In a study from Quebec, Canada, Lehoux et al (2002) studied the implementation of a telemedicine innovation in six specialties in a single hospital. They studied how the technologies linked (or failed to link) with existing roles and routines. They undertook a total of 37 in-depth interviews to address two main questions: (1) To what extent can teleconsultations be integrated into the routines of diverse medical specialities'? and (2) Why and how might clinicians use this technology? Their findings indicated that specialties relying on either thorough physical examinations or specialised investigative techniques were much less likely to restructure their work routines to accommodate

teleconsultation, which they viewed as 'limited'. Specialities that primarily used images or numerical data tended to perceive teleconsultation as more useful and readily aligned with their routines. The perceived enabling properties of teleconsultation increased as a function of the distance the patient would have to travel to be seen directly by a consultant. The constraining properties were linked to the type of information transmitted, since physicians believed that only 'objective' data could be safely consulted from a distance, whereas relying on the remote physician's interpretation of subjective information was considered inappropriate. These authors reached the important – if unsurprising – conclusion that the development of teleconsultation should be consolidated around applications whose theory of use is compatible with existing clinical routines, or offers opportunities to restructure clinical work according to the needs of providers and remote communities.

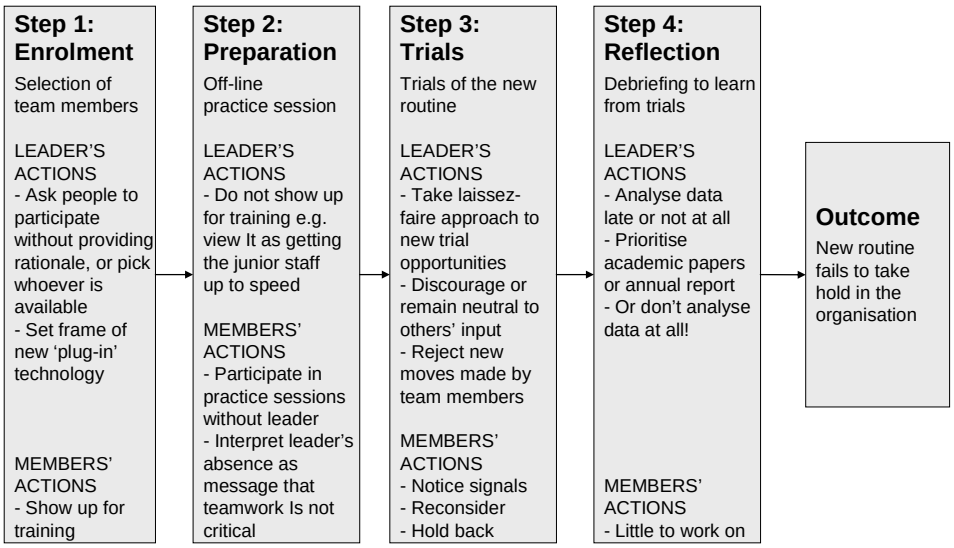
Organisational sociologist Amy Edmondson studied the attempted routinisation of minimally invasive cardiac surgery (MICS) by 16 hospital cardiac surgery teams in the USA – an innovation that was based on a new technology (the kit for 'keyhole' surgery) but which also required extensive changes to ways of working by the surgical teams (Edmondson et al, 2001). There was wide variation in success, and Edmondson used qualitative methods to compare the 7 most successful teams with the 7 least successful (figure 20). Edmondson found that successful teams had leaders who had framed the initiative as one that required wider changes in roles and interactions, selected their members carefully for their potential contribution to the new routine, presented the training as an opportunity to develop as a team, set a 'psychologically safe' atmosphere for negotiation and questions, and led the collection of, and reflection on, audit data.

Unsuccessful teams had leaders who framed the innovation as a 'plug-in technology', selected team members haphazardly or out of convenience, framed training as a way of getting juniors up to speed (and failed to turn up to it themselves), discouraged questioning or attempts at reframing, and prioritised the writing of academic papers rather than the use of data in the quality improvement cycle.

Figure 20. Explaining successful and unsuccessful attempts to routinise minimally invasive cardiac surgery (MICS, adapted from Edmondson)[30]



WHEN THE ATTEMPT TO ROUTINISE MICS FAILED:



6.1.3 Future research

Routinisation theory opens up an exciting new agenda for empirical research in healthcare organisations that links the 'micro' of human action and interaction with the 'macro' of organisational and institutional change (Giddens, 1984). Examples of preliminary questions for this agenda are shown in Box 3.

Box 3: Examples of research questions on the routinisation of innovation in healthcare organisations

- How do collaborative routines emerge in healthcare organisations, and how does their emergence link to the embedding of complex innovations?
- How are these routines shaped and sustained by the purposive action of individuals – and how does this process link to wider themes of organisational learning and quality improvement?
- What is the nature of the work which individuals and teams need to do to keep routines alive and adapt them responsively to change – and how can this process be optimised and supported?
- How is the enactment of particular routines by individuals influenced by such things as professional identity, capability, organisational power, and access to resources?
- How might systems and technologies intended to support collaborative healthcare routines actually interfere with them?
- Could the systematic study of existing routines be a useful starting point for the design of collaborative technologies (such as electronic records)?
- What is the link between 'failed' routines and the risk and safety agenda (for example, could critical event audit be adapted to consider the different levels of influence in Figure 1)?

6.2 Technology structuration theory

6.2.1 Theoretical basis

Technology structuration theory is closely linked to routinisation theory. Indeed, the latter (a 'middle range theory') might be seen as a specific application of the former (a 'macro theory' usually presented at a high level of abstraction), though the authors of

routinisation theory draw a distinction between them (Pentland & Feldman, 2007). Structuration theory, originally developed by Anthony Giddens and extended by Robert Stones as 'strong structuration theory', proposes that social life is more than random individual acts, but is not passively determined by social forces (Giddens, 1986; Stones, 2005). The 'micro' of human agency and the 'macro' of social structure are in a relationship with each other such that the repetition of the acts of individual agents [re]produces the structure. Traditions, norms, moral codes, and 'established' ways of doing things strongly influence our behaviour, but they gradually and iteratively change when we start to ignore them, replace them, or reproduce them differently.

Giddens himself made little mention of technology in his original structuration theory, but his theory is widely believed to be particularly useful for studying the introduction of technology. Two different groups, both based in the USA, have built on Giddens' work to address how the properties and utilisation of technology can be aligned with the study of the discursive relationship between social structure and individual agency. One group draws on the work of de Sanctis and Poole, and another (largely separate tradition) draws on that of Steve Barley and Wanda Orlikowski.

Barley and Tolbert introduced the useful concept of the 'script' to describe how social structures (which they refer to as 'institutions') are enacted by individuals (Barley & Tolbert, 1997; Barley, 1990). A script – a concept closely linked to 'routine' (but which is not necessarily about collaborative work in organisations) – is a recurrent and observable pattern of social action which embodies and reflects social structures. We kneel in (some) churches. We put our hands up in class (if we know the answer but not otherwise, and only if we are a pupil). If the doctor says 'say Ah', we open our mouth, allow a wooden stick to be placed on our tongue, and utter the appropriate expression. We do all these things because we know how to behave, and how others are likely to behave in response to the different actions we might contemplate. Those who do not behave as expected are usually classifiable as eccentric, gauche, criminal, resistant, or 'just off the boat' – i.e. they do not know (or are wilfully ignoring) social structures such as norms, moral codes, rules, social roles, and systems of authority.[66] Scripts amount to a 'grammar' of social action with 'moves' that novice actors in any field must learn and which more experienced actors actively shape (Pentland, 1995).

The change in social structures over time through the enactment of scripts is shown in figure 21, which is adapted from Barley and Tolbert's empirical application of structuration theory to the study organisational work (in which 'the script' is taken as the unit of analysis). The figure illustrates a technique called *temporal bracketing*, in which the same phenomenon is studied longitudinally by collecting data at successive time points. 'The script', for example, can be studied at Time 1, Time 2, and Time 3.

[66] Whilst scripts are an enticing and easily understood notion, Barley and others' work on this topic has been criticised for focusing exclusively on observed behaviour and ignoring the crucial role of language ('discourse') in the production and reproduction of social structures.[37]

Figure 21. Production reproduction and change overtime in scripts for social behaviour (adapted from Barely & Tolbert 1997)

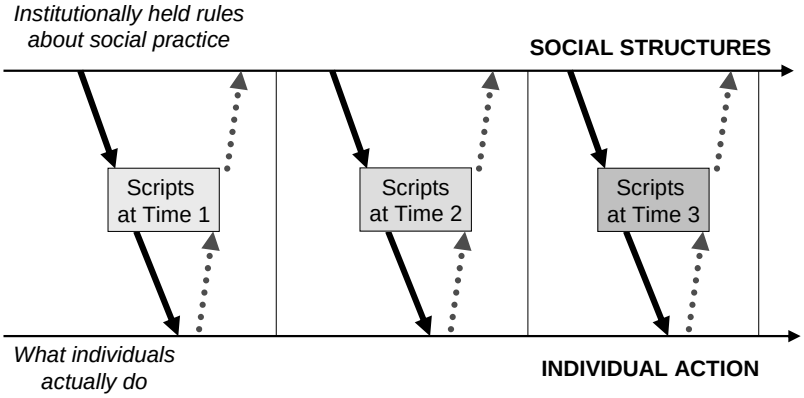


Figure 3: Production, reproduction and change over time in scripts for social behaviour (adapted from Barley & Tolbert 1997)

DeSanctis and Poole (1994) proposed the widely-cited Adaptive Structuration Theory (AST): *'adaptation of technology structures by organisational actors is a key factor in organisational change'* (page 122). A central concept in AST is appropriation (changing a thing by using it). If staff in a GP practice use the on-screen messaging facility to flag that coffee is ready, for example, they have 'appropriated' this technology; the 'script' of a receptionist putting her head round each doctor's door to convey this message changes to one that is much less intrusive to patients. The authors present AST as bringing together 'hard' (technocentric, rationalistic, quantitative, decision-focused) and 'soft' (interpretive, hermeneutic, qualitative, meaning-focused) IS research through the study of structuration. Confusingly, DeSanctis and Poole use the term 'structure' in two different ways – to denote social structures (as above), which they see as 'built into' technologies; and also in a more concrete, positivist way to denote the data and decision models which are also 'built into' technologies.

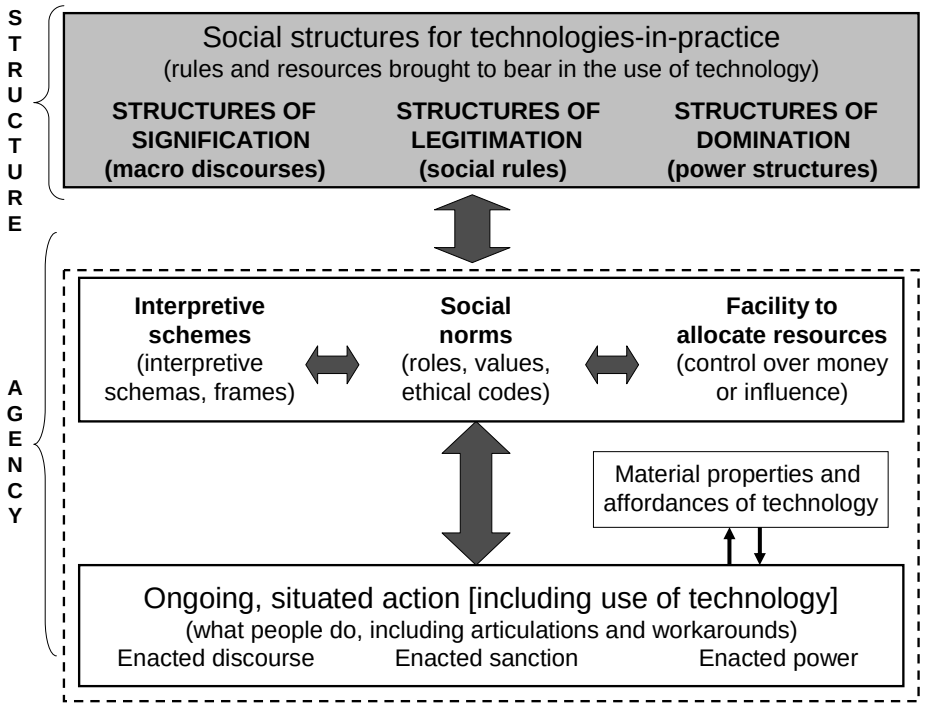
In applying AST empirically, DeSanctis and Poole propose a somewhat positivistic approach based on the development and testing of formal propositions and the classification and coding of human behaviour against a limited menu; all with a view to producing more-or-less predictive models of the factors that influence the processes and outcomes of technology use in organisations.

Orlikowski's application of structuration theory, shown in figure 22, is (arguably) more faithful to Giddens' original description than AST. Orlikowski (2000) firmly rejects the notion that social structures are 'built into' technologies, arguing instead that such structures are *enacted as people use those technologies*. Instead of the 'appropriation' of AST, Orlikowski talks of 'interpretive flexibility' (which places much greater emphasis on the actor's interpretation of his or her action in social context). In the coffee message example, the key issue for interpretive flexibility is not merely to ascertain that staff have begun to use the internal messaging system to call the doctors for coffee, but to explore *why* (from their perspective) they have done this. Do they, for example, explain their action in terms of this way of working being 'more professional', 'more time-efficient' or 'as instructed by the senior partner'? Given this emphasis on hermeneutic (meaning-making) analysis, it is not surprising that Orlikowski and others who follow her empirical approach favour detailed ethnography of work in practice over the counting or coding of behaviour.

A technology structuration perspective, argues Orlikowski (2000: 405), is *'inherently dynamic and grounded in ongoing human action'*. This has important implications for research, which must focus on technologies-in-use rather than on their abstract properties or people's ideas or plans about them. If, for example, the on-screen messaging system is never accessed by practice staff, it cannot be claimed to have 'structured' organisational life. However, once people begin to use it, in doing so they will reproduce (and perhaps change) prevailing discourses, the allocation of resources, and social norms relating to organisational work.[67]

Orlikowski's empirical work on information systems has focused particularly on collaborative work – in which multiple actors, working collectively around common tasks, engage in a dual process of adapting the meaning, properties and applications of technologies to a particular context, and a parallel process of adapting the context to the technology – the *[meta]structuring* of technology.

Figure 22. Technology structuration (adapted from Orlikowski, 2000)



If, as structuration theory contends, social structures are mediated by what humans 'know', then the role of technology in supporting 'knowing' is crucial. A practice-based perspective on knowledge in organisations sees it as emergent, embodied, embedded, and bound up with the materiality (physical properties and affordances) of technologies

[67] It could be argued that this insistence on social structures having no independent external reality but being 'instantiated in practice' is a touch *too* faithful to Giddens' original theory. Giddens himself has been widely criticised for reducing social structures to 'memory traces' in the minds of social actors – a framing which weakens the potential to ask radical questions about the institutionalised inequalities via which some groups have more access to 'empowering' technologies than others. The limited uptake of technology structuration theory by academics in the UK may be partly explained by the unpopular linking of Giddens and his structuration theory with New Labour's 'Third Way' politics, which (arguably) places responsibility for reducing inequalities onto the citizen-consumer (Greener, 2008; Clarke, 2005).

(Orlikowski, 2006). Orlikowski suggests that the materiality of technology serve as a 'scaffolding' for human knowledgability. So, for example, human knowledgability is shaped and constrained by the speed of a connection, the size of rooms, the affordances of software, the interoperability of programmes, and so on.

A central tenet of structuration theory is the recursive relationship between technology and work, and this has implications for what is generally known as 'training'. Training implicitly sees the technology as given and the user as an individual who must acquire certain skills and techniques. Arguably, a more fluid and reciprocal approach must be taken if 'training' is to be successful. Technology use mediation (TUM) has been defined by Orlikowski and colleagues (1995: 424) as the *'deliberate, ongoing and organisationally-sanctioned intervention within the context of use that helps to adapt new communication technology to that context, modifies the context as appropriate to accommodate that use of the technology, and facilitates the ongoing effectiveness of that technology over time.'* TUM is thus subtly different from standard implementation support such as on-the-job training or job redesign, and from individual-level structuring (the modifications that all users make to adjust the technology to their particular needs).

TUM is where a subset of organisational members (who are users of the technology themselves) take officially-sanctioned actions in order to make ongoing and episodic adjustments to the technology and to the institutional properties of the organisation on behalf of all users (Orlikowski et al, 1995; Davidson & Chiasson, 2005).[68] When a specialist technology (such as the EPR) is introduced, considerable contextualising work is needed to reconcile the properties of the technology with existing organisational practices (for example, deciding which functionalities of the software to activate and/or how to reconfigure certain organisational routines). Such contextualising is necessary (and indeed, may be even more necessary) even with 'plug and play' technologies because of the social design assumptions embedded in the software. TUM can – in theory – be provided either within the organisation or via external change agents or consultants.

6.2.2 Empirical examples of technology structuration theory applied to healthcare

Most of the empirical studies in this category focused on electronic patient records and will be covered in a separate review. But the use of technology structuration theory was actually developed for study of CT scanners. Barley's (1986) paper 'Technology as an occasion for structuring' was a landmark early study which used the 'script' as the unit of analysis to explore changes in medical work roles and interaction in two different hospitals following the introduction of the CT scanner. Whilst the technology itself is no longer new, Barley's study offers an important and extensively-cited methodology that could be applied to the study of contemporary technological innovations healthcare. Barley showed how the introduction of the CT scanner into hospital radiology departments was accompanied by changes in patterns of interaction between clinicians and technicians – and hence in the social order of the departments. He compared two

[68] TUM involves four phases: *establishment,* where the mediators set up the technology and propose how it will be used; *reinforcement,* in which users are encouraged and assisted to maintain the technology's reliable performance; *adjustment*, in which mediators refine rules and procedures around the technology's use within the system; and *episodic changes,* assessments and (where necessary) restructuring of the technology and related practices, which may be triggered by external events such as a new release of software.

different hospitals which introduced the same new technology (the CT scanner) with very different results. In an accessible analysis of Barley's study, organisational sociologist Karl Weick (1990: 19) comments:

'At first the technology is exogenous. When translated into a technical system, it either confirms ingrained interaction patterns or disturbs and reformulates them. These patterns are carried by scripts – standard plots and types of encounters whose repetition constitutes the setting's interaction order – which create reciprocal links between structure and action. Thus, the technology ratifies or alters scripts that have grown up as a result of previous structuring. When the new body-imaging technologies were introduced, radiologists and technicians alike drew on traditional, institutionalized patterns of signification, legitimation and domination to construct roles to deal with this technology and to interpret the strange products that it produced. However, the traditional pattern of technicians' deference to professional radiologists proved inadequate, especially at [Hospital A] because radiologists had only modest understanding of the technology. [..] Given this slippage, new patterns of action emerged and were incorporated into lasting scripts that made a lasting change in institutional structure.'

Thus, the 'same' technology had very different impacts (and was used differently) in two different hospitals because of complex and subtle differences in historical, contextual and social factors. This is perhaps unsurprising, but Barley's conclusion (captured in the title) that technology is an 'occasion for structuring' rather than deterministic of particular outcomes contrasts starkly with mainstream research in the medical field, which often assumes that technology A will have measurable and predictable impact B.

6.2.3 Future research

The technology structuration sub-traditions within organisational sociology and information systems research offer richly-theorised accounts of the nature of organisational work and how new technologies (with their promises of 'timeless' and 'spaceless' working) raise challenges as well as opportunities, particularly for the complex collaborative work that characterises much contemporary healthcare. Again, there is a huge potential research agenda in this field, for which examples of potential questions are given in Box 4 below.

Box 4: Examples of research questions on the introduction of technology in healthcare organisations from a technology structuration perspective

- How do individuals actively shape the technologies they are implementing, both during initial adoption and also over time – and how do they also shape their own role and the wider context to accommodate the technology?
- How do teams collaborating around common tasks (e.g. multi-disciplinary care of a patient) negotiate how their respective roles and practices will be shaped and aligned, and how do the material properties and constraints of the technologies impact on this in different settings?
- What is the nature of the 'workarounds' that individuals develop to ensure effective and efficient work routines despite the limitations of technologies? What sort of adaptations and interpretive flexibility are applied, and how might this aspect of 'embedding technology' be enhanced?
- In relation to electronic records and other communication artefacts, what communicative genres are in play in different situations and scripts? What audiences are implied in different entries on such genres, and how might genre theory be used to help [re]design such technologies to achieve the goal of 're-localisation' when multiple professional in multiple places seek to collaborate via networked technologies?

6.3 Actor-network theory

Actor-network theory (ANT) emerged in the discipline of science and technology studies (previously known as 'philosophy of science'). In contrast to technology structuration theory, whose development and application has been almost exclusively in north America, ANT has its roots in the 'French school' of Bruno Latour (who drew eclectically on the work of Michel Foucault) and has been taken forward mainly by researchers in Netherlands and Scandinavia. ANT is an example of an empirical philosophy – that is, a philosophical school whose ideas and theories are based on a careful observation of the real world rather than the contemplation of 'a priori' truths. Specifically, ANT scholars build their work on detailed ethnographic research, and ask ontological questions ('what is the nature of the reality we are discovering [and helping to define]?').

Whereas research traditions whose unit of analysis is 'the network' have generally considered either social networks (for example, the seminal work of Burt (2004) and Granovetter (1973) on the 'structural holes' and 'weak ties' which characterised the networks between humans) or technical networks (for example, the design and analysis of large-scale, distributed computer networks), ANT offers a novel and important idea: that it is more helpful to view networks as made up of *both* humans *and* non-humans. The word 'actor' in ANT can refer to either human or non-human, and is sometimes replaced by the less anthropomorphic term 'actant'.

The underpinning philosophy of ANT grew out of an early ethnographic study by Latour & Woolgar (1979) of the work of scientists in laboratories. He found a startling disjunction between what scientists said they did (objectively measure external reality) and what they actually did (argue amongst themselves about what reality *is* and how it should be measured). This finding links to the seminal work of a number of other theorists who have addressed the nature of practice, including Thomas Kuhn (1962) who considered the origin, development, and rejection of scientific paradigms; Lave and Wenger (1991) who developed the notion of communities of practice; and Brown and Duguid (1991) who applied the concept of communities of practice to innovation in organisations. All these perspectives have in common the idea that truth and knowledge are not something 'out there' to be discovered; rather, they are the *products* of performance and negotiation by practitioners in a community.[69]

The distinguishing contribution of ANT to innovation research includes a number of key concepts and ideas. The first is the network itself. In ANT, the essential, given properties of people and things are of no interest; what is of interest is what people and things *become* as a result of their position in a particular network of other people and other things (this is known as 'relational ontology'). The author of this review, for example, is only 'a systematic reviewer' because she is connected to a computer, a set of electronic databases, an infrastructure for obtaining funding, an agreed methodology, a peer-review process, a means of publishing her findings, and a future audience. As Berg (1999) has observed:

---

69 As Harris has pointed out, Latour's research findings on scientific practice were initially presented as a study in social constructivism (the first edition of Latour and Woolgar's book was subtitled 'the social construction of scientific facts'[49]) but Latour later recast his analysis in a new philosophy which is now called *relational ontology*, whose focus is on *what is done and how* rather than *what meanings are made* (the second version of the book was subtitled simply 'the construction of scientific facts').[53]

'The elements that constitute these networks should not be seen as discrete, well-circumscribed entities with pre-fixed characteristics. Rather, those entities acquire specific characteristics, roles and tasks only as part of a network. A 'physician' is only a 'physician' in the modern western sense because of the network of which s/he is a part and which makes his/her work and responsibilities a reality. [….] Because of this tight interrelation between elements in a network, the introduction of a new element or the disappearance of an element (as when a hospital stops training junior residents) often reverberates throughout the healthcare practice.'

The second key concept in ANT is what Latour called 'the sociology of translation'. By this, he meant that key players interact to build heterogeneous networks of human and non-human actors, forming alliances and mobilising resources as they strive to convert an idea into reality. Indeed, Latour (1996: 23) made a telling observation that *'By definition, a technological project is a fiction, since at the outset it does not exist'*. The central focus of ANT in this context is the process by which a technology project is 'brought into being' through the process of translation and how it changes over time. The picture is always a dynamic one, as actors interrelate, define one another, and realise their dreams (or not) by mobilising intermediaries, such as technical artefacts, texts, human skills and money (Callon, 1986; 1991). Translation is achieved by displacements that require discourse and the exercise of power, and it may or may not achieve the desired outcome.

This continuous, organic realignment of people and technologies – driven both by what humans desire and what technologies are capable of – is what Latour (1992) calls the 'chain of transformation'. What emerges may not be a unified, shared goal – indeed, the concept of the 'network' is that different actors often have conflicting goals, and outcomes are the result of struggles between different interest groups and the flow of power through the network. The ANT view of power is derived from the work of Foucault (1984), who argued that power is generated through the duality of relationships, rather than something individuals 'possess'.

The third distinguishing contribution of ANT to innovation research is a practice-focused view of 'organisation'. Traditionally, an organisation was a building (or collection of buildings) plus the people who worked there. These days, we are quite used to 'distributed organisations' with activities taking place in different locations, and to 'virtual organisations' where some or all members work from home; and we know that many organisations integrate horizontally and vertically with other organisations to deliver a process or product. ANT shifts the focus from 'the organisation' (which is an increasingly unhelpful concept in this distributed world) to 'organising' (the coming-together of people and technologies to achieve a particular shared goal) (Latour, 1995).

The fourth key notion in ANT is that networks, since they are so dynamic, are inherently unstable; their components never become locked in place or predictable. Stability of the network is always a truce of some sort, and the extent to which it is ever achieved depends on the degree to which translations are compatible and integrated (convergence of the network) and on the extent to which translations can withstand challenge and shape future translations (irreversibility of the network).[70] Elements of the network that are durable (such as materials) will lend stability; those that are ephemeral (such as

[70] Whilst Latour is occasionally criticised for a kind of 'anything goes' postmodern relativism, he explicitly distances himself from relativism partly on the grounds that networks may stabilise and become effectively 'irreversible'.

thoughts) will not. Latour observed that in the practice of science, 'factual' statements about the natural world are produced and stabilised (i.e. become progressively harder to challenge) through the use of *inscription devices* – a term he used to refer to the diagrams, textual notations, and so on which capture a particular set of relations between people and things, and which can be represented, transmitted, manipulated and so on by members of the community.

More generally, irreversibility of a network is achieved through 'black boxes' – configurations of actors (human and non-human) which are taken-for-granted as 'the way things are', and hence no longer questioned. A key contributor to this is what Latour (1990) called immutable mobiles – inscription devices that move within a network and its nodal points of passage, but which retain the same essential properties in different contexts and can be reproduced and scaled up or down, thereby allowing relations to be performed in the same way in a variety of different contexts and locations.

Mol has challenged the notion of immutable mobiles, on the grounds that 'immutability' might help the transferability of an object only in some contexts, while in other contexts the object would be more transferable if its properties were *not* fixed. A classic study in the ANT tradition is de Laet and Mol's (2000) account of the Zimbabwean Bush Pump (a low-tech device for pumping water out of the ground and cleaning it). The Bush Pump is an example of a 'fluid object' – one whose widespread success is explained by the fact that its essence changes as it becomes part of different actor-networks. A key reason for the success of this initiative, suggest the authors, was the 'decentring of the inventor' – an insightful individual who refused to patent the bush pump, thus allowing it to be modified as it travelled to different settings.

The tension between 'fixed' and 'fluid' objects has been captured by what Susan Leigh Star (2002) called 'boundary objects', which are: *'objects that dwell in more than one community of practice – a discipline, or a line of work, or a voluntary association. They have two important properties: they are loosely structured in common use, and become more tightly bound in particular locations. They are thus both ambiguous and clear, at different moments, for different purposes.'*

The fifth concept from ANT that links to innovation is 'unintended consequences'. Because actor-networks are heterogeneous and organically evolving open systems, a fixed input to the system will not produce a fixed output (Hanseth, 2007). Furthermore, the unintended consequences of introducing a new technology (or a new human) into the system will feed back on the system and produce further shifts in the relations between its members. Such phenomena cannot be predicted – they can only be described as they unfold. Furthermore, as Hanseth (2007) has observed, *'The more complex a system is, the more incomplete our knowledge will be, and the more unintended effects our interventions will produce. We can say that the more complex a system is, the more its overall behaviours will be caused by propagation of side-effects rather than intended effects.'* This, incidentally, is an portentous warning to those who would solve healthcare's problems by introducing large-scale IT systems aimed at linking across multiple boundaries.

The final distinguishing characteristic of ANT is what has been termed its 'flat ontology'. Whereas many sociological theories (e.g. structuration theory, social realism, Marxism) rest on the discursive relation between two 'layers' in society: the 'macro' (social structures, sometimes referred to as institutions) and the 'micro' (individual agency), ANT holds that there are no pre-existing layers but only *'a single plane of endlessly entangled translations'* (Harris, 2005: 173). The nearest a hard-line ANT theorist will get

to admitting the existence of social structures is the notion of the 'black box' (se above) – though even the latter represents only a set of stable-for-now relations that could change at any time. Callon and Latour (1986), for example, produced the widely-quoted statement back in 1986 that *'macro-actors are micro-actors seated on top of many (leaky) black boxes.'* More recently, Harris (2005: 165) summed up ANT's treatment of social institutions:

'…institutions are loci of methods of ordering, whose essential operation resides in the recurrent patterns by which the relations between humans (subjects) and non-humans (objects) are generated and maintained. These patterns are not architectonic, they do not precede or exceed the site of their operation: organisations (noun) are sustained by organisation (verb).'

In terms of its contribution to the literature on technology-based innovation, ANT may be particularly helpful in conceptualising innovations which are linked in complex ways to multiple different human actors and to multiple other technologies, and which seem to behave differently in different settings or at different times (and perhaps, those which behave similarly in different contexts). It draws our attention to how inscription devices (maps, diagrams, graphs, lists, pull-down menus) are used to capture and stabilise the relations between people and technologies. It also views as 'data' the arguments that occur in science and technology communities about the nature of reality (for example, about the standards that should be built into IT systems to reflect such things as the normal ranges for blood tests or the diagnostic codes for diseases (Hanseth et al, 2006)). Indeed, Star (2002: 115) has even defined a scientific discipline as *'a commitment to engage in disagreements'*. Finally, ANT brings into frame the unintended consequences of technologies and technology programmes, and requires us to give these at least as much attention as the outcomes we expected to see.

At a higher level of abstraction, it is worth highlighting that ANT is more interested in exploring dualities than resolving dualisms. A duality is a tension between two poles whereas a dualism is a fixed either-or.[71] We should, for example, shelve the unhelpful question of whether an innovation 'should' be immutable (i.e. with fixed and standardised properties) or fluid (with properties that change with the context). Rather, we should accept that there is a continuous and unresolvable tension between (on the one hand) the need to standardise some properties of technologies (for example to maximise technical inter-operability and the capacity of users to operate them) and (on the other hand) the need for technologies to be sensitive to local contingencies and interests – a tension sometimes referred to as the 'interplay between control and contingency' (Novek, 2002).

Another unresolvable tension recognised in ANT is the inherent gap between the formal and the informal. In an important conceptual paper, in which he used the electronic patient record as an example, Berg (1997) exhorted researchers to move beyond studying the dualism in which 'reality' (the lived body of the patient, or the practical reality of clinical medicine – which is messy, heterogeneous, concrete and impossible to

[71] Thinking about duality arguably allows a richer and less entrenched theorisation of reality. The male-female tension, for example, moves on from 'domination of women by men, always and necessarily until the revolution' and instead considers a dynamic tension between 'male' characteristics and values (emotionally cool, rationalist, competitive) and 'female' ones (emotionally warm, intuitive, collaborative). Traditional feminism explicitly favoured the latter as 'better', but a post-feminist 'duality' view would see problems in terms of the inherent tension (and strive for balance) between one and the other.

order in a single scheme) is compared to a 'model of reality' (the representation of this body and this practice in the electronic record – which is symbolic, clean, abstract, homogeneous and hence unproblematically sorted and coded). The electronic record is an example of a formal tool (i.e. one that contains a model of reality and operates via circumscribed input using rules). A 'dualism' approach leads the researcher to lament that the model does not correspond closely enough to reality (see, for example, examples cited in Hollan et al, 2000). But a 'duality' approach encourages a focus on the skilful human work that *links* the reality to the model using creativity, intelligence and flexibility. The point is not that human work is creative or that technologies have fixed functionality – it is that human creativity can link to particular functionalities in particular technologies to generate new possibilities.

'More and more,…authors are calling for the need to reconfigure this dichotomous opposition between the formal and the informal. The positions are too entrenched; the rhetorics, too outdated; the foundations, too essentialist. Several authors have argued that formal tools can indeed transform workplaces in various ways but that this generative power can be attributed neither to the tool nor to the human workers. Rather, the generative power of this configuration lies in the interrelation of the formal with the informal. The distance between representation and represented, the existence of the gap, is here seen as the fruitful tension that can produce new worlds.' (Berg, 1997)

ANT is not without controversy. Many academics have summarised the criticisms that have been levelled at it; three in particular are clearly written and linked to the use of ANT in the study of information systems (Harris, 2005; McLean & Hassard, 2004; Mutch, 2002). The main criticisms can be summarised as follows:

- The principle of 'general symmetry' between humans and non-humans in the actor-network (and hence the implication that either technologies have agency or humans don't). The idea that people are not thinking, feeling agents but components of a network runs counter to common sense. People are very different from things, and human desire and agency is a powerful force in social phenomena. Reducing humans to comparable status to technologies denies essential human virtues (wisdom, judgement, courage, and so on) and ducks out of key moral questions to which, surely, humans and not things must find the answers. For this reason, proponents of ANT have been accused of *'playing a game of epistemological chicken'* (McLean & Hassard, 2004). ANT's protagonists respond that the focus of analysis is not the individual human actor but the dynamic network of which s/he is a part: *'actor networks are relentlessly produced and reproduced. The point here is not whether the actants of a network are social or technical but…which associations are stronger and which are weaker' (ibid)*. But as Mutch has pointed out, *'treating non-humans symmetrically in methodological terms is not the same as conceding their ontological symmetry'* (Mutch, 2002).
- ANT's 'flat ontology', which fails to attend to the various ways in which macro-social structures shape and modify the process of social interaction and socio-material practices. By ignoring institutional sources of power and inequality, say its critics, ANT has little to say about the systematic exclusion that prevents some social groups from having a voice in the design and use of technologies. Mutch (2002) (drawing on social realist Margaret Archer) points out that 'humans' can be (a) biological organisms; (b) agents (members of groups or categories, whether predetermined such as age or gender, or voluntary such as 'possessing a medical degree'); and (c) social actors (relating to one another in particular ways that

reflect social roles and expectations). Whilst a particular 'social actor' (e.g. doctor) *emerges from* an individual who is female, aged 35 and has a medical degree, and this agent in turn *emerges from* a particular collection of organs and brain cells, these different conceptualisations of the individual should not (say the critics of ANT) be equated with, or reduced to, one another. Removing the layers of social structure arguably removes the scope for explanatory analysis and reduces the research exercise to description – albeit with what are often compelling narratives.

- The methodological problem of how to delineate an actor-network (e.g. with a view to studying it). The network is open, and hence must be artificially defined by the researcher. There is an argument for not defining the actor-networks in advance of a study (e.g. 'the primary healthcare team', 'the users of the electronic record') but see what is key in any particular study. But in practice, an emergent approach to using ANT is often so difficult as to be impractical, especially for new researchers.

6.3.1 Example of an empirical study of innovation using ANT

In a paper published in 2002 and based on a feminist reading of actor-network theory, Novek (2002) studied the introduction (and abandonment) of a networked drug distribution system ('Meditrol') in a long stay care facility in Canada. In this study, an 'ANT' approach meant that (a) the author used detailed qualitative methods to build a picture of the complex actor-networks involved in the use and non-use of Meditrol; (b) the network was analysed in terms of the different translations that different actor groups attempted (that is, on the goals they had and the people and technologies they mobilised in pursuit of those goals); (c) a key focus was on the inscription devices through which some elements of the network became 'black boxed' and impossible to challenge – and how the material properties of the technology led to a particular direction of 'black-boxing'; (d) the disagreements and negotiations between different groups about the nature of reality was captured and analysed as data; and (e) the unintended consequences of the introduction of Meditrol were a central concern.

Data were collected via questionnaires sent to all 158 nurses (of whom 102 responded) and in-depth interviews (13 in all) conducted with pharmacists, pharmacy managers and senior administrators (arguably, a weakness of the study is that interviews and questionnaires were used more than direct ethnographic observation). The technology supplied unit-dose, pre-packaged medication labelled with a specific patient's name direct to the ward, obviating the need for nurses to count out tablets from bulk supplies. The ward box was controlled by an electronic swipe card which had a 'lockout' function that exerted a strict control over when nurses could access the contents. This was intended to reduce errors in the dosage or timing of medication. This system was very widely used in US hospitals, and the Canadian hospital introducing it had a reputation for being both technologically innovative and patient-centred. By way of background, Novek (2002) highlighted the 'expert system' characteristics of technologies such as Meditrol:

'Networked drug distribution systems parallel and reinforce new management strategies in healthcare …, which in the name of efficiency have been designed to impose greater control over hospital workers, to transform traditional boundaries between occupations, and to establish conditions in which these occupations will work together. However, networking need not imply 'cooperative work'.... As computer networks reach across diverse occupational and professional boundaries, they can become the focal point for conflicting claims about their purpose, performance, and cultural significance.' (381)

And so it turned out. The automation of drug distribution was viewed positively by administrators, who had high hopes that the automated system would reduce distribution error and pilferage, enable tighter control to be kept on drug costs, and limit the amount of 'chit-chat time' that nurses wasted while checking medication in pairs. Meditrol was initially seen by pharmacists (both in this study and more generally) as 're-professionalising' their role – potentially reducing the drudgery of their work and freeing them up for more sophisticated clinical tasks such as advising and auditing. But the new system was also associated with threats to pharmacists' jobs, since an alternative option to promoting the pharmacist to an advisory clinical post is of course to reduce the numbers of pharmacists altogether. Implications for nursing roles were also ambiguous: the skilled task of distributing medication from bulk supplies was destined to become reduced to handing named packages to the appropriate patients. But it was by no means obvious whether nurses would gain or lose from the introduction of the system:

'Gone are the decentralized medication cabinets with their easily accessible bottles of pills and liquids. Now nurses' access to medication is mediated through abstract representations of their work encoded in automated dispensers designed and programmed for another department. This raises the concern central to modern nursing of dependence on technology (high tech), which is potentially subversive of nursing's ideology of care and attention to the needs of the patient (high touch). … At the same time, they are susceptible to the contradictory appeal of technology as an adjunct to nursing and a potential liberator from the drudgery of their most mundane daily tasks in favor of their core mandate of patient care. Successful enrollment would require that nurses translate automation into an adjunct rather than an obstacle to this mandate.' (384).

The automated drug distribution system was thus destined to become a 'boundary object' around which various battles of professional jurisdiction would be fought. In the event, the material properties of the technology, and especially the rigid time programming, proved dominant. Whereas the technology had been designed to support a pattern of work that was stable, predictable and routine, in reality, ward-based nursing work (and especially the *timing* of nursing work) was characterised by instability, unpredictability and heterogeneity. Managers (most of whom were educated to Masters level or above) had been keen to 'professionalise' the nurse's role by imposing a standardising, technical solution based on an abstracted model of nursing work. The front-line nurses resisted this, since in their view, professional nursing practice involved adapting and personalising the care model to fit in with the needs of the patient and other local contingencies. Initial battles between nurses and pharmacy managers over the various over-rides and workarounds that sprang up in practice gave way to support from the latter for the use of individual judgement and discretion.

In summary, an ANT analysis has highlighted the complex network of people and existing technologies into which Meditrol was introduced. The hoped-for 'stablisation of the network' never happened because the abstracted roles and rigid time-bound procedures that had been built into the technology aligned so poorly with other components of the network – especially the reality of front-line nursing work – that people simply reverted to previous ways of working. We have chosen automated drug distribution systems as one of our example case studies in section 7.

6.3.2 Future research

The above sections have illustrated that whilst ANT offers novel conceptualisations of the socio-technical world and focuses our attention on dynamic and relational aspects of this

world, it has been heavily criticised by social theorists. The usefulness of the ANT approach will depend on the research question, and Box 5 below shows some examples of questions for which ANT might prove particularly helpful. One of the appealing aspects of ANT is that its developers eschew a set methodology and encourage others to adapt it and use it in creative ways. Various authors have suggested 'blends' between selected elements of ANT and Foucauldian notions of power and discourse (Underwood, 2002; Fox, 1999), social realism (Mutch, 2002), interpretivism (Walsham, 2006), and structuration theory (Pentland & Feldman, 2007), though others have strongly rejected this hybrid approach (McLean et al, 2004).

Box 5: Examples of research questions on the introduction of technology in healthcare organisations from an actor-network theory perspective

- What are the actor-networks within which particular technologies are embedded, and how do these shape and constrain the use of these technologies?
- In any given actor-network, what translations are attempted by different groups of players when a new technology is introduced, and how does the network evolve as a result?
- What is the role of inscription devices in the spread and sustainability of particular technologies?
- What arguments are held in particular communities of practice about the nature of reality (especially with a view to inscribing such 'facts' in inscription devices and other formal tools?
- What are the unintended consequences of the introduction of particular technologies, and what knock-on effects do these have for the wider network?

7 Case studies

Key points

1 We present five retrospective case studies that illustrate how organisational factors and processes can shape the extent of adoption, implementation and assimilation of different types of technological innovations in healthcare. The case studies were selected to achieve maximum variety in the nature, complexity, setting and history of the innovation as well as in their perceived relative advantage and likely impact on organisational routines and relationships.

2 The case studies confirm the enduring applicability of Roger's original attributes as a way of generally considering which features of innovations suggest they will be more likely to be adopted by individuals. For example, 'ease of use' in the case of the thermacol incubator box, 'relative advantage' in the cases of PACS and CT scanners, and 'compatibility with existing values' in the cases of drug-eluting stents and the thermacol incubator box. As revealed in the drug-eluting stents case study, however, attributes such as apparent 'relative advantage' can become contested and debatable over time with implications for the longer term use of an innovation.

3 The case studies highlight some of the key features of the origins of different technological innovations that also shape the rate of their adoption. For example, whether there is limited/no industry involvement (thermocal incubator box) or close involvement in the development and marketing of the innovation (CT scanners), whether the technologies are developed internally through clinical practice (drug-eluting stents, thermocol incubator box) or developed externally (PACS), and whether they are evaluated prior (networked drug distribution system) or subsequent (drug-eluting stents) to their adoption into clinical practice.

4 However, the case studies highlight the limited predictive value of these attributes and features when applied not to individual adopters but to the adoption and assimilation of technological innovations into routine practice within the more complex setting of healthcare organisations. This is particular true when the innovation under consideration is required to go through a formal (or informal) decision-making process because of, for example, high cost as in the case of CT scanners, or the implementation process is complex as in the case of PACS, or if the innovation necessitates significant changes to existing work routines and practices as most clearly demonstrated by the networked drug distribution system case study (but also by the drug eluting stents and PACS cases). In such cases, organisational factors and processes such as the strategic positioning of the organisation as a relative leader in innovation (as highlighted in the case of networked drug distribution systems), existing professional boundaries and power relations (CT scanners), or the support of key clinicians (PACS) become much more important to take into account.

In response to the 'call for proposals' that the research team should 'identify a number of key technologies and provide evidence relating to how levels of adoption were determined' - and in order to test the plausibility of the revised model (section 5.4.2) by applying its components to various technological innovations - we used a purposive sampling framework to select five contrasting examples (see table 16 below) of the adoption, implementation and assimilation of technological innovations.

7.1 Selection of case studies

The principles of purposive sampling for case studies are set out by Stake (1995). Briefly, because case studies require in-depth analysis of context and processes, there is a trade-off between representing large numbers of cases and covering them in sufficient detail. As Stake comments, the transferability of case study findings to different settings is best judged via a detailed analysis of the 'rich picture' of the case itself rather than by seeking statistical inferences. He recommends that a small number of studies should be chosen which together represent the full range of variables of interest to the researchers. The comparisons between cases are thus achieved through contrasting narratives.

We selected cases to achieve maximum variety in the nature, complexity, setting and history of the innovation as well as in their perceived relative advantage and likely impact on routines and relationships (table 16):

The cases were as follows:

Case 1: Drug-eluting stent

Case 2: Picture archiving and communications systems

Case 3: Thermacol incubators

Case 4: Drug dispensing systems

Case 5: CT scanners

Table 16. Characteristics of technologies used as example case studies

	CASE 1: Drug-eluting stent	CASE 2: Picture Archiving & Communication System	CASE 3: Thermacol incubator	CASE 4: Networked drug distribution system	CASE 5: CT scanner
Nature of innovation	Clinical (surgical)	Clinical (radiological)	Clinical (nursing)	Clinical and administrative (pharmacy)	Clinical (diagnostic)
Complexity (of technology and the required infrastructure)	Moderately complex but freestanding technology	Complex technology, requires ICT network	Very simple, freestanding technology	Simple technology, requires ICT network	Complex but freestanding technology
Setting	Secondary care	Secondary and primary care	Community care	Secondary care	Secondary care
Development or procurement	Local	Central	Local	Local	Central
Relative advantage in eyes of potential adopters	Moderate (but to some extent uncertain)	High	Contested (some saw it as high, some as low)	Contested (clinicians – low; administrators – high)	High
Cost	Medium	High	Low	Medium	High
Main outcome of attempted introduction	Widespread adoption	Moderate adoption	Patchy adoption	Abandonment	Widespread adoption

7.1.1 Case 1: Drug-eluting stent

The concept of the stent grew directly out of interventional cardiologists' experience with angioplasty balloons. The balloon sometimes caused weakening of the wall of the coronary artery and although the artery would be opened successfully it collapsed after the balloon was deflated in some 30% of cases. The only option for such patients was then emergency bypass graft surgery to repair the problem. One way round this was to insert a stent after the angioplasty. Palmaz and Schatz were working on such a stent in the 1980s and the first stent was inserted into a human coronary artery in 1986 (Cheng T, 2003; Hoffmann R et al, 1998). In 1994 the Palmaz-Schatz stent was approved for use in the United States. But while stents virtually eliminated the acute complications of artery closure, the longer-term problem of restenosis persisted (Fattori R & Piva T, 2003). One way round this was to coat the stent with a drug that interrupts the biological processes that cause restenosis. The resulting drug-eluting stent which was successful in reducing restenosis from around 20-30% to 2-7%.

An important characteristic of the drug-eluting stent (common to many medical technologies) was that it evolved with time. There are three major parts to the drug-eluting stent – the stent itself, the drug included in the stent, and the method by which the drug was delivered (eluted) by the coating to the arterial wall – all of which could be refined. There was both clinical and commercial pressure to develop the basic stent so that newer generations were more flexible, easier to insert in the narrowed artery, and less likely to produce medium- and long-term complications. This evolution, along with accumulating evidence from long-term follow-up, led to changes in the perceived relative advantage of the drug-eluting stent over time.

For the first time since their introduction, the use of drug-eluting stents began to decrease slightly in late 2006. This was due partly to renewed uncertainty about their advantages (there was new evidence that the incidence of thrombosis might be higher in drug-eluting stents than bare metal stents, so that early reduction in restenosis rates is outweighed by later increase in thrombosis rates). The relative advantage over the older bare metal stents, especially in patients whose blockages were judged to be at very low risk for restenosis, was called into question. It is reported that this controversy has now led to fewer doctors recommending drug eluting stents and some insurance companies reconsidering their coverage of them (Kamerow, 2007). Second and third generation stent technologies are currently being researched, which use a bioresorbable polymer to deliver the drug, so that the after a few months of drug elution, the stent in effect becomes a bare metal stent.

This technology illustrates a more general principle with medical technologies that provide a specific treatment: the 'relative advantage' of such technologies differs according to the baseline risk and characteristics of the patient. Also, the key question is not just whether (and to what extent) the drug-eluting stent 'works'. It is, 'What are the relative advantages and disadvantages of the various treatments for patients with symptomatic coronary artery disease - medical therapy only, percutaneous transluminal angioplasty with stents, and coronary artery bypass grafting'. The evidence base on this question, like that on many complex therapeutic questions, continues to be debated (Nordmann et al, 2006; Rao et al, 2008; Taggart, 2007).

An interesting aspect of the drug-eluting stent as an innovation was how it emerged locally as an extension of an existing procedure (in this case, linked to patient safety), hence had high task relevance and feasibility, and merged seamlessly into existing practice. Arguably, this may have led it to it being 'over-adopted' as a result, since cardiologists saw it as a 'development' (and hence an improvement) on previous practice. That questions over its relative advantage led rapidly to a reduction in use illustrates a well-established finding that relative advantage is the most important attribute of an innovation. Other factors which have been shown to promote adoption of a new technology - namely compatibility with values and ways of working, and ease of use - were also evident in this example.

7.1.2 Case 2: Picture archiving and communications systems

Picture archiving and communication systems (PACS) are IT systems which handle the storage, retrieval, and presentation of medical images. The most common format for image storage is DICOM (Digital Imaging and Communications in Medicine) (Napoli, 2003). Most PACS handle images from various medical imaging instruments, including ultrasound, magnetic resonance imaging (MRI), computed tomography (CT), endoscopy, and radiographs ('X-rays'). DICOM is a set of compatibility standards that allow systems to interface, allowing (for example) a CT scanner made by one manufacturer, an MRI scanner made by a second company, and an ultrasound machine made by a third company to all communicate with the same PACS. It is because of DICOM that images from many different modalities can be displayed and interpreted at the same PACS workstation and sent to the same PACS archive.

PACS has two main uses:

- replacing hard copies of images (for example, X-ray films).
- remote access (enabling practitioners in different physical locations to access the same information simultaneously for teleradiology).

Typically a PACS network consists of a central server housing a database containing the images connected to one or more clients via a LAN (local area network) or a WAN (wireless accessible network) which provide or utilize the images. Modern radiology equipment feeds patient images directly to the PACS in digital form. PACS can provide a single point of access for images and their associated data and can interface with other hospital information systems. Data saved in the PACS can be tagged with unique patient identifiers (such as a social security number or NHS number) (Napoli et al, 2003). This interface can also potentially improve workflow patterns (Himes & Rosenfeld, 2004).

The concept of PACS was developed in Europe during the latter part of the 1970s, but no working system was completed at that time. The principles of PACS were first discussed at meetings of radiologists in 1982. It was first implemented in the USA in the early 1980s, and was introduced in the Netherlands, Belgium, Austria, France, Italy, Scandinavia, Germany and parts of the UK in the mid to late 1980s. Most systems could be characterized by their focus on a single department, such as radiology or nuclear medicine. European hospital-wide PACS with high visibility evolved in the early 1990s. Glass, a medical physicist working in London in the early 1990s, secured UK Government funding and managed a project over many years to transform Hammersmith Hospital in London into the first filmless hospital in the UK (Lemke, 2003). Thus, whilst PACS was commercially developed, examples of its successful embedding appeared to rest crucially on the input of local champions who played the politics and achieved the necessary resource allocation.

Whilst PACS was relatively slow to take on (mainly due to its high implementation complexity and need for investment in infrastructure), and appeared for many years not to meet its full potential (specifically, it remained departmental, rather than hospital-wide, despite being based on wireless

technology), it has latterly become viewed as one of the real success stories of the healthcare IT industry. There are a number of reasons for this, perhaps chief among them being that old-style X-ray films were physically extremely cumbersome (junior doctors spent a great deal of time and energy transporting them from one place to another) and could only be in one place at a time (hence were often 'unavailable' for meetings or clinic visits). The relative advantage of this technology was thus very high. Furthermore, it fitted readily into workplace routines since computer terminals were generally already available in key settings and 'gathering round the computer screen' was little different in practice form 'gathering round the X-ray box'. One early limitation was the resolution of the digital images which was considered less good than conventional films, but this was quickly resolved as the technology advanced. By 1997 a systematic literature review had concluded that there was good evidence that PACS had improved the quality and efficiency of care and that images were 'lost' significantly less often (Anderson & Flynn 1997). It also highlighted an unintended (or at least, to some extent unanticipated) consequence of PACS – that 'an unintended consequence of 'filmless' radiology is that computer maintenance, back-up, and support become mission-critical elements of patient care delivery'.

7.1.3 Case 3: The thermacol incubator box

The next case study looks at the use of a thermocol (polystyrene) box for thermal control of low birth-weight babies in resource-poor settings. This topic was explored in a research dissertation from Boston University (Ramani, 2007). In most resource-rich settings in the developed world and elsewhere, the problem of keeping premature babies warm has been addressed through relatively high-tech devices such as incubators, thermal mattresses, and radiant warmers (Almeida, 2000; Baker, 2000; Dahm & James, 1972). This solution is not possible in resource-poor settings, not only because of the cost of the devices but also because of weak infrastructure required to operate them (e.g. lack of electricity or frequent power cuts) and the lack of skilled personnel to operate and service them.

Ramani tells the story of how in the 1980s, an Indian paediatrician Dr Subhash Daga, discovered that locally available thermocol boxes (which resemble American beer-coolers) can serve as good, low-cost incubators for keeping babies warm (Daga et al, 1996). Daga had access to a ready supply o such boxes as vaccines were delivered to the hospital in them. He 'recycled' such boxes initially to keep babies warm when transferring between wards in the hospital, and later began sending babies home in a box. The advantages of these thermocol incubators were that they were cheap, accessible, transportable, required little skill to use, and needed very little maintenance (Govasi et al, 1998). The baby was clearly warmer in the box than out of it. Because the box was used on the ward as well as at home, the kept her baby in the box beside her for about a week before she was discharged, so she got used to this arrangement and trusted it. The innovation thus had many of the attributes associated with successful adoption - relative advantage, low complexity, trialability, observability, and (to some extent) compatibility with values and ways of working. Indeed, thermocol boxes might be seen as

'appropriate technology' - a concept introduced in the 1970s as a developmental approach that would resolve socioeconomic problems in low-income countries (Drucker, 1979).

However, the box was somewhat unusual for an 'incubator' in that it was opaque and one could not see the infant inside since the lid of the thermocol box had to be kept closed, with two small holes made on either side for ensuring the circulation of air. This raised some concerns amongst both staff and relatives (who felt, perhaps reasonably, that it was better for the new baby to be visible).

In the 1980s, Daga piloted his idea in an urban hospital and in villages in Maharashtra, India. Healthcare workers seemed to accept the concept initially (Daga & Daga, 1990; Daga et al, 1993). The utility of the box as an adjunct to other methods of preventing hypothermia was studied and the research was published (Daga et al, 1996; Shende et al, 1998). As a result in some Indian states it was included in funded health programmes, suggesting successful adoption. However, 25 years after its development, the thermocol box had largely disappeared from the 'official' Indian health system. However, Ramani identified that the thermocol boxes (known as 'T-boxes') are still being used in some hospitals both for ward-to-ward transfer and also on discharge. One 'reinvention' of the box in hospital settings has been to use it during CT scans. The baby is put inside the box and passed through the machine, and the box serves to protect the baby from hypothermia that could be caused from the cold blast of cooling fans. Diffusion of the idea of the T-box between hospitals appears to have occurred by transfer of doctors. There is also evidence that the boxes are being used widely in some rural areas.

Ramani hypothesizes that despite a clear medical advantage (they undoubtedly reduced the risk of hypothermia), the thermocol incubators did not diffuse because of what she calls the low 'social value' of a low-tech plastic box in a healthcare system that assigned great value to high-tech, hygienic and 'branded' western medicine. The low social value of the incubator was partly attributed to comparisons with conventional incubators (but since babies placed in these incubators sometimes died, there was much suspicion surrounding them in some areas), but also from the fact that the box, being white, gathered dirt and soon came to look unhygienic and tattered. Interestingly, some of the pockets of successful adoption of this innovation were in very poor, isolated rural areas, where people had no choice about the technology and were also (perhaps) less influenced by media images of 'good' medicine. Interviewees in less isolated areas suggested modifying the box by adding branded logos of international healthcare organisations (such as the WHO), which, they believed, would increase people's confidence in it.

Another interesting aspect of the thermocol box was 'reinvention' in a way that linked to tribal birth traditions. In some tribal cultures, there was a tradition of placing the newborn infant in a sling ('jhoola') made from the mother's sari and hanging this from a beam in the family hut. This kept the baby above floor level, keeping it safe from animals and other hazards. But the risk of hypothermia was high. Cultural beliefs that the jhoola was a 'safe' place for the baby were strong. A simple modification to the thermocol box (the attachment

of handles) allowed it to be incorporated in the jhoola - which not only aligned with the cultural tradition of keeping the baby 'within the mother's sari' but also reduced the box's tendency to gather dirt.

This case study illustrates the enduring applicability of Rogers' original attributes of innovations (relative advantage, compatibility, low complexity, trialability, observability and reinvention) for innovations whose uptake is largely a matter of individual choice (rather than organisational strategy). When all these attributes were achieved in the eyes of potential adopters, the thermacol box was often used readily. The box's low compatibility with prevailing social values, and especially the association of good medicine with high-tech, branded kit, reduced its uptake in some areas but where these expectations were less strong the innovation survived. Finally, the jhola story illustrates how local reinvention of a technology can dramatically improve its fitness for purpose.

7.1.4 Case 4: Networked drug distribution systems

Novek studied the introduction (and subsequent abandonment) of a networked drug distribution system in a long stay care facility in Canada, in a paper published in 2002 and using actor-network theory as its theoretical lens (Novek 2002). The technology, 'Meditrol', supplied unit-dose, pre-packaged medication labelled with a specific patient's name, direct to the ward, obviating the need for nurses to count out tablets from bulk supplies. The ward box was controlled by an electronic swipe card which had a 'lockout' function that exerted a strict control over when nurses could access the contents, intended to reduce error in the dosage or timing of medication. At the time, this system was very widely used in US hospitals, and the Canadian hospital introducing it had a reputation for being both technologically innovative and patient-centred. Novek highlights the 'expert system' characteristics of technologies such as Meditrol and the resulting tensions between clinical and managerial control:

'Networked drug distribution systems parallel and reinforce new management strategies in healthcare …, which in the name of efficiency have been designed to impose greater control over hospital workers, to transform traditional boundaries between occupations, and to establish conditions in which these occupations will work together. However, networking need not imply 'cooperative work'.... As computer networks reach across diverse occupational and professional boundaries, they can become the focal point for conflicting claims about their purpose, performance, and cultural significance.' (Novek 2002: 381)

And so it turned out. The automation of drug distribution was viewed positively by administrators, who had high hopes that the automated system would reduce distribution error and pilferage, enable tighter control to be kept on drug costs, and limit the amount of 'chit-chat time' that nurses wasted while checking medication in pairs. Meditrol was initially seen by pharmacists (both in this study and in other published studies) as 're-professionalising' their role – potentially reducing the drudgery of their work and freeing them up for more sophisticated clinical tasks such as advising and auditing. But the new system was also associated with threats to pharmacists' jobs, since an alternative

option to promoting the pharmacist to a more senior post is of course to reduce the numbers of pharmacists altogether. Implications for nursing roles were also ambiguous: the skilled task of distributing medication from bulk supplies was destined to become reduced to handing named packages to the appropriate patients. But it was by no means obvious whether nurses would gain or lose from the introduction of the system:

'Gone are the decentralized medication cabinets with their easily accessible bottles of pills and liquids. Now nurses' access to medication is mediated through abstract representations of their work encoded in automated dispensers designed and programmed for another department. This raises the concern central to modern nursing of dependence on technology (high tech), which is potentially subversive of nursing's ideology of care and attention to the needs of the patient (high touch). … At the same time, they are susceptible to the contradictory appeal of technology as an adjunct to nursing and a potential liberator from the drudgery of their most mundane daily tasks in favor of their core mandate of patient care. Successful enrollment would require that nurses translate automation into an adjunct rather than an obstacle to this mandate.' (Novek 2002: 384)

The automated drug distribution system became something of a battleground on which various disputes of professional jurisdiction were fought. Furthermore, the material properties of the technology, and especially the rigid time programming that had been inscribed in the system as 'modern' and 'efficient' (presumably with a view to making drug dispensing more modern and efficient), contributed in large part to its downfall. Whereas the technology had been designed to support a pattern of work that was stable, predictable and routine, in reality, ward-based nursing work (and especially the timing of nursing work) was characterised by instability, unpredictability and heterogeneity (for example, a patient might be off having an X-ray, or on the lavatory, when their drug dose is due; good nursing is more about accommodating these inevitable perturbation than abolishing them).

Managers (most of whom were educated to Masters level or above) had been keen to 'professionalise' the nurse's role by imposing a standardising, technical solution based on an abstracted model of nursing work. The front-line nurses resisted this, since in their view, professional nursing practice involved adapting and personalising the care model to fit in with the needs of the patient and other local contingencies. Initial battles between nurses and pharmacy managers over the various over-rides and workarounds that sprang up in practice gave way to support from the latter for the use of individual judgement and discretion.

There are many important lessons to be learnt from the failure of this innovation. In terms of Rogers' original attributes, 'relative advantage' and 'compatibility' were both low. Furthermore, the work routines required by the new technology (inscribed into the technology by someone who failed to incorporate the messiness and unpredictability of ward-based nursing work) were impossible to follow in practice without endangering patients' safety and comfort.

7.1.5 Case 5: CT and MRI scanners

Computed tomography (CT) is a medical imaging method that is now widely used throughout the world; it offers a historical case study of how a 'revolutionary' technology changed roles and routines. In CT scanning, digital geometry processing is used to generate a three-dimensional image of the inside of an object from a large series of two-dimensional X-ray images taken around a single axis of rotation. Computed tomography was originally known as the 'EMI scan' as it was developed at a research branch of EMI. It was later known as computed axial tomography (CAT or CT scan). CT produces a large volume of data which can be manipulated, through a process known as windowing, in order to demonstrate the internal structures of the body in a way that provided vastly improved information compared to previous imaging methods (especially the plain X-ray).

The first commercially viable CT scanner was invented by Sir Godfrey Hounsfield in Hayes, United Kingdom at EMI Central Research Laboratories. Hounsfield conceived his idea in 1927, but it was not publicly announced until 1972. Cormack of Tufts University in Massachusetts independently invented a similar process, and both Hounsfield and Cormack shared the 1979 Nobel Prize in Medicine (Richmond, 2004). The original 1971 prototype took 160 parallel readings through 180 angles, each 1° apart, with each scan taking a little over five minutes. The images from these scans took 2.5 hours to produce, so one early problem was that the technique was impractical in a busy imaging department. The first 'production' X-ray CT machine was limited to making relatively low-resolution scans of the brain and was first used in clinical practice at London's Atkinson Morley Hospital in 1972.

The CT scanner is an important 'paradigm case' of an expensive, organisational-level innovation which required major changes to work routines and patient pathways. A landmark study of the changes in roles and interaction patterns following the introduction of a new technology, based on a study of CT scanners and using structuration theory as the theoretical lens, was Steve Barley's 1986 classic study 'Technology as an occasion for structuring' (Barley, 1986). Barley showed how the introduction of the CT scanner into hospital radiology departments was accompanied by changes in patterns of interaction between clinicians and technicians – and hence in the social order of the departments. He compared two different hospitals which introduced the same new technology (the CT scanner) with very different results. In an accessible analysis of Barley's study, organisational sociologist Karl Weick comments:

'At first the technology is exogenous. When translated into a technical system, it either confirms ingrained interaction patterns or disturbs and reformulates them. These patterns are carried by scripts – standard plots and types of encounters whose repetition constitutes the setting's interaction order – which create reciprocal links between structure and action. Thus, the technology ratifies or alters scripts that have grown up as a result of previous structuring. When the new body-imaging technologies were introduced, radiologists and technicians alike drew on traditional, institutionalized patterns of signification, legitimation and domination to construct roles to deal with this technology and

to interpret the strange products that it produced However, the traditional pattern of technicians' deference to professional radiologists proved inadequate, especially at [Hospital A] because radiologists had only modest understanding of the technology. [..] Given this slippage, new patterns of action emerged and were incorporated into lasting scripts that made a lasting change in institutional structure' (page 19)(Weick 1990)

Thus, the 'same' technology had very different impacts (and was used differently) in two different hospitals because of complex and subtle differences in historical, contextual and social factors. This is perhaps unsurprising, but Barley's conclusion (captured in the title) that technology is an 'occasion for structuring' rather than deterministic of particular outcomes in an organisation is an important one.

The slow but steady adoption of CT scanners provides an interesting contrast to the adoption pattern of the later innovation magnetic resonance imaging (MRI) scanners, whose adoption was more patchy (Hillman & Schwartz, 1985; Richmond, 2004). Analysis of attributes of the technologies and attributes of the regulatory, reimbursement, and market environments surrounding the early diffusion of these technologies provides insight into their different diffusion patterns. In particular, the technical and financial uncertainties surrounding MRI (in short, it was a much more expensive technology whose advantages over CT scanning were limited to particular conditions) inhibited its diffusion compared with that of CT. In the US, for example, the public healthcare funding programme Medicare would only fund MRI scans in certain restricted circumstances (based on disease-related groups or DRGs), to reimburse healthcare providers. This has had the impact of reducing overall MRI diffusion in hospitals but stimulated purchases of MRI by nonhospital organisations (who orient themselves to individuals and health maintenance organisations seeking 'private' MRI scans).

The US Food and Drug Administration's premarket approval (PMA) programme has changed marketing strategies and influenced the diffusion of MRI to a lesser degree. However it has been argued that the ways in which healthcare systems evaluate and adopt new, expensive, diagnostic technologies may also cause problems in their uptake. There is a suggestion that changes should be made to this to make the system more responsive to present needs (Hewer & Wood, 1989; Hillman & Schwartz, 1985;Hillman, 1986; Richmond, 2004).

In conclusion, the adoption of CT and MRI scanners contrasts markedly with that of 'simple' technologies such as the thermacol box or even the drug-eluting stent. In the case of the latter examples, Rogers' original attributes (such as relative advantage or trialability) account in large part for the fortunes of the innovation. But in situations where the innovation requires high financial investment by the organisation and/or extensive changes to work routines, Rogers' attributes are a necessary but not sufficient precondition for successful adoption and both the inner context (organisational aspects) and the outer context (external environment) become a dominant factor. Appendix 11 summarises the characteristics of the cases in relation to the components of the model.

8 Conclusions and recommendations

Key points

1 The process of how or why NHS organisations decide to adopt certain technological innovations, and how or why such innovations are successfully implemented and assimilated into routine practice is not clear from existing studies.

2 This review found only 33 processual studies of sufficient quality (10 of which were undertaken in the NHS) from which to begin to generalise some theoretical constructs to inform practice and guide future primary research.

3 The adoption, implementation and assimilation of technological innovations comprise both social and organisational processes, and outcomes are largely determined by the dynamics between these. Whilst a detailed set of 'instructions' that guarantee success for any particular technological innovation cannot be formulated, forwarding a set of evidence-based 'design principles' may help practitioners make sense of the complexity they face. Such principles are intended to help practitioners in understanding and managing the adoption, implementation and assimilation of healthcare technologies into the routine practice of their organisations. In applying the principles, practitioners should take into account the relevant social and organisational aspects of their context and the specific technological innovation under consideration.

4 There is a need for rigorous, longitudinal and qualitative studies in order to develop better explanatory models with regards to the adoption, implementation and assimilation of technological innovations. Such models - and accompanying theories – will provide a better understanding of the organisational factors and processes that shape the rate of use of beneficial innovations, and enable the design of organisational interventions aimed at improving decision-making and implementation strategies.

8.1 Overall conclusions

This review has sought to extend and deepen our understanding of the 'inner context' through which technological innovations must travel in order to be adopted, implemented and assimilated within healthcare organisations. Building on the findings of our own earlier, broader, review of the diffusion of healthcare innovations (Greenhalgh et al, 2005), and the views of other commentators summarised in this review, our appraisal of the existing, though limited, evidence-base relating specifically to technological innovations in healthcare leads us to continue to reject a naïve model of adoption and assimilation. In May et als (2003: 602) words, such a model 'assumes a linear, rational process in which high-quality research will readily lead to the acceptance of an innovation and its integration into practice'. For the purpose of moving beyond such simplistic models, in this review we have explicitly privileged the findings of qualitative, processual studies of healthcare organisations over those of deterministic studies (although recognising the value of the latter in generating research hypotheses which can then be tested by other research approaches).

Our review supports the identified shortcomings[72] in the still dominant (almost exclusively non-healthcare specific) models of innovation adoption which typically:

- view the adoption decision as a one-off event (as opposed to a process)
- adopting organisations as unitary actors
- pay little or no attention to 'politics' and considerations of power
- perceive individuals within organisations as passive recipients of an innovation, and
- uncritically accept objectivist notions of information.

The deficiencies in these dominant models are heightened by a healthcare context which is characterised by it's 'non-unitary, systemic nature; diverse stakeholders (including clinicians, managers and patients), each with their distinct values and goals as well as different levels of influence; and the importance of exercising subjective judgment as opposed to objective calculation as a decision mode' (Maguire, 2002). On these latter two points, as Fitzgerald et al's (2002) empirical studies in the NHS suggest, 'in healthcare, the adopters use more nebulous criteria for judging the efficacy of an innovation than the profit-orientated criteria used in a commercial setting. So high levels of ambiguity are created, partly, by the 'fuzzy' nature of the evidence and also by the complexity of the range of other factors which are taken into account and by the existence of multiple stakeholders' (1445). Furthermore, amongst healthcare organisations there is variation in authority relationships and governance structures and these exhibit varying degrees of integration. And so, as we have already noted, (Greenhalgh et al, 2005: 11):

'Different organisations provide widely differing contexts for innovations, and a number of features of organisations (both structural and 'cultural') have been shown to influence the likelihood that an innovation will be successfully assimilated.'

What is therefore clear from the preceding review and case studies is the highly political, contested and variable nature of adoption decision-making processes in the context of healthcare organisations. And yet we have found only a handful of studies which have offered any insight into such political dimensions. As Fitzgerald (2002) argues, the impact of variable contexts is under-researched and 'we need to know more about how adoption decisions are made within multi-professional groups and within large and complex organisations' (1433). Finally, increasingly technologies go beyond single organisational (and sectoral) boundaries so studies taking a single organisation or sector (for example, acute care) as the unit of analysis are increasingly likely to be missing key aspects of adoption and assimilation decisions.

In seeking to answer the original 'call for proposals' we hoped to be able to further refine and deepen our understanding of the issues underlying some related and research questions which we identified in our original review

[72] See, for example, Maguire, 2002.

(Greenhalgh et al, 2005)[73]. However, gaps in the evidence-base continue to make formulating recommendations pertaining to decision-making processes concerned with the adoption of technological innovations problematic:

'few scholars of technology implementation have made [an] attempt to provide a more general account of the influences between new technology and social action. Until such theories are produced, it will be difficult to test empirically our understanding of the impact of new technology to improve theory or provide useful advice to practitioners.' (Black, 2004: 574)

So, for example, without such theories ' … findings that large organisations adopt technologies more frequently than small ones lead to no [such] satisfying intervention' (Greer, 1985: 678)[74].

In section 6 of this review we have forwarded three theoretical perspectives that provide examples of how primary research in this topic area and context may usefully move forward. In the meantime, the process of how or why healthcare organisations decide to adopt certain technologies, and how or why such technologies are successfully implemented and assimilated into routine practice is still not clear from existing studies. This is in large part due to the dominant models and design of studies (mostly cross-sectional survey-based and deterministic, and undertaken outside the contemporary context of the NHS) as critiqued above. However, we did find 33 processual studies of sufficient quality (10 of which were undertaken in the NHS) to begin to generalise some theoretical constructs to inform practice (section 8.2) and guide future primary research (section 8.3).

8.2 Recommendations for practitioners: design principles for the adoption, implementation and assimilation of technological innovations

One objective of this review is to make recommendations for actions that the NHS should consider in order to facilitate the increased adoption,

[73] These included: (1) the extent to which 'restructuring' initiatives can improve the ability to adopt, implement and assimilate technological innovations? For example, will a planned move from a traditional hierarchical structure to one based on semi-autonomous teams with independent decision-making power improve innovativeness?; (2) how can we improve the absorptive capacity of healthcare organisations for new knowledge? In particular, what is the detailed process by which ideas are captured from outside, circulated internally, adapted, reframed, implemented and assimilated in a healthcare organisation, and how might this process be systematically enhanced?; and (3) what steps must be taken by service organisations when moving towards a state of 'readiness', and how might this overall process be supported and enhanced?

[74] As we commented in our original review - and despite the large number of studies that have taken size as a key determinant of adoption of innovations - there is certainly no evidence thus far that manipulating the size of an organisation per se (for example, by providing incentives for small GP practices to merge into group practices, as was done in England in the 1960s), or tinkering with its structure, will make that organisation more innovative

implementation and assimilation of beneficial technological innovations. To inform this we need a good understanding of how organisational characteristics and features influence technological adoption, implementation and assimilation (Reardon & Davidson, 2007), hence the review of empirical studies in section 5.

As this review found, and we have highlighted elsewhere (Bate et al, 2006: 217), the adoption, implementation and assimilation of technological innovations comprises both social and organisational processes. This means that the management of innovation is predominantly an issue of managing both the social and organisational factors associated with those processes, and (importantly) the dynamics between them. Whilst it is clear that we cannot form a detailed set of instructions that guarantee success for a particular technological innovation (May et al, 2003: 603)[75], we can at least try to help make sense of the complexity faced by practitioners.

Our chosen approach to this task is to formulate evidence-based design principles[76] (Romme, 2003; Van Aken, 2004, 2005a, 2005b). Drawing on the lessons from earlier work for the NHS SDO Programme to derive design principles based on the 'innovation journey' of NHS Treatment Centres[77] (Bate et al, 2006) - and the application of the same approach to other change interventions in the NHS (Bate & Robert, 2007) - we present below a series of design principles to guide practitioners in helping manage the adoption, implementation and assimilation of healthcare technologies into the routine practice of their organisations. Through the findings of the 33 processual studies described in this review - and the insights offered by the newer theoretical perspectives forwarded in section 6 and our subsequent retrospective case studies (section 7) - we seek to formulate the design principles upon which practitioners can make judgements and decisions, including where and when it might be sensible to depart from them (Bate & Robert, 2007: 80-81).

---

[75] For example, empirical research into a service innovation in the contemporary NHS found that even a combination of (a) high relative advantage (even when it is widely acknowledged), (b) close compatibility with the values, norms and perceived needs of adopters and (c) a high potential to adapt, refine and modify an innovation is insufficient to guarantee the successful implementation and spread of a complex organisational innovation. Such findings seem to confirm that it is the interaction between an innovation, its intended adopters and its context that determines the adoption rate and the success or otherwise of its local implementation (Bate et al, 2006: 214).

[76] Plsek et al (2007) describe their experience in pilot tests of four different methods for extracting *design rules* from existing programs of organisational change in the healthcare sector. Similarly, Rogers et al (2008) have formulated seven *design rules* for 'driving innovation in access to secondary care in the NHS'.

[77] We identified 74 such factors from our research on Treatment Centres. We detailed these in the form of 'design principles' for managing innovation in service delivery and organisation. These 74 principles were categorised under seven headings: (1) dealing with complexity, non-linearity and unpredictability; (2) creating 'enabling' structures and systems; (3) navigating the politics of innovation and securing stakeholder engagement; (4) building the innovation network; (5) creating a learning process; (6) changing behaviour and culture; and (7) leadership.

Taking May et al's point above, we would emphasise that the principles below are guides - not hard and fast rules - suggesting that 'if you try this, chances are it will work', not it will definitely work, or work every time. When reflecting on these principles, practitioners should take into account the relevant social and organisational aspects of the setting and the specific technological innovation under consideration. The principles are organised below in terms of four broad challenges for healthcare organisations (with cross-references to the relevant processual studies reviewed earlier in this report):

- how to improve an organisation's decision-making processes and systems with regard to the adoption of technological innovations
- how to increase an organisation's absorptive capacity for new knowledge about technological innovations
- how to ensure a receptive organisational context for technological innovations
- how to improve organisational readiness for a specific technological innovation

8.2.1 Improving decision-making processes and systems with regard to the adoption, implementation and assimilation of technological innovations

a) establish/strengthen an overall management structure for the adoption and decision-making process (Parvinen & Tolkki, 2007; Weiner et al, 2004; Pare, 2007) which connects all the relevant stakeholders; forums and committees should enable managers and clinicians to consider technological innovations together (Ferlie et al, 2002)[78].

b) as part of this structure consider forming a local HTA committee (McGregor, 2005) with a decision-making and implementation remit that includes not only implementation of NICE guidance but also the adoption of other technological innovations.

c) decision-making about innovations should consider technological, organisational and social concerns together (Pare, 2007) and be based not only on benefits for patients but also in terms of implications for specific groups of staff who need to collaborate in their implementation and assimilation. The more the risks and benefits of an innovation map onto the interests, values and power of the staff, the easier it will be for the innovation to be implemented and assimilated (Denis et al, 2002); successful implementation will depend upon an innovation being perceived as appropriate and relevant (May et al, 2003).

d) recognise the key role that clinical leaders play in enabling the assimilation of technological innovations into routine practice and the

[78] Bear in mind that new or different processes and systems may shift the locus of adoption decision making in the organisation or the set of actors involved (and this may change the values or preferences invoked) (Maguire, 2002) so alignment with the overall organisational strategy is important.

possible need for processes and systems to overcome professional barriers (Ferlie et al, 2002; Ferlie et al, 2005; Barley, 1986; Lang, 2005).

e) obtain regular feedback on improvements (or not) in both patient and staff experiences, and systematically follow up how innovations are assimilated into routine work practices.

f) seek guidance covering good practice from external sources (such as the National Technology Adoption Centre).

8.2.2 Increasing absorptive capacity for new knowledge about technological innovations

a) equip staff with the skills and capacity to 'horizon-scan' and capture new ideas, for example by establishing/strengthening organisational forums/networks (beyond the organisation) which can help spread innovations (Williams et al, 2008) and facilitate learning and problem solving (Ferlie et al, 2005).

b) encourage and support staff to attend specialist workshops and conferences and visit other sites (knowledge exploitation and exploration is crucial to the innovation process).

c) establish/strengthen internal organisational mechanisms for exchange of both tacit and explicit knowledge (within the organisation) across professional boundaries (Williams et al, 2008; Ferlie et al, 2002, 2005; Barley, 1986; Lang, 2005).

d) encourage improvisation and improvisational behaviour through small-scale innovation experiments and develop and test various prototype solutions (Weiner at al, 2004; Anmar, 2004; Karsh, 2004).

e) seek opportunities to embed a 'culture of questioning' within the innovation process (Edmondson, 2001) so that events and experiences can be learnt from as innovative processes are also learning processes (Waterman et al, 2007; Black, 2004; Edmondson, 2001; Karsh 2004).

8.2.3 Ensuring a receptive organisational context for technological innovations

a) the adoption, implementation and assimilation of technological innovations often necessitates collaboration between multiple professional and occupational groups; often the strength of the relationships between such groups will heavily influence the outcome of the innovation process (Ferlie et al, 2002; Fitzgerald et al, 2002; Ferlie et al, 2005; May et al, 2003; Wainwright & Waring, 2007; Barley, 1986). Navigating the politics of innovation and securing stakeholder engagement is therefore crucial (Pare, 2006; 2007).

b) earmark money, staff and other resources that will be available to support new technological innovations (Waterman et al, 2007) including developing training for nurturing adoption champions and leaders (Williams et al, 2008).

c) senior management should articulate clear goals and priorities for the organisation with a 'roomy' and adaptive strategic plan (Weiner et al, 2004; Williams et al, 2008) that informs decisions about strategic choice points for an innovation.

d) strengthen relations and communication at middle management levels.

e) establish/strengthen high quality data capture systems to give timely feedback on performance of innovations (Karsh, 2004).

8.2.4 Improving organisational readiness for a specific technological innovation

a) identify the decision system(s) - both formal and informal - that is/are most critical to the adoption and assimilation of the specific innovation (Greer, 1985).

b) clarify relationships and interdependencies between units, departments and the wider organisation as they relate to the specific technological innovation; develop new procedures and protocols which integrate the new technology with professional knowledge and practice, map the stakeholder relationships and governance with the process of care (Pare, 2007).

c) consider the relative distribution of expertise when implementing a new technology; a relative balance in operational knowledge between different groups will lead to greater learning and collaboration, and a quicker realisation of the benefits of the technology.

d) ensure that there is a concise, evidence and costs/benefits (Pare, 2007) based business case for the innovation and be clear about motives, aspirations and intentions; make the case relevant by incorporating local data and reflecting local needs (McGregor, 2005).

e) involve end users at an early stage (Weiner, 2004) and take account of their needs and existing clinical practices and patterns; address the 'what's in it for me' for all key groups and make dialogue and face-to-face interaction a feature of the innovation process; active involvement, participation and training of end users will heighten feelings of ownership (Karsh, 2004; Williams et al, 2008).

f) be aware of the potential need to create new or extended roles that cross traditional boundaries; crate slack for staff to grow into any new role and responsibilities and do not accept innovation as 'overtime' work.

g) permit open and frank discussion of concerns from both staff and patient perspectives; ensure adequate discussion and negotiations prior to implementation.

h) develop, dry-run and test systems (performance management, scheduling, booking, information etc.) in advance of going 'live', as successful adoption depends upon successful assimilation of the technology with existing systems (May et al, 2003; Karsh, 2004; Weiner, 2004).

i) attend to and put in place clinical governance arrangements well in advance of implementation; identify skills gaps early on and address them through formal training programmes (Denis et al, 2002; Stricklin, 2003; Karsh, 2004).

j) budget and allocate adequate resources for ongoing training (knowledge and skills), support and maintenance (Weiner, 2004).

k) if appropriate, hold official launch events as a symbol of the importance being attached to the innovation by the organisation.

8.3 Recommendations for further primary research

In our earlier, broader review (Greenhalgh et al, 2005) we strongly emphasised the need for more research on the mechanisms and processes that determine whether a specific innovation will be successful in a particular healthcare setting. Our current, more focused, review has found that there has been very little such research undertaken in the NHS with regard to technological innovations with the exception of the 10 studies reviewed in section 5.3.3; the need to develop new theory-driven[79] process models that might begin to reveal interactions of variables that potentially affect the outcome of adoption processes therefore remains (Tabak, 1999: 266). In short, this review confirms that we still need rigorous, longitudinal and qualitative studies in order to develop better explanatory models with regards to the adoption, implementation and assimilation of technological innovations. With such models - and accompanying theories - we can better design strategies and 'design principles' for organisational interventions aimed at improving decision-making processes. In section 6 we have drawn attention to three 'technology-in-practice' perspectives, the application of which in empirical studies of innovation adoption and assimilation we believe may offer some new insights.

Rye & Kimberly (2007) also set out a research agenda based on the finding from their related and recent systematic review that 'issues relating to both theory and research design … systematically hinder our ability to draw inferences in single studies, accumulate knowledge across studies, and/or understand the full complexity of the adoption phenomenon' (254). Regarding research design they suggest future research needs to:

- enhance the conceptualisation and measurement of constructs
- use longitudinal research designs
- sample a more comprehensive set of healthcare provider organisations (i.e. future research needs to comprise more than one case to enable cross-case analysis as this will increase the likelihood of generating novel theory), and
- examine how organisations gain access to innovations.

[79] Grol et al (2005: 125) also argue that 'future studies on change interventions need to focus more on applying specific theories of change to healthcare'.

In doing so, they suggest that 'it would be useful to think about organisational decision-making research and the unique and complex authority structures and political dynamics found in healthcare … currently the preponderance of adoption and diffusion research … either do not contemplate this research or do so superficially' (256). They go on to suggest that researchers should consider multiple decision-making perspectives including bounded rationality models, politics and power models and garbage can models[80]. In this regard, our review finds that Greer's study (in 1985) remains one of the central reference points cited by others in terms of decision-making processes as they relate to the adoption, implementation and assimilation of technological innovations.

Our own recommendations for future primary research essentially boil down to the need for holistic, longitudinal case studies that explore how system dynamics emerge and play out, especially at different levels of healthcare organisations (with a sensitivity to the positive and negative feedback loops that link factors and processes together). As noted, qualitative methods are well suited to exploring this messy terrain of multilevel theoretical and empirical interactions (Kimberly & Rye, 2007: 258)

More specifically, future research might profitably focus on examining the impact of complex authority structures (formal and informal), political dynamics and conflict/consensus within an organisation on the adoption, implementation and assimilation of innovations. Dawson & Buchanan (2005) highlight the potential role of narratives in helping to understand political processes in technological change. In particular, our review suggests that team functioning plays an important role in technological implementation and assimilation in an organisation (because within healthcare organisations the clinical team is one of the most important organisational levels at which information is communicated and work is negotiated). This layer of the organisational structure is rarely examined explicitly, with most studies concentrating on either individual or organisational characteristics (Gosling, 2003). However, as House et al (1995) argue such 'micro and macro processes cannot be treated separately and then added up to understand behavior in organisations.' Consequently, future research needs to be multi-level as the macro, meso and micro levels of organisational systems have different as well as overlapping contributions to make at various stages of the adoption, implementation and assimilation process.

So how might future research explore the patterns of relationships, interconnections and interactions among the organisations or systems parts, ideally over time? As well as the perspectives offered in section 6, ourselves and others (Rye & Kimberly, 2007: 256) would suggest that it could be grounded in organisational decision-making theory (i.e. discovered through grounded theory and/or adapted from organisation theory to the setting). By studying negotiation, bargaining and compromise as part of decision making processes within hospitals (Teplensky, 1995), researchers could begin to

[80] A point we previewed in an earlier empirical study of NHS Treatment Centres as an innovation on service delivery and organisation (Bate et al, 2006).

investigate the effects of processes and dynamics with variables such as group conflict resolution styles, group level of agreement, participation of individuals in the group decision, group cohesiveness, communication and leadership style on innovation adoption in organisations (Tabak, 199: 266). Ferlie et al (2005) suggest building on Van de Ven et als work and focusing on the boundaries between professional groups, individual professionals and associated communities of practice in the local enactment of innovations.

Two further specific recommendations would be to explore, firstly, the strategic significance of innovation adoption and, secondly, the disengagement from - or discontinuance of - innovation use. With regard to the latter recommendation, as we noted in our original review of more than 200 empirical research studies only one studied the discontinuance of an innovation; a similar paucity of such studies was revealed by this review. Consequently, little is known about how technological innovations are assimilated into routine practice in the contemporary NHS and the impacts such innovations have on staff once they have been adopted and implemented. Nor do we know a great deal about just how staff respond to the (often mandated) implementation of innovations and how these responses accentuate or limit the benefits of the innovations in question.

References

Abelson, J. 2001. Understanding the role of contextual influences on local health-care decision-making: the case study results from Ontario, Canada. *Social Science & Medicine*, 53: 777-793

Aiken, M., and Hage, J. 1971. The organic organization and innovation. *Sociology*, 5: 63-82

Almeida PG, Chandley JM, & Rubin LP 2000, 'Improving admission temperature of very low birth weight (VLBW) newborns: an interventional trial', *Pediatric Research*, vol. 47, p. 282A.

Anderson, N., de Dreu, CKW., and Nijstad, BA. 2004. The routinization of innovation research: a constructively critical review of the state-of-the-science. Journal of Organizational Behaviour, 25: 147-173

Anderson, D. & Flynn, K. 1997, *Picture archiving and communication systems: A systematic review of published studies of diagnostic accuracy, radiology work processes, outcomes of care, and cost*, 5 edn, Management Decision and Research Center, Health Services Research & Development Service, Boston, MA.

Angle, HL., and Van de Ven, AH. 2000. Suggestions for managing the innovation journey. In: *Research on the management of innovation. The Minnesota studies*. Oxford; OUP, pp. 663-698

Armer, JM., Harris, K., and Dusold, JM. 2004. Applications of the concerns-based adoption model to the installation of telemedicine in a rural Missouri nursing home. Journal for Nurses in Staff Development, 20(1): 42-49

Argyris C. 1985. *Strategy, change and defensive routines*. London: Pitman Publishing.

Baker JP 2000, 'The incubator and the medical discovery of the premature infant', Journal of Perinatology, vol. 20, no. 5, pp. 321-328.

Baldridge JV,.Burnham RA. 1975. Organisational innovation: individual organisational and environmental impacts. *Administrative Sciences Quarterly,* 20:165-76.

Barley S. 1986. Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly* 31:78-108.

Barley SR. 1990. The alignment of technology and structure through roles and networks. *Administrative Science Quarterly* 35:61-103.

Barley SR and Tolbert PS. 1997. Institutionalization and structuration: studying the links between action and institution. *Organisation Studies* 18(1):93-117.

Barlow, J., Burn, J., and Lockhart, G. 2008. *All change please*. London; Policy Exchange.

Bate, S.P., Robert, G., Gabbay, J et al. 2006. *The development and implementation of NHS Treatment Centres as an organisational innovation*. Report for the National Co-ordinating Centre for NHS Service Delivery & Organisation Research & Development programme (NCCSDO). Available from http://www.sdo.nihr.ac.uk/files/project/45-final-report.pdf

Bate, S.P and Robert, G. (2007) ''Towards more user-centric organisational development: lessons from a case study of experience-based design', *The Journal of Applied Behavioural Science*, 43(1): 41-66

Bate, S.P., Mendel, P., and Robert, G. 2008. *Organising for Quality. The improvement journeys of leading hospitals in Europe and the United States.* Oxford; Radcliffe Publishing.

Becker MC. 2004. Organisational routines: A review of the literature. *Industrial and Corporate Change* 13:643-677.

Ben-Tovim DI, Dougherty ML, O'Connell TJ, and McGrath KM. 2008. Patient journeys: the process of clinical redesign. *Med J Aust* 188(6 Suppl):S14-S17.

Berg M. 1997. Of forms, containers, and the electronic medical record: some tools for a sociology of the formal. *Science, Technology, & Human Values* 22(4):403-433.

Berg M. 1999. Patient care information systems and healthcare work: a sociotechnical approach. *Int J Med Inform* 55(2):87-101.

Black, LJ., Carlile, PR., and Repenning, NP. (2004) A dynamic theory of expertise and occupational boundaries in new technology implementation: building on Barley's study of CT scanning. Administrative Science Quarterly, 49(4): 572-607

Booth-Clibborn, N., Packer, C., Stevens, A. 2000. Health technology diffusion rates. Statins, coronary stents and MRI in England. Int J Technol Assess in Healthcare, 16(3): 781-786

Braithwaite J, Iedema RA and Jorm C. 2007. Trust, communication, theory of mind and the social brain hypothesis: Deep explanations for what goes wrong in healthcare. *Journal of Healthcare Organisation and Management* 21(4/5):353-367.

Braithwaite J. 2004. An empirically-based model for clinician-managers' behavioural routines. *Journal of Healthcare Organisation and Management* 18(4):240-261.

Brennan S. 2007. The biggest computer programme in the world ever! How's it going? *Journal of Information Technology* 22:202-211.

Brown JS, Duguid P. Organisational learning and communities-of-practice: toward a unified view of working, learning, and innovation. Organisation Science 1991; 2(1):40-57.

Burt RS. Structural holes and good ideas. American Journal of Sociology 2004; 110(2):349-399.

Callon M. Some elements of a sociology of translation: domestication of the scallops and the fishermen of St. Brieuc Bay. In: Law Je, editor. Power, action, and belief: a new sociology of knowledge. London: Routledge; 1986.

Callon M. Techno-economic networks and irreversibility. In: Law Je, editor. *A sociology of monsters: Essays on power, technology and domination*. London: Routledge; 1991.

Callon M, Latour B. Unscrewing the big Levitiathan: how actors macro-structure reality and how sociologists help them to do so. In: Knorr-Cetina K, Cicourel AV, editors. Advances in social theory and methodology. Routledge & Kegan Paul: 1986.

Cameron, KS., and Quinn, RE. 1999. *Diagnosing and changing organisational culture. Based on the Competing Values Framework*. Reading, MA; Addison-Wesley

Camison-Zornoza, C., Lapiedra-Alcami, R., Segarra-Cipres, M. et al. 2004. A meta-analysis of innovation and organizational size. Organization Studies, 25: 331-361

Champagne, F., Denis, J-L., Pineault, R. et al. 1991. Structural and political models of analysis of the introduction of an innovation in organisations: the case of the change in the method of payment of physicians in long-term care hospitals. *Health Services Management Research*, 4: 94-111

Cheng T. 2003. Switzerland is small in size but big on cardiology . *International Journal of Cardiology*, 94[3], 307-316

Clarke J. 2005. New Labour's citizens: activated, empowered, responsibilized, abandoned? *Critical Social Policy,* 25(4):447-463.

Crosson, JC., Isaacson, N., Lancaster, D. et al. 2008. Variation in electronic prescribing implementation among twelve ambulatory practices. *J Gen Intern Med*, 23(4): 364-371

Daft, RL., and Becker, SW. 1978. *The innovative organisation: innovation adoption in school organisations*. New York; North Holland

Daga AS & Daga SR 1990, 'Health information for primary neonatal care', Journal of Tropical Pediatrics, vol. 36, no. 3, pp. 141-142.

Daga SR, Daga AS, Dighole RV, Patil RP, & Dhinde HL 1993, 'Rural neonatal care: Dahanu experience', Indian Pediatrics, vol. 29, no. 2, pp. 189-193.

Daga SR, Patil RP, & Shende SR 1996, 'Styropor box as an adjunct to kangaroo care,', International Child Health, vol. VII, no. 1, pp. 81-82.

Dahm LS & James LS 1972, 'Newborn temperature and calculated heat loss in the delivery room', Pediatrics, vol. 49, pp. 504-513.

Damanpour F. 1991. Organisational innovations: a meta-analysis of effects of determinants and moderators. *Academy of Management Journal*, 34:555-90.

Damanpour F. 1992. Organizational size and innovation. *Organization Studies* ,13:375-402.

Damanpour F. 1996. Organizational complexity and innovation: developing and testing multiple contingency models. *Management Science*, 42:693-716

Damanpour F. 2001. The dynamics of the adoption of product and process innovations in organizations. *Journal of Management Studies*, 38:45-65

Damanpour, F., and Schneider, M. 2006. Phases of the adoption of innovations in organisations: effects of environment, organisation and top managers. *British Journal of Management*, 17(3): 215-236

Daniels, N., and Sabin, J. 2002. *Setting limits fairly: can we learn to share medical resources?* Oxford; Oxford University Press

Danjoux, NM, Martin, DK, Lehoux, PN et al. 2007. Adoption of an innovation to repair aortic aneurysms at a Canadian hospital: a qualitative case study and evaluation. *BMC Health Services Research*, 7: 182

Darzi, A. 2008. *High quality care for all: NHS Next Stage Review final report.* London; Department of Health

Davidson E and Chiasson E. 2005. Contextual influences on technology use mediation: a comparative analysis of electronic medical record systems. *European Journal of Information Systems* 14(1):6-18.

Davidson E. 2000. Analyzing genre of organisational communication in clinical information systems. *Information Technology & People* 13(3):196-209.

Dawson, P. 1994. *Organisational change: a processual approach*. London; Paul Chapman

Dawson, P. 2003. *Reshaping change: a processual approach*. London; Routledge

Dawson, P., and Buchanan, D. 2005. The way it really happened: competing narratives in the political process of technological change. *Human Relations*, 58: 845-863

de Kervasdoue, J. 1981. Institutions, organizations, medical disciplines, and the dissemination of research results. *Organization Studies*, 2/3: 249-266

de Laet M, Mol A. 2000. The Zimbabwe bush pump: mechanics of a fluid technology. *Social Studies of Science,* 30(2):225-263.

DeSanctis G and Poole MS. 1994. Capturing the complexity in advanced technology use: adaptive structuration theory. *Organisation Science,* 5(2):121-147.

Denis JL, Hebert Y, Langley A, Lozeau D, Trottier LH. 2002. Explaining diffusion patterns for complex healthcare innovations. *Healthcare Management Review*, 27:60-73

Dobson PJ. 2002. Critical realism and IS research: Why bother with philosophy? *Information Research* 7(2):124

Dopson S, Fitzgerald L, Ferlie E, Gabbay J, Locock L. 2002. No magic targets! Changing clinical practice to become more evidence based. *Healthcare Management Review*, 37:35-47.

Drazin, R., and Schoonhoven, CB. 1996. Community, population and organisation effects innovation: a multilevel perspective. *The Academy of Management Journal*, 39: 1065-1083

Drucker PF. India and 'Appropriate Technology'. Wall Street Journal 1889, 18. 1979.

Edmondson AC, Bohmer RM and Pisano GP. 2001. Disrupted routines: Team learning and new technology implementation in hospitals. *Administrative Science Quarterly* 46:685-716.

England, I., Stewart, D. and Walker, S. (2000) Information technology adoption in healthcare: when organisations and technology collide. Australian Health review, 23(3): 176-185

Epstein RM. 1999. Mindful practice. *JAMA* 282(9):833-839.

Escarce, JJ. 1996. Externalities in hospitals and physician adoption of a new surgical technology: an exploratory analysis. Journal of Health Economics, 15: 715-734

Fairclough N. 1997. *Critical discourse analysis: The critical study of language*. Harlow: Pearson Education Limited.

Fattori R & Piva T. Drug-eluting stents in vascular intervention. Lancet 361[9353], 247-249. 2003.

Feldman M and Pentland BT. 2002. Reconceptualizing organisational routines as a source of flexibility and change. *Administrative Science Quarterly* 48:94-118.

Feldman M. 2003. A performative perspective on stability and change in organisational routines. *Industrial and Corporate Change* 12:727-752.

Feldman MS. 2000. Organisational routines as a source of continuous change. *Organisation Science* 11:611-629.

Fendrick, AM., Escarce, JJ., McLane, C. et al. 1994. Hospital adoption of laparoscopic cholecystectomy. Medical Care, 32(10): 1058-1063

Ferlie, E., Fitzgerald, L. Wood, M. 2000. Getting evidence into clinical practice: an organisational behaviour perspective. Journal of Health Services Research & Policy, 5(2): 96-102

Ferlie, E., Fitzgerald, L., Wood, M. et al. 2005. The nonspread of innovations: the mediating role of professionals. Academy of Management Journal, 48(1); 117-134

Fiol CM. 1996. Squeezing harder doesn't always work: continuing the search for consistency in innovation research. *Academy of Management Review*, 21:1012-21.

Fitzgerald L, Ferlie E, Wood M, Hawkins C. 2002. Interlocking interactions, the diffusion of innovations in healthcare. *Human Relations,* 55:1429-49.

Fitzgerald, L., Ferlie, E., and Hawkins, C. 2003. Innovation in healthcare: how does credible evidence influence professionals. Health and Social Care in the Community, 11(3): 219-228

Fleuren, M. Wiefferink, K., and Paulussen, T. (2004) Determinants of innovation within healthcare organisations. Literature review and Delphi study. *International Journal for Quality in Healthcare*, 16(2): 107–123

Foucault M. The History of Sexuality, Volume 1. Harmondsworth: Penguin; 1984.

Fox, S. 1999. Communities of practice, Foucault, and actor network theory. 3rd International Conference on Organisational Learning; Lancaster: The Management School, Lancaster University; 1999

Fraser SW and Greenhalgh T. 2001. Coping with complexity: educating for capability. *BMJ* 323(7316):799-803.

Freeman, R. 1999. Divergent stakeholder theory. *Academy of Management Review*, 24(2): 237-241

Friedman, LH. And Myrtle, RC. 1996. Factors affecting decisions to adopt medical technologies in acute care hospitals. JHHSA, Spring: 466-489

Friedman, LH., and Goes, JB. 2000. The timing of medical technology acquisition: strategic decision-making in turbulent environments. Journal of Healthcare Management, 45(5): 317-331

Gagnon, M-P., Lamothe, L., Fortin, J-P. et al. 2005. Telehealth adoption in hospitals: an organisational perspective. Journal of Health Organisation and Management, 19(1): 32-56

Gallivan, M. 2001. Organisational adoption and assimilation of complex technological innovation: development and application of a new framework. The DATABASE for Advances in Information Systems, 2001, 32(3): 51-85

Garvin DA, Edmondson AC and Gino F. 2008. Is yours a learning organisation? *Harv Bus Rev* 86(3):109-16, 134.

Gelijns, AC., and Their, SO. 1990. Medical technology development: an introduction to the innovation-evaluation nexus. In: Gelijns, AC, ed. Medical innovation at the crossroads, vol. 1. Modern methods of clinical investigation. Washington DC; National Academy Press

Giddens A. 1984. *The constitution of society: outline of the theory of structure*. Berkeley, CA: University of California Press.

Giddens A. 1986. *The Constitution of Society*. Berkeley, CA: University of California Press.

Gittell J., and Weiss L. 2004. Linking coordination networks and organisational design to improve the coordination of work. *Journal of Management Studies,* 41(1): 127-153

Goelman A. 2005. *A spatial structuring approach to IT use and workplace change: What's space got to do with it?* Massachusetts Institute of Technology.

Goelman A. 2006. Spatial structuring at work: Comparing physician use of computer mediated communication. *MIT Workplace Centre / Department of Urban Studies and Planning*.

Goffman E. *The Presentation of Self in Everyday Life*. New York: Penguin; 1969.

Gosling AS, Westbrook JI, Braithwaite J. 2003. Clinical team functioning and IT innovation: a study of the diffusion of a point-of-care online evidence system. *J Am.Med Inform.Assoc*. 10:244-51.

Govasi DV, Swaminathan M, & Daga SR 1998, 'Appropriate technology in the transportation of sick newborns in developing countries,', Tropical Doctor, vol. 28, pp. 101-102.

Granovetter MS. The strength of weak ties. The American Journal of Sociology 1973; 78(6):1360-1380.

Green, LW. 2001. From research to best practices in other settings and populations. *American Journal of Health Behaviour*, 25: 165-178

Green, LW. and Johnson, JL. 1996. Dissemination and utilisation of health promotion and disease prevention and knowledge: theory, research and experience. *Canadian Journal of Public Health*, 87: 11-17

Greenberg, D., Peterburg, Y., Vekstein, D. et al. 2005. Decisions to adopt new technologies at the hospital level: insights from Israeli medical centers. Int J Technol Assess Healthcare, 21(2): 219-227

Greener I. Expert patients and human agency: Long-term conditions and Giddens' structuration theory. Social Theory and Health 2008; 6:273-290.

Greenhlagh T and Peacock R. (2005) Effectiveness and efficiency of search methods in systematic reviews of complex evidence: audit of primary sources. *British Medical Journal*, 331: 1064-65.

Greenhalgh T, Robert G, Macfarlane F, Bate P and Kyriakidou O. 2004. Diffusion of innovations in service organisations: systematic literature review and recommendations for future research. *Millbank Quarterly* 82:581-629.

Greenhalgh, T., Robert, G,. Bate, S.P., Macfarlane, F., and Kyriakidou, O. (2005). *Diffusion of Innovations in Health Service Organisations*. Oxford: Blackwells

Greenhalgh, T. 2008. Role of routines in collaborative work in healthcare organisations. *BMJ*, 337: 1269-1271

Greenhalgh T, Stramer K, Bratan T. et al. 2008. '10% technology, 90% business change': A case study of the introduction of the Summary Care Record in England using diffusion of innovations theory. *BMJ*, 337: a1786

Greer AL. 1981. Medical technology: assessment, adoption and utilization. *Journal of Medical Systems*, 5:129-45

Greer, AL. 1984. Medical technology and professional dominance theory. Soci Sci Med, 18(10): 809-817

Greer AL. 1985. Adoption of medical technology: the hospital's three decision systems. *International Journal of Technology Assessment in Healthcare*, 1:669-90.

Grol RPTM, Bosch MC, Hulscher MEJL, Eccles MP and Wensing M. 2007. Planning and studying improvement in patient care: the use of theoretical perspectives. *The Milbank Quarterly* 85(1): 93-138

Hage J,.Aiken M. 1967. Program change and organizational properties. A comparative analysis. *American Journal of Sociology,* 72:503-19.

Hage, J., and Dewar, R. 1973. Elite values versus organizational structure in predicting innovation. *Administrative Science Quarterly*, 18: 279-90

Hanseth O. Integration-complexity-risk: the making of information systems out-of-control. In: Ciborra CU, Hanseth O, editors. Risk, complexity and ICT. Oslo: Edward Elgar; 2007.

Hanseth O, Jacucci E, Grisot M, Aanestad M. Reflexive standardization: side effects and complexity in standard making. Mis Quarterly 2006; 30:563-581.

Harris J. The ordering of things: organisation in Bruno Latour. The Sociological Review 2005; 53(S1):163-167.

Healthcare Industries Taskforce. 2004. *Better health through partnership: a programme for action. Final report*. London: Department of Health.

Hewer RL & Wood VA. Availability of computer tomography of the brain in the United Kingdom. BMJ 298[1219], 1220. 1989.

Higgs, G., Smith, DP., Gould, MI. 2005. Findings from a survey on GIS use in the UK National Health Service: organisational challenges and opportunities. Health Policy, 72: 105-117

Hillman AL & Schwartz JS. The Adoption and Diffusion of CT and MRI in the United States: A Comparative Analysis. Medical Care 23[11], 1283-1294. 1985.

Hillman BJ. Government Health Policy and the Diffusion of New Medical Devices. Health Services Research 21[5], 682-710. 1986.

Himes JA & Rosenfeld K. Integrating digital systems: commitment and collaboration. Radiology Management 26[3], 28-30. 2004.

Hoffmann R, Mintz GS, Popma JJ, Satler LF, Kent KM, Pichard AD, & Leon MB. Treatment of calcified coronary lesions with Palmaz–Schatz stents. European Heart Journal 19[8], 1224-1231. 1998.

Hollan J, Hutchins E, Kirsh D. Distributed cognition: toward a new foundation for human-computer interaction research. ACM Transactions on Computer-Human Interaction 2000; 7(2):174-196.

House R, Rousseau DM, Thomas-Hunt M. 1995. The meso paradigm: a framework for the integration of micro and macro organisational behaviour. *Research in Organizational Behaviour*, 17:71-114.

House of Commons Health Committee, 2005. *The Use of New Medical Technologies within the NHS. Fifth Report of Session 2004–05. Volume I. Report, together with formal minutes*. London: The Stationery Office

Howard-Grenville JA. 2005. The persistence of flexible organisational routines: The role of agency and organisational context. *Organisation Science* 16:618-636.

Jackson MH, Poole MS and Kuhn T. 2001. The social construction of technology in studies of the workplace. In: Lievronouw L, Livingstone SM, editors. *Handbook of New Media*. London: Sage.

Kaluzny, AD., Veney, JE., Gentry, JT. 1974. Innovation of health services: a comparative study of hospitals and health departments. The Milbank Memorial Fund Quarterly, 52(1): 51-82

Kamerow D. Stents or surgery? BMJ 334, 7594. 2007.

Kautz K., and Larsen, EA. 2000. Diffusion theory and practice: disseminating quality management and software process improvement innovations. *Information, Technology and Practice*, 13(1): 11-26

Karsh, B.T. 2004. Beyond usability: designing effective technology implementation systems to promote patient safety. *Quality & Safety in Healthcare*, 13: 388-394

Khandwalla, PN. 1974. Mass output orientation of operation technology and organisational structure. *Administrative Science Quarterly*, 19: 74-97

Kimberly, JR. 1978. Hospital adoption of innovation: the role of integration into external informational environments. *Journal of Health and Social Behaviour*, 19(4): 361-373

Kimberly, J. 1981. Managerial innovation. In: Nystrom, PC., Starbuck, WH. Eds. *Handbook of Organizational Design*, p. 84-104. NY; OUP

Kimberly, JR., and Cook, JM. 2008. Organizational measurement and the implementation of innovations in mental health services. *Adm Policy Ment Health*, 35: 11-20

Kimberly JR, and Evanisko JM. 1981. Organisational innovation: the influence of individual, organisational and contextual factors on hospital adoption of technological and administrative innovation. *Academy of Management Journal*, 24:689-713.

King, N. 1992. Modelling the innovation process: an empirical comparison of approaches. *Journal of Occupational & Organisational Psychology*, 65(2): 89-100

Klein, KJ., and Sorra, JS. 1996. The challenge of innovation implementation. *Academy of Management Review*, 21: 1055-1080

Knudsen, HK., and Roman, PM. 2004. Modeling the use of innovations in private treatment organizations: the role of absorptive capacity. *Journal of Substance Abuse Treatment*, 26: 51-59

Koch, MJ., Lam LW, and Meyer, AD. 1996. *Hospital adoption of medical technology: a multi-stage model*. Academy of Management Proceedings; Healthcare Administration Division

Kuhn TS. *The structure of scientific revolutions*. Chicago: University of Chicago Press; 1962.

Kukafka, R., Johnson, SB, Linfante, A. et al. (2003) Groudning a new information technology implementation framework in behavioural science: a systematic analysis of the literature on IT use. *Journal of Biomedical Informatics*, 36: 218-227

Lang, PO., Schwarze, ML., and Alexander, GC. 2005. New technologies meeting old professional boundaries: the emergence of carotid artery stenting. *J Am Coll Surg*, 200(6): 854-860

Lansisalmi, H., Kivimaki, M., Aalto, P. et al. 2006. Innovation in healthcare: a systematic review of recent research. *Nursing Science Quarterly*, 19: 66-72

Latour B. *Aramis, or love of technology*. Translated by Catherine Porter. London: Harvard University Press; 1996.

Latour B, Woolgar S. *Laboratory life: the social construction of scientific facts*. London: Sage; 1979.

Latour B. *Reassembling the social : an introduction to actor-network-theory*. Oxford: Oxford University Press; 1992.

Latour B. Social theory and the study of computerized work sites. In: Orlikowski WJ, Walsham G, Jones M, editors. *Information technology and changes in organisational work*. London: Chapman and Hall; 1995. 295-307.

Latour B. Drawing things together. In: Lynch M, Woolgar S, editors. *Representations in Scientific Practice*. Cambridge,MA: MIT Press; 1990.

Lave J, Wenger E. *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press; 1991.

Lee, G., and Xia, W. 2006. Organizational size and IT innovation adoption: a meta-analysis. *Information & Management*, 43: 975-985

Lehman, WEK., Greener, JM and Simpson, DD. 2002. Assessing organisational readiness for change. *Journal of Substance Abuse Treatment*, 22(4): 197-209

Lehoux P, Sicotte C, Denis JL, Berg M and Lacroix A. 2002. The theory of use behind telemedicine: how compatible with physicians' clinical routines? *Soc Sci Med* 54(6):889-904.

Lemke HU. 2003 PACS developments in Europe. *Computer Medical Imaging Graphics* 27[2-3], 111-120. 2003.

Liaropoulos, L. 1997. Do we need 'care' in technology assessment in healthcare? *Int J Technol Assess Healthcare*, 13(1): 125-127

Liddell, A., Adshead, S., and Burgess, E. (2008) *Technology in the NHS. Transforming the patient's experience of care.* London; The King's Fund

Lu, Y-C., Xiao, Y., Sears, A. et al. 2005. A review and a framework of handheld computer adoption in healthcare. International Journal of Medical Informatics, 74: 409-422

Maguire, S. 2002. Discourse and adoption of innovations: a study of HIV-AIDS treatments. Healthcare Management Review, 27(3): 74-88

Mantzana, V. and Theristocleosus, M. 2005. Towards a conceptual framework of actors and factors affecting the EAI adoption in healthcare organisations. *Proceedings of the 13th European Conference on Information Systems*, Regensberg, Germany, May 26-28, 2005

May, C., Harrison, R., Finch, T. et al. 2003. Understanding the normalization of telemedicine services through qualitative evaluation. J Am Med Inform Assoc, 10: 596-604

May, C. 2006. A rational model for assessing and evaluating complex interventions in healthcare. *BMC Health Services Research*, 6: 86

May, C., Finch, T, Mair, F. et al. (2007) Understanding the implementation of complex interventions in healthcare: the normalisation process model. *BMC Health Services Research*, 7: 148

McGregor, M., and Brophy, JM. 2005. End-user involvement in health technology assessment (HTA) development: a way to increase impact. Int J Tech Assess Healthcare, 21(2): 263-267

McLean C, Hassard J. Symmetrical Absence/Symmetrical Absurdity: Critical Notes on the Production of Actor-Network Accounts. Journal of Management Studies 2004; 41(3):493-519.

McLoughlin, I. 1999. *Creative technological change*. London; Routledge

McLoughlin, I., and Badham, R. 2005. Political process perspectives on organisation and technological change. *Human Relations*, 58(7): 827-843

Mingers J. 2004. Real-izing information systems: critical realism as an underpinning philosophy for information systems. *Information and Organisation* 14(2):87-103.

Meyer AD,.Goes JB. 1988. Organisational assimiliation of innovations: a multi-level contextual analysis. *Academy of Management Review*, 31:897-923.

Mike, V., Krauss, AN., Ross, GS. 1998. Responsibility for clinical innovation: a case study in neonatal medicine. Evaluation & the Health Professions, 21: 3-26

Moch, MK. 1976. Structure and organizational resource allocation. Administrative Science Quarterly, 21(4): 661-674

Moch, MK., and Morse, EV. 1977. Size, centralization and organizational adoption of innovations. American Sociological Review, 42(5): 716-725

Mohr LB. 1969. Determinants of innovation in organisations. *American Political Science Review*, 63:111-26.

Mogard HT, Bunch EH and Moen A. 2006. Implementing communication systems in the community health services. The healthcare workers experiences. *Stud Health Technol Inform* 124:347-355.

Mustonen-Ollila E,.Lyytinen K. 2003. Why organizations adopt information process innovations: a longitudinal study using diffusion of inn ovations theory. *Information Systems Journal*, 13:275-97.

Mutch A. Actors and networks or agents and structures: towards a realist view of information systems. Organisation 2002; 9(3):477-496.

Napoli M, Nanni M, Cimmara S, Crisafulli P, & Marano P. Picture archiving and communication in radiology. Rays 28[1], 73-81. 2003.

Nathanson, CA., and Morlock, LL. 1980. Control structure, values and innovation: a comprarative study of hospitals. Journal of Health and Social Bheaviour, 21(4): 315-333

Nordmann et al. Mortality in randomized controlled trials comparing drug-eluting vs. bare metal stents in coronary artery disease: a meta-analysis. European Heart Journal 27[2784], 2814. 2006.

Novek J. IT, Gender and Professional Practice: Or Why an Automated Drug Distribution System was Sent Back to the Manufacturer. Science Technology Human Values 2002; 27(3):379-403.

Nystrom, PC., Ramamurthy, K., Wilson, AL. 2002. Organizational context, climate and innovativeness: adoption of imaging technology. Journal of Engineering and Technology Management, 19: 221-247

Obstfelder A and Moen A. 2006. The electronic patient record in community health services--paradoxes and adjustments in clinical work. *Stud Health Technol Inform* 122:626-631.

Orlikowski, WJ. 1992. The duality of technology: rethinking the concept of technology in organisations. *Org Science*, 3: 398-427

Orlikowski WJ and Yates J. 2006. ICT and organisational change: a commentary. *The Journal of Applied Behavioral Science* 42(1):127-134.

Orlikowski WJ, Yates JA, Okamura K and Fujimoto M. 1995. Shaping electronic communication: the metastructuring of technology in the context of use. *Organisation Science* 6(4):423-444.

Orlikowski WJ. 2002. Knowing in practice: Enacting a collective capability in distributed organizing. *Organisation Science* 13(3):249-273.

Orlikowski WJ. 2006. Material knowing: the scaffolding of human knowledgeability. *European Journal of Information Systems* 15:460-466.

Orlikowski WJ. 2000. Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organisations. *Organisation Science* 11(4):404-428.

Osborne, SP. 1998. Naming the beast: delivering and classifying service innovations in social policy. *Human Relations*, 1998, 51: 1133-54

Østerlund C and Carlile P. 2005a. Relations in practice: Sorting through practice theories on knowledge sharing in complex organisations. *The Information Society* 21:91-107.

Østerlund C, Dosa NP and Arnott Smith C. 2005b. *Mother knows best: Medical record management for patients with spina bifida during the transition from pediatric to adult care*. Washington, DC: AMIAA.

Østerlund C. 2006. Combining genres: How practice matters. Hawaii: HICSS.

Østerlund C. 2002. *Documenting dreams: patient-centered records versus practice-centered records*. PhD thesis. MIT Sloan School of Management.

Østerlund C. 2003a. Documenting practices: The indexical centering of medical records. *Outlines* 2:43-68.

Østerlund C. 2003b. How practice matters: a relational view of knowledge sharing. In: Huysman M, Wenger E, Wulf V, editors. *Communities and technologies: Proceedings of the first international conference on communities and technologies*. Dordrecht, NL: Kluwer Academic Publishers: 1-22.

Østerlund C. 2004a. Mapping medical work: documenting practices across multiple medical settings. *Journal of the Center for Information Studies* 5:35-43.

Østerlund C. 2004b. *Two doctors' documenting practices: How the indexical centring of medical records integrates the encoding, communication and coordination of patient care*. 2nd Annual Meeting of the Document Academy. School of Information Management and Systems: University of California, Berkeley.

Pare, G., Sicotte, C. and Jacques, H. (2006) The effects of creating psychological ownership on physicians' acceptance of clinical information systems. JAMIA, 13(2): 197-205

Pare, G. and Trudel, M-C. 2007. Knowledge barriers to PACS adoption and implementation in hospitals. International Journal of Medical Informatics, 76: 22-33

Parvinen, P. and Tolkki, O. 2007. Using the benefits of picture archiving and communicating systems – constraints in stakeholder governance. Int J Healthcare Technology and Management, 8(6): 644-660

Pentland BT. 1995. Grammatical Models of Organisational Processes. *Organisation Science* 6(5):541-556.

Pentland BT, Feldman MS. Narrative Networks: Patterns of Technology and Organisation. Organisation Science 2007; 18(5):781-795.

Perlow LA, Gittell JH and Katz N. 2004. Contextualizing patterns of work group interaction: Toward a nested theory of structuration. *Organisation Science* 15(5):520-536.

Pettigrew, A. 1990. Longitudinal field research on change: theory and practice. Organization Science, 1(3): 267-292

Pettigrew, A. 1997. What is a processual analysis? *Scandinavian Journal of Management*, 13(4): 337-48

Pierce JL,.Delbecq AL. 1977. Organisational structure, individual attitudes and innovation. *Academy of Management Review,* 2:27-37.

Pinder R, Petchey R, Shaw S and Carter YH. 2005. What's in a Care Pathway? Towards a cultural cartography of the new NHS. *Sociology of Health and Illness* 27(6):759-779.

Plsek, P., Bibby, J., Whitby, E. 2007. Practical methods for extracting explicit design rules grounded in the experience of organisational managers. *The Journal of Applied Behavioural Science*, 43: 153-170

Poole, MS., and DeSanctis, G. 1990. Understanding the use of group decision support systems: the theory of adaptive structuration. In: J Fulk and C Steinfield (eds). *Organization and Communication Technology*. Newbury Park, Ca; Sage

Potvin, L. 1996. Methdological challenges in evaluation of dissemination programs. *Can J Public Health*, 87(suppl 2): 579-983

Poulsen, PB., Vondeling, H, Dirksen, CD et al. 2001. Timing of adoption of laparoscopic cholecystectomy in Denmark and the Netherlands: a comparative study. *Health Policy*, 55: 85-95

Pratt MG, Rockmann KW and Kaufmann JB. 2006. Constructing professional identity: The role of work and identity learning cycles in the customization of identity among medical residents. *Academy of Management Journal* 49:235-262.

Ramani, S. 2007, The cradle, the cuddle, or the carton? A socio-cultural evaluation of an innovation that prevents hypothermia among babies in low-resource areas of India, Boston University.

Rao C, Aziz O, Singh Panesar S, Jones C, Morris S, Darzi A, & Athanasiou T. Cost effectiveness analysis of minimally invasive internal thoracic artery bypass versus percutaneous revascularisation for isolated lesions of the left anterior descending artery. BMJ, 334, 621. 2008.

Reardon, JL., and Davidson, E. 2007. An organizational learning perspective on the assimilation of electronic medical records among small physician practices. European Journal of Information Systems, 16: 681-694

Richmond C. Obituary: SirGodfrey Hounsfield. BMJ 329[687], 687. 2004.

Reed M. 2005. Reflections on the realist turn in organisation and management studies. *Journal of Management Studies* 42(8):1622-1644.

Renholm M, Leino-Kilpi H and Suominen T. 2002. Critical pathways. A systematic review. *Journal of Nursing Administration* 32(4):196-202.

Roback, K., Gaddlin, P-O., Nelson, N. et al. 2007. Adoption of medical devices: perspectives of professionals in Swedish neonatal intensive care. Technology and Healthcare, 15: 157-179

Robert, G., Stevens, A., Gabbay, J. 1999. *'Early warning systems' for identifying new healthcare technologies.* Health Technology Assessment, 3(13)

Robertson, TS., and Wind, Y. 1980. Organisational psychographics and innovativeness. The Journal of Consumer Research, 7(1): 24-31.

Robertson, TS., and Wind, Y. 1983. Organisational cosmopolitanism and innovativeness. The Academy of Management Journal, 26(2): 332-338

Rodriguez C and Pozzebon M. 2005. *The Discursive Construction of Configurable Artifacts:Following Initial Steps of a Clinical Information System Implementation*. Montréal, Canada: HEC (downloadable from http://gresi.hec.ca/SHAPS/cp/gescah/formajout/ajout/test/uploaded/cahier 0506.pdf).

Rodriguez, C. and Pozzebon, M. (2006) 'A Paradoxical World: Exploring the Discursive Construction of Collaboration in a Competitive Institutional Context'. APROS 11: Asia-Pacific Researchers in Organisation Studies: 11th International Colloquium, Melbourne, Australia, 4-7 December 2005.

Rogers EM. 1995. *Diffusion of innovations*. New York: Free Press.

Rogers, H., Maher, L., Plsek, P. 2009. Better by design: using simple rules to improve access to secondary care. *BMJ*, 338: 384-387

Romme, AGL. 2003. Making a difference: organisation as design. *Organization Science*, 14(5): 558-573

Rosen, R. and Mays, N. 1998. The impact of the UK NHS purchaser-provider split on the 'rational' introduction of new medical technologies. *Health Policy*, 43: 103-123

Ryan B,.Gross N. 1943. The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology* 8:15-24.

Rye, C.B. & Kimberly, J.R. (2007). The adoption of innovations by provider organisations in healthcare. *Medical Care Research and Review*, 64(3): 235-278

Savitz, LA., Kaluzny, AD., Kelly, DL. 2000. A lifecycle model of continuous clinical process innovation. *Journal of Healthcare Management*, 45(5): 308

Scott, WR. 1990. Innovation in medical care organizations: a synthetic review. *Medical Care Review*, 47(2): 165-192

Scott WR. 2001. *Institutions and organisations*. Thousand Oaks, CA: Sage.

Shende SR, Daga SR, & Kinikar NA 1998, 'Use of a styropor box for thermal control of low birth-weight babies after discharge from hospital', *Journal of Tropical Pediatrics*, vol. 44, no. 3, pp. 183-184.

Sharma, B., Danjoux, NM, Harnish, JL et al. 2006. How are decisions to introduce new surgical technologies made? Advanced laparoscopic surgery at a Canadian community hospital: a qualitative case study and evaluation. *Surg Innov*, 13: 250-256

Sicotte C, Denis JL, Lehoux P and Champagne F. 1998a. The computer-based patient record challenges towards timeless and spaceless medical practice. *Journal of Medical Systems* 22(4):237-256.

Sicotte C, Denis JL and Lehoux P. 1998b. The computer based patient record: a strategic issue in process innovation. *Journal of Medical Systems* 22(6):431-443.

Slappendel, C. 1996. Perspectives on innovation in organizations. *Organization Studies*, 17(1): 107-129

Sloan, FA., Valvona, J., Perrin, JM. 1986. Diffusion of surgical technology. An exploratory study. *Journal of Health Economics*, 5: 31-61

Snyder, RA., and Fields, WL. 2006. Measuring hospital readiness for information technology innovation: a multisite study of the organizational information technoklogy innovation readiness scale. *J of Nursing Measurement*, 14(1): 45-55

Snyder-Halpern, R. 2001. Indicators of organizational readiness for clinical information technology/systems innovation: a Delphi study. International Journal of Medical Informatics, 63: 179-204

Southon, FCG., Sauer, C., and Dampney, CNG. 1997. Information technology in complex health services: organizational impediments to successful technology transfer and diffusion. JAMIA, 4: 112-124

Stake R. 1995. *The art of case study research*. London: Sage.

Star SL. Infrastructure and ethnographic practice: working on the fringes. Scandinavian Journal of Information Systems 2002; 14(2):107-122.

Stones R. 2005. *Structuration theory*. Basingstoke: Palgrave-Macmillan.

Strang D,.Soule S. Diffusion in organizations and social movements: from hybrid corn to poison pills. *Annual Review of Sociology* 1998; **24**:265-90

Stricklin, MLV., and Struk, CM. 2003. Point of care technology: a sociotechnical approach to home health implementation. Methods Inf Med, 2003, 42: 463-70

Tabak, F., and Barr, SH. 1999. Propensity to adopt technological innovations: the impact of personal characteristics and organisational context. Journal of Engineering and Technology Management, 16: 247-270

Taggart DP. Coronary revascularisation David P Taggart BMJ 2007 334: 593-594. BMJ 334, 593-594. 2007.

Taylor AJ and Randall C. 2007. Process mapping: enhancing the implementation of the Liverpool Care Pathway. *Int J Palliat Nurs* 13(4):163-167.

Teplensky, JD., Pauly, MV, Kimberly, JR. et al. 1995. Hospital adoption of medical technology: an empirical test of alternative models. *Health Services Research*, 30(3): 437-465

Themistocleous, M. 2002. *Evaluating the adoption of Enterprise Application Integration in multinational organisation.* PhD thesis, Department of IS and Computing, Brunel University, London

Themistocleous, M. 2004. Justifying the decision for EAI implementations: a validated proposition of factors. *Journal of Enterprise Information Management*, 17(2): 85-104

Timmons, S. 2001. How does professional culture influence the success or failure of IT implementation in health services? In: L Ashburner, ed. *Organisational behaviour and organisational studies in healthcare: reflections on the future*, p. 218-31. Basingstoke; Palgrave

Tornatzky LG, Fleischer M. 1990. *The processes of technological innovation*. Lexington, MA:Lexington Books.

Underwood, J. 2002. Stakeholders, signs and ANT: A theoretical basis for IS? Canberra: Workshop Information Systems Foundations: Building the Theoretical Base. 1-2 October 2002; Canberra: Australian National University; 2002.

Van Aken JE. 2004. Management research based on the paradigm of the Design Sciences: the quest for tested and grounded technological rules. *Journal of Management Studies* 41(2): 219-246

Van Aken JE. 2005a. Valid knowledge for the professional design of large and complex design processes *Design Studies* 26: 379-404

Van Aken JE. 2005b. Management research as a Design Science: articulating the research products of Mode 2 knowledge production. *British Journal of Management* 16: 19-36

Van de Ven AH, Polley DE, Garud R, Venkataraman S. 1999. *The Innovation Journey*. Oxford: Oxford University Press.

Van de Ven, AH., and Polley, D. 2008. Learning while innovating. *Organization Science*, 3(1): 92-116

Wainwright, DW and Waring, TS. 2007. The application and adaptation of a diffusion of innovation framework for information systems research in NHS general medical practice. *Journal of Information Technology*, 22: 44-58

Walsham G. Doing interpretive research. Eur J Inf Syst 2006; 15(3):320-330.

Walker, R. 2003. Evidence on the management of public services innovation. Public Money & Management, April: 93-102

Walston, SL., Kimberly, JR. and Burns, LR. 2001. Institutional and economic influences on the adoption and extensiveness of managerial innovation in hospitals: the case of reengineering. Medical Care Research and Review, 58(2): 194-228

Wang, BB, Wan, TTH, Burke DE et al. 2005. Factors influencing health information system adoption in American hospitals. *Healthcare Management Review*, 30(1): 44-51

Waterman, H., Marshall, M., Noble, J. et al. 2007. The role of action research in the investigation and diffusion of innovations in healthcare: the PRIDE Project. Qualitative Health Research, 17: 373-381

Weick KE. 1995. *Sensemaking in organisations*. Thousand Oaks, CA: Sage.

Weick KE. 1990. Technology as equivoque: sensemaking in new technologies. In: Goodman PS, Sproull LS, editors. *Technology and organisations*. San Francisco, CA: Jossey-Bass: 1-44.

Weiner, BJ., Savitz, LA., Bernard, S et al. 2004. How do integrated delivery systems adopt and implement clinical information systems? Healthcare Manage Rev, 29(1): 51-66

Weingart, SN. 1993. Acquiring advanced technology. Decision-making strategies at twelve medical centers. Int J Technol Assess Healthcare, 9(4): 530-538

Wenger E. 1996. *Communities of practice: Learning, meaning and identity*. Cambridge: Cambridge University Press.

West, M. 1990. The social psychology of innovation in groups. In: M. West & J. Farr. *Innovation and creativity at work: psychological and organisational strategies.* Wiley; Chichester

West, M. 2002. Sparkling fountains or stagnant ponds: an integrative model of creativity and innovation implementation in work groups. *Applied psychology: An International Review*, 51: 359-424

West, M. and Farr, J. 1990. *Innovation and creativity at work: psychological and organisational strategies.* Wiley; Chichester

Williams, I., and Dickinson, H. 2008. *Knowledge for adoption: a review of the literature on knowledge-based facilitation of technology adoption in healthcare*. Birmingham; Health Services Management Centre, University of Birmingham

Wilson CB. 2008. Adoption of new surgical technology. *British Medical Journal*, 332:112–4.

Wilson T, Berwick DM and Cleary PD. 2003. What do collaborative improvement projects do? Experience from seven countries. *Jt Comm J Qual Saf* 29(2):85-93.

Wolfe B. 1994. Organisational innovation: review, critique and suggested research directions. *Journal of Management Studies*, 31:405-31.

Yates J and Orlikowski WJ. 2002. Genre systems: structuring interaction through communicative norms. *The Journal of Business Communication* 39(1):13-35.

Yates J and Orlikowski WJ. 1992. Genres of organisational communication: a structurational approach to studying communication and media. *Academy of Management Review* 17(2):299-326.

Yates J. 1999. Explicit and implicit structuring of genres in electronic communication: reinforcement and change of social interaction. *Organisation Science* 10(1):83-103.

Yusof, MM., Stergioulas, L., and Zugic, J. 2007. Health information systems adoption: findings from a systematic review, *Studies in Health Technology & Information*, 129(1): 262-266

Zaltman G, Duncan R, Holbeck J. 1973. *Innovations and organisation*. New York: Wiley.

Zhu, K., Kraemer, KL., Xu, S. 2006. The process of innovation assimilation by firms in different countries: a technology diffusion perspective on E-business. Management Science, 52(10): 1557-1576

Zmud, RW. 1982. Diffusion of modern software practices. Influences of centralisation and formalisation. *Management Science*, 28(12): 1421-1431

Appendix 1 Data extraction form

AUTHOR/TITLE OF PAPER:				
UNIQUE IDENTIFIER:				
NAME OF REVIEWER:				
A [FIRST SIFT] Is the paper relevant to our research question and worthy of further consideration?				
1 **Relevance** Is the paper about the process of adoption of a (non-pharmaceutical) technological innovation in a healthcare organization? (a) If YES, is it: - NHS - other healthcare system (state) (b) If NO, reason(s) for exclusion: - non-healthcare sector - pharmaceutical technology - organizational innovation (not a technology) - not about process of adoption - only about individual adopter/user characteristics (non-organisational) - other (please state)				YES NO
2 **Worth** Does the paper go beyond superficial description or commentary – i.e. is it a broadly competent attempt at research, enquiry, investigation or study? [If a confident 'no' to either of these, reject now]				
B How does the paper fit into our taxonomy?				
Paradigm What is the predominant theoretical 'lens' used? [if more than one, put double circle round the dominant one]	1Complexity/general systems theory	2 Social network theory	3 Social influence theory (classical adoption)	4 Communication theory
	5 Marketing theory (including social marketing)	6 Political influence theories	7 Knowledge utilisation theory	8 Behaviour theories (e.g. concerns based adoption model, TBP)
	9 [Adult] learning theory	10 Organisational theory	11 Classical management theory	12 Classical economic theory
	12 Other (specify) (e.g. Technology Acceptance Model)		NOTES	
1 Type of paper What is the research design or review style	1 Theory or conceptual framework	2 Editorial review, commentary or opinion	3 Systematic review	4 RCT
	5 Non-RCT experimental or quasi-experimental study	6 Questionnaire survey	7 Qualitative interview study (inc. focus group)	8 Ethnographic study ('anthropological' case study)

[classify as the MAIN pitch of the paper]	9 Mixed methodology case study	10 Action research	11 Tool/ checklist/ model	12 Guideline/ protocol
	13 Comparative case study	14 Network analysis	15 Attribution study	
	OTHER [Specify]			

2 Unit of analysis [ring one or more]	Individual	Group or team	Organisation	Inter-organisational	Regional/ national	Multi-level
	NOTES					

C Bottom line for this review			
Relevance Does the paper have an important message for our research question? [circle one]	1 Essential to include	2 Relevant but not essential	3 Marginal relevance
Methods Does the paper fulfil the established quality criteria for papers in its domain? [circle one]	4 Outstanding	5 Some limitations	6 Many important limitations

Does the paper explore:	
♦ how NHS organisations undertake the assessment of the need for healthcare technology	Y / N
♦ the role of procurement processes and how they work	Y / N
♦ the linkages between managerial and clinical decision-making in relation to technology adoption	Y / N
♦ organisational and cultural factors affecting technology adoption in healthcare in healthcare organisations (and whether and how they differ from other organisations)	Y / N
♦ the organisational processes and systems that inhibit or support the adoption of technological innovation in healthcare organisations	Y / N

D Appraisal questions for primary studies

e.g. Oakley (2000): 'The distinguishing mark of good research is the awareness and acknowledgement of error and [hence] the necessity of establishing procedures which will minimise the effect such errors have on what counts as knowledge.'

1 **Question** Did the paper address a clear research question and if so, what was it? In particular, were complex terms such as 'hospital at home', 'private finance' defined clearly and unambiguously?				
2 **Design** What was the study design and was this appropriate to the question?				
3 **Funding** Who funded the study?	1 National govern-ment	2 Inter-national (e.g. EU)	3 Research charity	4 No external funding
	5 Private (e.g. pharma)	6 Service (e.g. NHS, HMO)	7 Profession (e.g.RCN)	8 Not stated
4 **Actor 1 ['resource system']** In this study, from whom is the innovation said to come?				
5 **Innovation** What is the nature of the (non-pharmacological) technological innovation?				

6 **Context** What was the context of the study? Was this sufficiently well described that the findings can be related to other settings? [NB Transferability of case study findings to different settings is best judged via a detailed analysis of the 'rich picture' of the case itself]	
7 **Actor 2 ['user system']** Who is receiving the innovation (or to whom is it being sent or marketed)?	
8 **Dissemination process** What (if any) were the elements the active dissemination process?	
9 **Decision-making and adoption process**	
10 **Implementation process** What (if any) were the elements the active implementation process?	
11 **Sampling** Did the researchers include sufficient cases/settings/observations? [could conceptual rather than statistical generalisations be made?]	
12 **Data collection** Was the data collection process systematic, thorough and auditable?	
13 **Data analysis** Were the data analysed systematically and rigorously? Have sufficient data been presented to allow the reader to assess independently whether analytical criteria have been met? How were disconfirming observations dealt with?	
14 **Results** What are the main results and in what way are they surprising, interesting, or suspect? [Include any intended and unintended consequences]	
15 **Conclusions** Did the authors draw a clear link between data and explanation (theory)? If not, what are your reservations?	
16 **Critical processes** What processes does the paper identify as critical to the adoption of innovations? HYPOTHETICAL OR ASSUMED	
ACTUALLY DEMONSTRATED	
17 **Reflexivity** Are the authors' positions	

and roles clearly explained and biases considered?	
18 **Any ethical reservations?**	

Appendix 2 Excluded studies from Rye and Kimberly, 2007

Study included in Rye & Kimberly, 2007 (first author, year)	Focus; reason(s) for exclusion if 'No'
Aiken, 1971	Second paper (see Hage, 1967) from study of 'New programs or services in health and welfare organisations in Midwest US' through interviews conducted in 1967; unclear as to how many technological innovations were considered and nature of organisations under study
Arndt, 1995	Investigates factors associated with the adoption of corporate restructuring by hospitals in Massachusetts; concerned with administrative rather than technological innovation
Baker, 2001	Empirically examines the relationship between HMO market share and the diffusion of magnetic resonance imaging (MRI) equipment; concerned with environmental/contextual factors
Baker, 2002	Empirically examines the relationship between HMO market share and the diffusion of neonatal intensive care units; concerned with environmental/contextual factors
Banaszak-Holl, 1996	Studies factors associated with an emerging healthcare service delivery innovation, the provision of specialty care in designated units in nursing care facilities; largely concerned with innovative model of service delivery rather than technological innovation
Becker, 1970	Traces diffusion of 'programs' (measles immunisation and diabetes screening) rather than 'procedures'; concerned with innovations in service delivery rather than technological innovation
Burns, 1993	Studies factors effecting adoption of matrix management in a group of hospitals; concerned with administrative rather than technological innovation
Castle, 2001	Examines organisational and market factors associated with nursing homes that are most likely to be early adopters of two service innovations (special care units and subacute care services); concerned with innovations in service delivery rather than technological innovation
Cockerill, 1999	Examines the adoption of physician impact analysis (PIA) among hospitals; concerned with administrative rather than technological innovation
Dopson, 2002	Not organisational processes
Duffy, 1992	De-adoption of technological innovation (intermittent positive breathing pressure); concerned with de-adoption
Eisenberg, 1989	Not adoption process
Friedman, 2000	Examines the relative role of decision-maker influence and environmental factors on the timing of MRI acquisition in hospitals operating in three western US states with different

	levels of environmental uncertainty; concerned with environmental/contextual factors
Glandon, 1995	Develops and tests a model of the adoption of a managerial innovation that of cost accounting systems based upon standard costs; concerned with managerial rather than technological innovation
Greer, 1986	Unable to retrieve reference
Hage, 1967	First paper from study of 'New programs or services in health and welfare organisations in Midwest US' through interviews conducted in 1964; unclear as to how many technological innovations were considered and nature of organisations under study
Hage, 1973	Third paper (see Hage, 1967) from study of 'New programs or services in health and welfare organisations in Midwest US' that compares the concept of elite values with leader values, member values, and the three structural variables of complexity, centralization, and formalization in predicting innovation; unclear as to how many technological innovations were considered and nature of organisations under study
Hirth, 2000	Examines the impact of managed care mechanisms, particularly capitation on the decisions of dialysis units with respect to use of cost-increasing technologies that enhance quality of care, cost-cutting practices that reduce quality of care, and amenities desired by patients that are unrelated to quality of care; concerned with environmental/contextual factors
Kaluzny, 1973	Narrative review of research into innovation in health services
Lee, 1985	Estimate of the impact of prospective reimbursement on diffusion; concerned with environmental/contextual factors
Li, 2004	Describes the extent of adoption of diabetes care management processes in physician organisations in the U.S. and investigates the organisational factors that affect the adoption of diabetes care management processes; concerned with administrative rather than technological innovation
Mohr, 1969	Identifies the determinants of innovation in public agencies; unclear as to how many technological innovations were considered and nature of organisations under study
Romeo, 1984	Presents evidence on the effects of prospective hospital reimbursement on the diffusion of new medical technologies in American hospitals; concerned with environmental/contextual factors
Rosner, 1968	Studies how the economic orientation of an organisation can influence its innovativeness (as measured in terms of adoption of new pharmaceuticals); concerned with pharmaceutical technological innovation
Rosner, 1968	Pharmaceutical technological innovation
Walston, 2001	'Managerial' innovation (reengineering)
Westphal, 1997	Not technological innovation (total quality management)
Young, 2001	'Management' practices (total quality management)

Appendix 3 Narrative overviews addressing adoption and assimilation of technological innovations in healthcare organisations

Author / year	Field of study	Scope of the review	Method used	Main findings relevant to this review
Anderson 2004	Organisational psychology	Poses a series of questions and challenges to the state-of-the-science of innovation research	Content analysis of selected research published between 1997 and 2002	Identifies a routinisation of innovation research, with a heavy focus on replication–extension, cross-sectional designs, and a single level of analysis. Suggests five priorities for future work: study innovation as an independent variable, across cultures, within a multi-level framework, and use meta-analysis and triangulation.
Greer, 1981	Sociology	Focuses on knowledge gaps in understanding the process of implementing, utilizing and abandoning adopted technological innovations in healthcare	Narrative review	Promotion of the appropriate diffusion of technology in healthcare is handicapped by (1) thorny conceptual, ethical and methodological problems in technology assessment, (2) a lack of consistent findings on the factors affecting technology adoption and utilisation; and (3) a disturbing lack of apparent connection between assessment, adoption and utilisation
Karsh, 2004	Human factors engineering	To 'show that process design principles and guidelines exist which can be followed to reduce the likelihood of technology rejection and increase the likelihood of acceptance' (389). Review is applied to technologies aimed at increasing patient safety (for example, CPOE).	Eclectic review of vast literatures (technology acceptance, technology implementation, diffusion of innovations, organisational justice, etc); no clear search strategy	Helpful critique of survey based studies that use 'satisfaction with technology' or 'technology acceptance/willingness to use' (rather than measures of actual use). Provides nine generic design principles for technology implementation
Kimberly, 2008	Organisational studies	To review organisational measures related to implementation of new practices and technologies in sectors other than mental health, and discuss potential application of these measures to mental health implementation research	Narrative review	Highlights Pettigrew and Van de Ven as exemplars of process-based studies
Meyers, 1999	Organisation and management	Reviews a large, fragmented body of work on implementation in organisations, including process engineering, information technology, human resource	Narrative review; search strategy was not given and inclusion and quality criteria	Well-written review with conceptually clear taxonomy

Author / year	Field of study	Scope of the review	Method used	Main findings relevant to this review
		management, and marketing; synthesises findings to develop a conceptual framework and derives propositions about effects of key factors on implementation	were implicit rather than explicit	
Strang and Soule, 1998	Sociology	An overview that begins on similar territory to that covered by Rogers – classical diffusion from a sociological perspective – but also includes a critical analysis of a wider body of literature relevant to diffusion of innovations in organisations	Narrative review; selection of primary studies seems eclectic and quality criteria are not given	A sound and readable review whose strength is its scholarly and creative commentary
Williams, 2008	Knowledge management	Aims to: (1) examine the role of knowledge-based interventions in technology adoption and options for knowledge-related improvement; (2) explore the relationship between knowledge management and: change; adoption; organisations, and; return on investment; and (3) review the evidence on knowledge-related strategies for overcoming barriers to technology adoption	A 'review of reviews' supplemented by reviews of individual studies in areas where broader reviews of the evidence were not found	Unsurprisingly, concludes that: barriers to technology adoption range from factors relating to the technologies themselves (and the individuals adopting them), to the organisational and structural contexts of adoption. Suggests knowledge-related interventions to counter these barriers can be grouped under five headings (technology specification and assessment:; dissemination techniques; electronic decision support tools; networks and facilitated interaction; and skills and leadership development). Overall, concludes that adoption behaviour should be viewed from a multi-determinant perspective.
Wolfe, 1994	Organisation and management	A broad overview of innovation research in the organisation and management literature; good sense of vast expansion in empirical work in this tradition in 1980s and 1990s, e.g. identified 1299 journal articles and 351 dissertations addressing 'organisational innovation'	Eclectic review of vast literature. No clear search strategy but highly systematic framework for analysis	Useful source on key theoretical influences in organisational research

Appendix 4 Meta-analyses addressing adoption and assimilation of technological innovations in organisations[81]

Authors / date	Source of studies	Sample size	Aims of meta-analysis	Main findings and comments
Camisón-Zornosa, 2004	ABI/INFORM and INFOTRAC-general Business File International 1970-2001 plus handsearch of leading journals in ISI; empirical studies	52 primary studies including 87 correlation coefficients	To update Damanpour's 1992 study (see below) using the same methodology and review effects of alternative ways of measuring organisational size	Confirms a significant and positive correlation between size and innovation (albeit average size effect is quite low: 15%). Provides evidence that contradictory results in previous studies likely due to divergences in methods used to operationalise key variables. Contradicts Damanpour's (1992) finding that size is less positively related with innovation in service firms than in industrial firms. Highlights difficulties in generalising from previous studies that have employed a wide range of ways of operationalising key variables under study (e.g. size)
Damanpour, 1991	Sociological Abstracts 1960–1988, plus references from recent review articles and other sources*	23 (21 papers and two books)	To test the hypothesis that the rate of adoption of multiple innovations (organisational innovativeness) is determined by particular organisational factors ('determinants'); in all, 14 structural, process, resource and cultural variables were tested	Statistically significant association between 10 of the 14 determinants and organisational innovativeness; the strongest and most significant determinants were specialisation, functional differentiation and external communication. Results suggest that relations between these determinants and innovation are stable across studies, casting doubt on previous assertions of their instability
Damanpour, 1992	Sociological Abstracts; Psychological and Economic Abstracts (no date range supplied), plus	20 (18 papers and two books)	To specify the strength of the association between organisational size and organisational innovativeness, and to delineate the role of various moderators of this association	Organisational size is positively related to innovation; moderators included the measure of size (e.g. relation between size and innovativeness increased if size was measured by turnover rather than number of staff), type of organisation (for-

[81] Although encompassing studies of technological innovations in healthcare organisations, the meta-analyses summarised here did not focus exclusively on this specific type of technology or organisational context.

Authors / date	Source of studies	Sample size	Aims of meta-analysis	Main findings and comments
	other sources as above			profit companies had a closer correlation between size and innovativeness), and stage in the innovation process (more closely related to implementation than initiation), but not to the nature of the innovation. Size was probably a proxy for other variables, e.g. slack, complexity (see subsequent study in row below)
Damanpour, 1996	Sociological, Psychological and Economic Abstracts (1991); empirical studies published 1960–1990 in English language	21 studies including 27 separate correlations on complexity and 36 correlations on size	To explore further the relationship between organisational complexity (independent variable) and innovativeness (dependent variable); two measures of complexity were used: (a) structural complexity and (b) organisational size; also considered 14 'contingency factors' that mediated or moderated this relationship	Both structural complexity and organisational size are positively related to organisational innovation and explain, respectively, about 15% and 12% of variation in it; contingency factors common to both indicators were: environmental uncertainty; use of service organisations; focus on technical innovations; and focus on product innovations Again, the demonstrated impact of organisational factors on innovativeness appears stable and challenges previously held views that the empirical literature is inconsistent
Lee, 2006	ABI/INFORM 1980-2004	21 studies including 54 correlations of the size-IT adoption relationship	To examine: (a) the cumulative, aggregate effect of organisational size on IT innovation adoption; (b) the moderating effects of contextual variables (type of innovation, type of organisations, stage of innovation adoption, scope of size, type of size measure, industry sector) on the relationship; and (c) the moderating effect of size measures on the relationship	Analysis of the cumulative correlations across studies revealed a significant, positive relationship between organisational size and IT adoption. The direction and strength of the relationship between organisational size and IT innovation adoption depends on type of innovation, type of adoption organisation, adoption stage, scope of size measure and type of size measure. The only non-significant effect was in the non-for-profit organisation subgroup suggesting that organisational size may not be an advantage in adopting IT innovations for non-for-profit organisations

Appendix 5 Systematic reviews addressing adoption/assimilation of technological innovations in healthcare organisations

Authors / year	Scope of review	Methodological approach	Number of studies reviewed	Main findings	Strengths and limitations in relation to our own research question
England, 2000	Adoption and implementation of IT in healthcare organisations	Narrative review of *'organisational variables'* (leader characteristics; internal characteristics; external characteristics) and *'technological variables'* that impact on diffusion of innovations. Draws largely on mass communication theory (e.g. Rogers)	Not clearly stated	*Organisational variables*: The observed slow diffusion of major IT systems across health is predictable. The formalisation which exists for patient safety, the reduction of organisational slack, strong professional alignment and the centralisation of control of major IT all act to reduce the rate of innovation. *Technological variables*: strategic health systems (e.g. EPRs) score badly for their ability to diffuse. They are complex, not easily trailled, benefits are not proven and the chance to observe them installed in similar organisations is limited.	Calls for further research on role of leaders but is a (selective) overview of traditional diffusion of innovation theory plus some organisational variables.
Fleuren, 2004	Determinants of innovations in healthcare organisations	Literature review supplemented with a Delphi study intended to achieve consensus on the determinants identified from the literature review	57 studies were retrieved and 49 determinants were identified that either impeded or facilitated the innovation process. One further determinant was identified through the Delphi process	12 of the 50 determinants were 'related to the organisation'	As authors comment, they found very few well designed innovation studies and none were based on a theory
Kukafka, 2003	Narrative review of IT use behaviour in order to plan multi-level interventions to	Hierarchy of evidence with randomised trials seen as 'best evidence'; identifying whether studies adopted single or multi-	24 of 142 references retrieved met eligibility criteria	61% of studies mentioned theory but 0% considered two or more levels. Authors conclude that studies omit two fundamental	Did not focus exclusively on healthcare organisations. Acknowledges 'multiple factors at the

Authors / year	Scope of review	Methodological approach	Number of studies reviewed	Main findings	Strengths and limitations in relation to our own research question
	enhance IT use	level perspective		propositions: (1) IT usage is influenced by multiple factors, and (2) interventions must be multi-dimensional	individual, group and organisational levels' that influence use behaviour. Provides a helpful overview of (1) behavioural intention theories (Theory of Reasoned Action, Theory of Planned Behaviour, Technology Acceptance Model), (2) Diffusion theory, and (3) Social Cognitive Theory.
Lansisalmi, 2006	Conditions and factors facilitating and inhibiting innovation in healthcare organisations, and propose some guidelines for future research in the field	The authors conducted a multidimensional content analysis and summarized the foci and methods used in the 31 research studies on innovations in healthcare organisations.	Reports on innovation in healthcare organisations were located using computer searchers of electronic journals and reference databases. Of the 704 studies identified, only 31 were empirical studies, in peer-reviewed international journals (in English) on the topic of generation, adoption, or diffusion of innovations, or determinants of innovativeness in healthcare organisations.	The majority of the 31 identified studies dealt with the adoption of innovations and new practices and were cross-sectional designs applying quantitative methods, or multiple case studies applying qualitative methods.	Research recommendations similar to ours (see section 8 - five pathways for future research are recommended: (a) multilevel approaches studying innovation simultaneously on individual, group, and organisational levels; (b) a combination of quantitative and qualitative data; (c) use of longitudinal designs (innovation both as the dependent and independent variable); (d) application of experimental designs in interventions; and (e) exploration of innovation generation and structural innovations.
Lu, 2005	Handheld computers or personal digital assistants (PDAs)	Applied Davis's Technology Acceptance Model as a reviewing framework to categorize articles. Used: (1) system characteristics; (2) benefits; (3) adoption and (4) barriers, to present and summarize findings.	More than 200 articles were identified on Medline. Ninety-five of were reviewed, based on their relevancy to the adoption of PDAs.	Studies showed that PDAs were used widely in healthcare providers' practice, and the level of use is expected to rise rapidly. Major barriers to adoption were identified as usability, security concerns, and lack of technical and organisational support.	Focus is on one specific IT-based technology
Rye, 2007	Provider healthcare organisations and the adoption stage of the diffusion process	Systematic review seeking to (1) create a comprehensive census of studies examining the adoption of and disengagement from innovations in healthcare provider organisations (2)	55 studies met all criteria	Presents an organising framework of what previous researchers have explored – see section 5.3.2	Addresses exactly same research question but does not aim to provide lessons/guidance for practitioners.

Authors / year	Scope of review	Methodological approach	Number of studies reviewed	Main findings	Strengths and limitations in relation to our own research question
		organise these studies into an inductively derived classification scheme (3) assess the studies strengths and weaknesses, (4) reflect on implications for future research			
Yusof, 2007	Case studies of adoption of health information systems (HIS) in clinical settings (explicitly excluded other study designs such as surveys)	Used the 'Human, Organisation and technology-fit' evaluation framework to determine dominant factors influencing HIS adoption	55 studies were selected	As well as the fit between the human, organisation and technology factors, the critical adoption factors were: *technology* (ease of use; system usefulness; system flexibility; time efficiency; information accessibility and relevancy); *human* (user training, user perception, user roles, user skills, clarity of system purpose, user involvement); and *organisation* (leadership and support; clinical process; user involvement; internal communication; inter-organisational system)	Focus on organisational factors as enablers of technology adoption. More than half of the case studies reviewed cited specific individuals in both leadership and support positions as one of the most important factors. However, focus only on HIS and no attention to process of adoption/assimilation. 'Critical adoption' factors identified by simple count of occurrences in reviewed studies.

Appendix 6 Process based empirical NHS studies addressing assimilation of technological innovations in healthcare organisations

Author / year	Technological innovation and context	Study design and size	Aim/Hypothesis tested	Main findings relevant to this review
Ferlie, 2000	Two of four innovations ('change issues') studied in the NHS were largely technological: devolution of anticoagulation clinic to primary care by means of a computer support system; minimal access surgery for inguinal hernia)	The design had two stages: in the first stage, factors affecting the career of the selected innovation across an NHS region assessed through interviews with opinion leaders. In the second stage, micro-system interview-based case studies in four hospitals.	To study the relationship between research evidence and clinical behaviour change	Specific organisational and social factors affected the impact of scientific evidence on the diffusion of the technologies
Ferlie, 2005 [expansion of Ferlie, 2000 above]	Same two technological innovations as above	As above.	To explain barriers to the spread of innovation in multi-professional settings like healthcare	Complex, contested and nonlinear innovation careers emerged. Authors argue that social and cognitive boundaries between different boundaries retard spread, as individual professionals usually operate within uni-disciplinary communities of practice. Confirm nonlinear models of innovation (e.g. Van de Ven et al, 1999) and highlights multi-professionalisation as barrier to spread
Fitzgerald et al., 2002	Eight 'evidence into practice' case studies of which 2 technological and non-pharmaceutical (as above)	As in second stage above.	How is complex evidence implemented at organisational level? Study had 3 foci: (1) the role of certain forms of knowledge in the process of adoption and diffusion (2) the nature of adoption decisions (3) influence of differing contexts on the diffusion process	There is no single, all-or-none adoption decision. Diffusion influenced by interplay of (a) credibility of evidence (b) characteristics of multiple groups of actors; (c) features of the organisation; and (d) context. Authors comment on the ambiguous, contested and socially mediated nature of new scientific knowledge.
Fitzgerald, 2003	Use of aspirin for prevention of secondary cardiac incidents and HRT for prevention of osteoporosis	Comparative, longitudinal case studies; data collection consisted of two phases: a macrostage and a	The objectives were: (a) to trace the relative uptake/impact of four innovations across the West Midlands region and to establish the	Even for those innovations supported by robust scientific evidence, diffusion is a complex and problematic process. Adoption decisions are not

Author / year	Technological innovation and context	Study design and size	Aim/Hypothesis tested	Main findings relevant to this review
	in UK primary healthcare 1997-1999 (West Midlands region)	micro-stage	pattern of diffusion; (b) to examine the impact of these innovations on the practices of different professional groups involved in the delivery of primary healthcare; and (c) to identify other social, organisational and managerial factors which affect this diffusion process.	made in isolation by individual clinicians, but frequently through a process of debate within local communities of practice. Illustrates and develops the critical role of context to our understanding of the processes of diffusion (e.g. Kimberly & Evanisko 1981). Primary care must be conceived of as an organisational form that has dramatically different characteristics to those of the acute sector. Understanding the nature of the primary-care context also has implications for the effective management of change.
Mantzana, 2005	Enterprise Application Integration (EAI) technology to develop integrated IT infrastructure in UK acute specialist NHS Trust	Interview-based case study (n=16) of EAI adoption	Claims to be a novel approach that: (a) identifies the healthcare actors that are involved in the EAI adoption process and (b) combines these actors with the factors influencing the adoption of EAI.	This paper initially identified healthcare actors and then their relationships with the influential factors. Actor-centred but poor quality and simplistic.
May, 2003	Telehealthcare in 11 sites in the United Kingdom	Draws together the findings of three separate studies that included observation and semistructured interviews relating to approximately 582 discrete data collection episodes. Data were analyzed separately in each of three studies. Cumulative analysis was conducted by constant comparison.	To make the case for a complementary model of telemedicine evaluation that uses qualitative research methods to understand the formative processes through which new systems are designed, developed, implemented, and evaluated by their users.	(1) implementation of telemedicine services depends on a positive link with a (local or national) policy level sponsor; (2) adoption of telemedicine systems in service depends on successful structural integration so that development of organisational structures takes place; (3) translation of telemedicine technologies into clinical practice depends on the enrollment of cohesive, cooperative groups; (4) stabilization of telemedicine systems in practice depends on integration at the level of professional knowledge and practice, where clinicians are able to accommodate telemedicine through the development of new procedures and protocols. Concludes overall that a rationalized linear diffusion model of ‘‘telehealthcare’’ is inadequate in assessing the potential for normalization, and the political, organisational, and ‘‘ownership’’ problems that govern the process of

Author / year	Technological innovation and context	Study design and size	Aim/Hypothesis tested	Main findings relevant to this review
				development, implementation, and normalization need to be accounted for.
Rosen, 1998	Three technologies (vascular stenting, triple test and excimer laser) each studied in three hospitals in 3 health authority sites (selected to include adopting and non-adopting hospitals and teaching and non-teaching hospitals)	Retrospective case studies of decision-making processes involving 51 semi-structured interviews with those involved with introduction of the technologies	Was the purchaser-provide split in the NHS contributing to rational technology diffusion?	Decisions not to adopt the triple-test (in two sites) and to start using vascular stents (in one site) were made by clinician-only groups. If money or resources were explicitly required then the decision-making group inevitably expanded to include a wider group of clinical and non-clinical managers. Style, membership and level of authority of decision-making groups varied. Overall, suggests that a short-term view is taken of the clinical and organisational impact of new technologies in hospitals; consistent with findings from US (Weingart, 1993) and Greer's (1984) 'fiscal-managerial' emphasis of within-hospital decision-making.
Timmons, 2001	Computerised care-planning system in three UK hospitals	Semi-structured interviews	Explored perceived barriers to use of the new computer system by nurses	A wide range of tactics was employed by nurses, aimed at ensuring non-adoption. Findings explained in terms of internal power relations and meaning of the system for staff.
Wainwright, 2007	Information and Communication Technology (ICT) in general medical practice in the NHS	Semi-structured interviews with core set of staff (GP, practice manager and practice nurse) in five general practices in north of England	To examine four adaptations of diffusion of innovations (DOI) theory in order to identify a pragmatic, relevant and rigorous conceptual framework that may be used to explain the complex issues arising from the adoption and assimilation of IS within small healthcare practices	Highlights high level of politics influencing the adoption and diffusion process. Suggests Gallivan's (2001) model could provide insights into these power, political, cultural and organisational issues
Waterman, 2007	An information source in 2 PCTs in England and 2 Local Health Boards in Wales about practice services designed specifically for patients and members of the public with the purpose of overcoming the known barriers to their engagement with the use of health performance	Action research. 103 members of the public, practice staff from 19 general practices, NHS managers from 4 Primary Care Organisations	Argue that a particular strength of action research is its propensity to innovate, diffuse innovations, and research innovation diffusion simultaneously	Action research can be employed to diffuse innovations that need a high level of adaptation in each new setting or where there is a great deal of complexity and mismatch between different groups of people and parts of an organisation, providing there is a need or desire to research the innovation further.

Author / year	Technological innovation and context	Study design and size	Aim/Hypothesis tested	Main findings relevant to this review
	information.			

Appendix 7 Process based empirical studies in healthcare (non-NHS) addressing assimilation of technological innovations in healthcare organisations

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
Armer, 2004	Telemedicine in rural US nursing home	Interviews, participants observation, survey, chart reviews	To examine how telemedicine would affect communication between and among community health professionals.	The study uses the 'Concerns-Based Adoption Model' to provide an educational/learning perspective on adoption process. While the majority of respondents expressed awareness of the technology, they also expressed a high concern for informational and personal implications. Findings from this study provided feedback for the implementation and training phases of the project and support the appropriateness of this educational model to the healthcare setting. It was found that technical assistance on the nursing units during the initial stages of using the telemedicine technology (largely e-mail and Internet searches) built confidence and facilitated utilization.
Barley, 1986 (see section 6 and also appendix 9)	US hospital radiology	Qualitative comparative case study (using ethnography and interviews)	Why did the introduction of the 'same' technology (CT scanner) play out differently in two different settings?	The 'same' technology, when introduced in different contexts, will have different impacts (and be used differently and support different roles) because of complex and subtle differences in historical, contextual and social factors
Black, 2004	Computed tomography in two US hospitals	Systems dynamic modelling using data from Barley's 1986 study (see above)	Development of a new approach to analysing interconnections between new	Moves beyond Barley's original findings to suggest that it is not necessarily

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
			technologies and social action; aims to develop a theory to explain why the implementation of a new technology often disrupts occupational roles in ways that delay occupational benefits.	'decentralisation' of decision-making that leads to realisation of benefits of new technology but the opportunity for different occupational groups to redefine discretion and control through mutual learning. Such a finding supports, for example, Edmondson et als (2001) conclusion that putting 'teams' of doctors, nurses and technicians through extensive simulated training is one way of realising better the gains a new technology offers.
Crosson, 2008	e-prescribing in ambulatory medical practices in US	Multi-method qualitative case study of ambulatory practices before and after e-prescribing implementation. Sixteen physicians and 31 staff members working in 12 practices scheduled for implementation of an e-prescribing program were purposively sampled to ensure a mix of practice size and physician specialty.	To develop new insights into factors that influence the effective implementation and use of e-prescribing in typical ambulatory care settings.	Five practices fully implemented e-prescribing, 3 installed but with only some prescribers or staff members using the program, 2 installed and then discontinued use, 2 failed to install. Members of successful practices exhibited greater familiarity with the capabilities of health information technologies and had more modest expectations about the benefits likely to accrue from e-prescribing. Members of unsuccessful practices reported limited understanding of e-prescribing capabilities, expected that the program would increase the speed of clinical care and reported difficulties with technical aspects of the implementation and insufficient technical support.
Danjoux, 2007	New technology for repair of abdominal aortic aneurysms (endovascular aneurysm repair [EVAR]) in academic health sciences centre in Canada	A qualitative case study of the decision to adopt EVAR using a modified thematic analysis of documents and semi-structured interviews Interviews were conducted with individuals identified to have the most involvement with the innovation (3 vascular surgeons, 1 hospital decision-maker, 1	To describe and evaluate the adoption of a new health technology used by surgeons for the treatment of aortic aneurysms called endovascular aneurysm repair (EVAR). 'Accountability for Reasonableness' was used as a conceptual framework for fairness in priority setting processes in healthcare	There were two key decisions regarding EVAR: the decision to adopt the new technology in the hospital and the decision to stop hospital funding. The decision to adopt EVAR was based on perceived improved patient outcomes, safety, and the surgeons' desire to innovate. This decision involved very few stakeholders. The decision to stop funding of EVAR involved all key

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
		radiologist)	organisations	players and was based on criteria apparent to all those involved, including cost, evidence and hospital priorities.
Denis et al., 2002	Four innovations - 2 of which were technological innovations: laparoscopic cholecystectomy and multiple use dialysis filters - selected as a maximum variety sample in Canadian hospitals and primary care	Qualitative cross-case analysis based on four in-depth case studies.	Adoption of complex innovations is determined by subtle and complex interactions between multiple variables – notion of an 'adopting system' (with key actors, roles etc). How then can practitioners (e.g., technology assessment agencies; professional practice regulators, patient advocates) intervene to promote sensible decision making concerning the adoption of innovations?	New practices must be analyzed not only in terms of their benefits for patients, but also in terms of their implications for the specific groups of people who need to collaborate in their implementation. This study suggests that those interested in promoting wisdom in the adoption of innovations must become deeply aware of the specific ways in which they are likely to interact with their social contexts. Only then can measures be taken to ensure that beneficial innovations receive the support they deserve and that risky ones are treated with circumspection.
Edmondson, 2001	Minimally invasive cardiac surgery in US	Qualitative (ethnographic) comparative case study in 16 hospitals, in which the 7 most successful teams were compared with the 7 least successful	What accounts for the successful introduction (or not) of the technology for minimally invasive cardiac surgery?	Successful teams were characterised by a leader who framed the project as one of developing wider routines (as opposed to individuals learning to use a plug-in technology. Complex technology-supported innovations should not be viewed as plug-in technologies but as opportunities for teams to develop new routines
Greer, 1984	Research conducted in 25 community hospital in central US and including (1976 onwards) CAT scanning, coronary bypass surgery, phacoemulsification; (1980 onwards) radioimmunoassy, batch blood analysis, ultrasound, radionuclide scanning, fibreoptic endoscopy, coronary PTA, neonatal intensive care, laser surgery and fetal monitoring.	Based on 378 interviews with community hospital staff conducted in three waves in 1976, 1977-1979, and 1980. Interviews focused on technology adoption process at interviewees primary hospital	To examine the theoretical and empirical bases for hypotheses of 'professional dominance' and the utility of these hypotheses in explaining hospital decisions to adopt new medical technologies	A seminal paper that emphasises non-unitary nature both of professionals in healthcare and of hospitals. Found that appropriate application of professional dominance theory requires specification both of the type of physician exercising influence and of the hospital decision systems within which it is exercised. Differentiates between three decision systems (medical-individualistic, fiscal-

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
				managerial and strategic-institutional).
Greer, 1985	As above	As above	How do decision-makers values and purposes guide them, what resources do they deploy toward realising their values and with what outcomes?	Three decision-making systems are salient in hospitals with regard to technology adoption: medical-individualistic, fiscal-managerial and strategic-institutional
Koch, 1996 [same dataset as Greer, 1984, above]	Twelve medical innovations in 25 US community hospitals	As in Greer, 1984, above. Multivariate and discriminant analyses of the 300 potential adoptions studied.	Conceptualises hospitals' adoption of medical technology in terms of discrete stages (building on and testing Meyer & Goes (1988) model): Knowledge-Awareness; Evaluation-Choice; and Adoption-Implementation.	Multivariate analysis provided strong support for the three-stage model proposed. Results also suggest that support or opposition of an organisations CEO substantially shapes the outcome of an innovation proposal (in both stage 1 and 2). Upon acquisition (stage 3) strategic factors emerged as most potent predictors of utilisation and readoption; implies that in hospitals many technical innovations are acquired with little consideration given to the levels of demand for the innovation existing in the organisations environment.
Lang, 2005	Carotid artery stenting in US medical centers	Qualitative analysis of key informant interviews with 15 physicians, including four internationally renowned key opinion leaders, representing five medical centers with differing experience adopting CAS.	To discover how physicians, both individually and collectively through their departments and professional societies, view the diffusion of an important new technology.	Variation in beliefs about the safety and efficacy of CAS within specialties was overshadowed by variation across the specialties examined. CAS challenges physicians from several specialties to safely and effectively manage the uptake of an emerging technology crossing traditional specialty lines. Local collaboration of individual physicians and the departments and professional organisations they comprise, will have an important impact on how this technology is adopted
McGregor, 2005	Mechanism in large Canadian teaching hospital to increase the influence of health technology assessments (HTAs) on hospital decisions regarding	Case study description of a hospital HTA unit that presents the scientific evidence relating to technology and develops policy recommendations	Locally developed HTAs would have greater influence on hospital policy	Local in-house HTA has had major impact on adoption of new technology and that success due to (a) relevance (by incorporating local data and reflecting local

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
	adoption of technologies	based on evidence sensitive to local circumstances/values		needs), (b) timeliness, and (c) formulation of policy reflecting community values by a local representative committee. Suggests that small HTA units in close proximity to local decision-makers can influence process of adoption.
Meyer and Goes, 1988	Health-related technologies (main focus was large pieces of equipment) in US private (non-profit) community hospitals in 1980s	Comparative case study with 300+ interviews, and observation and surveys focusing on 12 innovations in 25 hospitals over 6 years; 300 potential adoption decisions	Assimilation of innovations by organisations is influenced by (a) environment, organisational context and leadership; (b) attributes of the innovation; and (c) interaction between these.	Assimilation of innovations was a lengthy and complex process; hypotheses were broadly confirmed.; innovation attributes explained 37% of variance. The notion of 'assimilation' as a 9-stage process rather than an all-or-none event is a potentially useful framework for studying organisational adoption.
Mike, 1996	Transcutaneous oxygen monitoring in neonatal intensive care in the US	Technology-based case study drawing on 26 taped interviews with industry professionals and 10 taped interviews with biomedical investigators.	To obtain an industry perspective on the development and adoption of medical technology (including how ideas for new products arise and reach stages of development and marketing, and to describe the nature of the interaction with the medical community)	Overarching theme of complexity and uncertainty, and of the doctor as a pivotal player in the introduction and diffusion of medical technology
Pare, 2006	Physician order entry (POE) system and physician users in Quebec, Canada	Postal questionnaire to 91 physicians	That feelings of ownership towards a technological innovation may be developed through active physician involvement and participation in the system implementation process.	'Psychological' ownership of a POE system is positively associated with physicians' perceptions of system utility and system user friendliness.
Pare, 2007	PACS in Canadian hospitals	Retrospective, multiple case study (observation, interviews and documentation) of implementation process at 2 hospitals	To better understand the nature of the challenges faced in adopting and implementing PACS, the conditions for success and strategies that can be implemented in order to maximise the benefits that can be derived from PACS	Crucial to anticipate and address organisational and behavioural challenges from the very first phase of the innovation process, in order to ensure all participants will be committed to the project. Must take into consideration all the technical ,economic, organisational and human factors from first phase of the innovation process

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
Parvinen, 2007	Picture archiving and communicating systems (PACS) in Imaging Centre in Finland	Stakeholder analysis: structured interviews with 30 stakeholders concerning the PACS adoption process, and linked to governance analysis of the Centre	To investigate different stakeholder management settings in four different phases of technology adoption: introduction, acquisition, implementation and utilisation	Stakeholder governance of healthcare technology adoption operates in three different domains: stakeholder management (serving and satisfying the various active parties of healthcare service delivery); governance (incentives, ownership, and information in the contractual relations of the stakeholder); and micro-process level management issues (the extensive utilisation of the technology where all the advantages and benefits materialise). However, there was no control over the overall adoption process which caused an asymmetry of information between different process phases
Randeree 2007	Electronic medical records in US small group practices	Three case analysis of physician groups involving interviews with CIO or practice manager.	Explores (1) the actual versus expected costs and benefits that small practices will encounter, (2) what items or concerns caused the budget to increase and what primary themes should be investigated prior to the adoption of EMRs, and (3) documents the implementation of EMRs in small practices.	Results show that planning was a key common variable missing; the anticipated downtime was longer than expected and the workflow disruption and maintenance costs were underestimated. Suggests that EMR adoption can be encouraged through higher reimbursements for physicians that adopt EMRs.
Roback, 2007	Medical devices in neonatal intensive care in Sweden	Interview study with twenty-four respondents who were recruited through the assistance of key persons at 10 selected NICUs	To investigate the process leading to the adoption or rejection of medical devices.	Adoption was found to be primarily initiated by vendor activities, but professionals preferably sought information about functionality from close colleagues. Full integration of devices was sometimes not achieved, and even though the adopting units had good introduction routines, there was no systematic follow-up of how adopted devices had been integrated in the work practices. Three factors were found to be the major explanatory variables of the adoption of medical devices: (1) the subjective

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
				expected value of the device, (2) information and learning, and (3) the innovativeness of the adopting unit.
Sharma, 2006	Advanced laparoscopic surgical procedures in community hospital, Canada	Qualitative case study of four advanced laparoscopic procedures introduced at the hospital between 2000 and 2005	To study priority setting in the context of surgical innovations by describing current decision-making processes for the adoption of advanced laparoscopic surgery and then analyzing the decision-making process using the 'accountability for reasonableness' framework.	There was no structured, explicit process for making decisions about introducing new surgical technologies. The decision to adopt advanced laparoscopic surgery was made primarily on the basis of its relevance to patient care. The process for making decisions about the adoption of new surgical technologies can be improved
Southon, 1997	PAS clinical system in NSW, Australia	Interviews involving over 60 staff at all levels of the service were analyzed for key themes, and the results were shared and compared to enable a continuing critical assessment.	While innovation/diffusion theory is relevant to certain aspects of the case, this paper focuses on the IT project in its wider organisational context. Consequently, it uses Scott-Morton's IT-organisational fit analytical framework. Two components of the transfer of the system were considered: the transfer from a different environment, and the diffusion throughout a large, divisionalized organisation.	There was a lack of fit in the business environments and strategies, organisational structures and strategy-structure pairing as well as the management process-roles pairing. The diffusion process experienced problems because of the lack of fit in the strategy–structure, strategy–structure–management processes, and strategy–structure–role relationships. Concludes that there is a need to take a more sophisticated approach to understanding the complexities of organisational factors than has traditionally been the case.
Stricklin, 2003	Point of Care technology in home health agency in US	Description and evaluation of specific change process implemented in home health agency in US incl pre-implementation focus groups, implementation and post-implementation.	To identify the key factors influencing nurses' acceptance and use of POC technology in clinical work. Uses a 'Values Approach' (Lewin forcefield analysis) plus a socio-technical approach	Suggests guiding principles for successful POC implementation (training; system functionality; implementation; user satisfaction)
Weiner, 2004	Clinical information systems in 5 US hospitals	Multiple, embedded case study design with two units of analysis for exploring how adoption and implementation processes vary (a) by organisational context and (b) by IT characteristics.	Organisations in different stages of the integration life cycle vary in terms of their experience and expertise with innovation, their readiness and tolerance for change, and their ability to generate and make	Four general themes emerged in this study: (1) the importance of early end-user involvement in needs identification, priority setting, and design of populationlevel IT systems; (2) system-level senior managers

Author/year	Technological innovation and context	Study design and size	Hypothesis tested	Main findings relevant to this review
			use (i.e., learn from) new knowledge.	generally did not provide leadership in terms of setting the agenda for decision-making about clinical information systems but can provide a strategic perspective on clinical IT decision-making that IS professionals and technology friendly physicians often do not possess; (3) developing a transition plan, providing appropriate incentives, and instituting supporting policies led to more rapid migration to new systems; (4) despite greater experience with innovation and greater organisational tolerance for change, later-stage leaders grappled as much as earlier-stage leaders with the challenges of managing the pace, scope, and intensity of change associated with clinical information systems implementation.

Appendix 8 Deterministic empirical NHS studies addressing assimilation of technological innovations in healthcare organisations

Author / year	Technological innovation and context	Study design and size	Aim/Hypothesis tested	Main findings relevant to this review
Booth-Clibborn, 2000	Statins, coronary stents and MRI in West Midlands region of England	Small retrospective study using primary care prescribing data and questionnaires to acute hospital trusts (responses from 13 pharmacies, 4 cardiology departments and 19 radiology departments).	To describe the rate and pattern of diffusion of three selected new healthcare technologies and to explain the main influences on their introduction	The principal influences on the adoption of statins were reported as the direct promotion of statins in the hospital (national and local guidelines and an enthusiastic individual were also important influences, as was the cost – a deterrent to diffusion); the principal influences on the adoption of coronary stents were an enthusiastic individual supporting their use and the development of local guidelines; and the principal influence on the adoption of MRI scanners was the cost (a deterrent) and the presence of national and local guidelines and an enthusiastic individual
Higgs, 2005	Geographical Information Systsems (GIS) in 80 English Health Authorities	Mixed-methods: postal questionnaire and semi-structured interviews	To explore the importance of behavioural, cultural and organisational factors on the diffusion of GIS in the NHS	The questionnaire survey highlighted both organisational/institutional factors as well as detailed software and data issues. The former include factors such as work time constraints, insufficient staff and financial resources to fully implement systems as well as the lack of training/guidance in the use of GIS based techniques. Draws attention to the difficulties of reconciling 'bottom up' and 'top down' modes of technology adoption

Appendix 9 Deterministic empirical studies in healthcare (non-NHS) addressing assimilation of technological innovations in healthcare organisations

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
Ammenwerth, 2006	A nursing documentation system in German hospital	Literature review and case study of adoption in several departments of a German University Hospital.	Uses the FITT framework to better analyse the socio-organisational-technical factors that influence IT adoption.	The FITT framework helped analyze the process of IT adoption during an IT implementation but it may be difficult or even impossible to analyse the complex and interacting factors that predict success or failure of IT projects in a socio-technical environment.
Ash, 1997a	End user online literature searching, the computer-based patient record, and electronic mail systems in Academic Health Science Centers in US	A random sample of 67 academic health sciences centers with accredited medical schools was selected, followed by a proportional random sample of 629 individuals working in informatics and 706 library staff. A Guttman-like scale was developed to measure infusion, or depth or sophistication, of each of the three innovations at each institution. Diffusion was measured by a question previously developed.	1. To what extent do communication, participative decision making, top-management support, planning, the existence of champions, and reward systems affect internal diffusion of each of the three innovations? 2. To what extent do communication, participative decision making, top-management support, planning, the existence of champions, and reward systems affect infusion of each of the three innovations?	Organisational attributes are important predictors for diffusion of information technology innovations. Individual variables differ in their effect on each innovation. The set of attributes seems less able to predict infusion. It is recommended that both infusion and diffusion be measured in future studies because there is little relation between them. It is further recommended that individuals charged with implementing information technology in the health sciences receive training in managing organisational issues.

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
Ash, 1997b	Computer-Based Patient Record in 67 institutions with accredited schools of medicine in US	Survey of the perceptions of 629 informatics experts included 78 questions related to the CPR plus six questions about the respondent. Data from individuals within institutions were aggregated so analysis could be done at the organisational level.	A model outlined three theoretical factors: Innovation Attributes (attributes inherent in the CPR itself); Organisational Attributes; and Boundary-Spanning Attributes (related to marketing efforts).	Organisational Attributes, especially decision making and planning, are important predictors of internal diffusion of the CPR within organisations. One explanation for the negative relation between planning and diffusion may be that careful planning takes time and diffusion is thus impeded. The significance of participative decision making points to a need for involving clinicians and other users throughout the implementation process.
Caccia-Bava, 2006	IT in US hospitals	Postal questionnaire of 192 hospital CEOs exploring organisations culture, ability to absorb new technology, and the extent to which latest IT implementation operational for at least one year had been a success.	(1) the level of managerial IT knowledge is directly related to the success level of a new IT implementation; (2) the extent of internal and external communication channels is directly related to the success level of a new IT implementation; (3a) hospitals with stronger levels of the corporate culture dimensions of group, developmental, and rational, will have a higher level of managerial IT knowledge; (3b) hospitals with stronger levels of the corporate culture dimensions of group, developmental, and rational, will have a higher level of communication channels	Absorptive capacity has two dimensions (managerial IT knowledge and communication channels), which are highly correlated. Both dimensions are related to systems success, supporting (1) and (2), respectively. Also as hypothesized (3a and 3b), strong developmental and rational cultures, and weaker hierarchical culture, are significantly related to both dimensions of absorptive capacity. Organisations can enhance their absorptive capacity by establishing structures that facilitate both the formal and informal cross-functional communication and managerial IT knowledge within the organisation.
Callen, 2007	Computerised provider order entry systems in to hospitals in Australia	Data were collected using the Organisational Culture Inventory and a user-satisfaction survey administered to a	The organisational culture of a health facility is an important factor for successful implementation. This study measures hospital culture and links this to the mandatory use of a CIS.	Organisational culture affects clinicians' attitudes to the use of CIS. The relatively constructive culture found at Hospital A indicates broad clinician support for CPOE use. The aggressive/defensive culture at Hospital B suggests discouragement of uptake as by definition clinicians would tend to oppose new ideas.

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
		population of 249 clinicians from the two hospitals.		
Castle, 2001	Special and subacute care units in nursing homes in USA 1992–1997	Analysis of national dataset	Organisations with (a) larger size; (b) membership of a chain; (c) for-profit and (d) greater proportion of private patients will adopt the innovation more rapidly	Size, chain membership and proportion of private patients were all significantly associated with earlier adoption
Day, 2007	Videophone technology in hospices in mid-west US	Telephone interviews with 17 staff in 2 hospices where technology had been introduced but was underutilised	To determine possible reasons for underutilization in hospices and to provide an in-depth understanding of attitudes and perceptions that may lead to failure of a telehealth implementation in the context of TAM	The TAM provides a good framework for an understanding of telehealth underutilization – perceived usefulness was high but lack of perceived ease of use
Dirksen et al., 1996	Six surgical endoscopic procedures, (e.g. appendicectomy, cholecystectomy) in the Netherlands	Retrospective survey of 138 surgeons (response rate 82%)	Perceptions of 3 attributes of the procedure, 6 of the system context, 3 social influence factors, plus perceived 'competition'	Different surgical procedures had very different adoption patterns, and different attributes had different impact depending on the procedure; 'extra benefit' was a precondition for further evaluation by potential adopters
England, 2007	IT in Australia and New Zealand	A two-stage study was used. The first stage involved 3 qualitative interviews with top health executives and analysed their opinions and beliefs using an innovation diffusion theory framework. The second stage involved quantitative surveys of 8 senior health executives to gain an understanding of their opinions regarding the organisational and	To understand IT investment decisions from the perspective of senior health system executives.	Health executives hold a range of views that potentially inhibit the increased adoption of IT in health. In particular, beliefs about the technology itself have been identified as the most influential deterrents. The executives' beliefs about the current state of IT were more influential in the innovation adoption process than the executives' beliefs about their organisations.

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
		technological drivers and the level of IT adoption.		
Escarce, 1996	Laparoscopic cholecystectomy (lc) in US surgical practices	Postal survey of 1,345 surgeons and hazard model to assess impact of explanatory variables timing of adoption	(1) factors associated with greater revenue gains from adopting lc are expected to result in earlier adoption; (2) factors that decrease the costs of adopting lc are expected to lead to earlier adoption; (3) factors associated with surgeons' capacity to reduce quickly their initial uncertainty about the profitability and clinical benefits of adopting lc are expected to result in earlier adoption; (4) prior adoption by one or more surgeons in a hospital is anticipated to hasten adoption by other surgeons in the same hospital	Surgeons' access to information about lap chole and their human capital attributes had a significant influence on surgeons' adoption behaviour. Evidence that early adoption of lc by some surgeons in a hospital had a profound effect on the adoption behaviour of other surgeons in the same hospital. States that attitudinal data reported by survey respondents suggest that hospitals generally were passive participants in the diffusion of laparoscopic cholecystectomy but among surgeons analyses could not control for hospital effects because authors did not know the hospitals where surgeons practised
Fendrick, 1994	Laparoscopic cholecystectomy (lc) in general, acute care hospital in Pennsylvania, US	Questionnaire survey with 164 responders (79%)	To assess the impact of various hospital characteristics on the timing of lc adoption	lc adoption was significantly associated with increasing bed size, urban location, and participation in residency training. In general, results suggest that lc was first performed in large, urban, but not necessarily university, settings
Friedman, 1996	Nine technologies (auto analyzer; cardiac ultrasound; CT; ESWL; hemodialysis; MRI; NICU; PET; quantitative EEG)	Postal questionnaire to 535 'decision-makers' at 126 hospitals in southern California; 95 responses (17.8%)	To explore considerations affecting the acquisition of different types of medical technology. Seeks to learn about the 'behavioural factors' affecting technology acquisition decisions (for example, is technology adoption a well thought out and rational process or is it more affected by political pressure and organisational dynamics?)	Senior physicians had the highest level of influence on the decision to acquire a technology (amongst six defined decision-makers) in case of all 9 technologies. Chief financial officers had a greater level of influence in those hospitals which were early adopters of 'radical' technologies. Amongst six defined 'decision considerations and influences' (those factors which express the basic values and culture of the organisation), input from the medical staff was reported to be the most important variable. Overall, technology acquisition appears to be a physician centred activity with less consideration given to strategic or economic factors.

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
Friedman, 2000	MRI in US	Questionnaire survey of CEO, COO, CFO, medical chief of staff and chairperson of governing board of 184 hospitals with 100 or more beds in Southern California, Oregon and Washington. 94 responders in total	To examine the relative role of decision-maker influence and environmental factors on the timing of MRI acquisitions in hospitals with differing levels of environmental uncertainty	Physicians and CEOs had much greater influence on the acquisition decision than did other decision makers. Physicians and CEOs each had considerable influence on the earliness of MRI adoption, although physician influence was somewhat more powerful. In hospitals where physicians and CEOs were influential players in adoption decision making, adoption of MRI tended to occur earlier than in hospitals where others were more influential on the adoption decision. Also reinforces need to view external factors as well as organisational factors role in shaping adoption and assimilation processes
Gagnon, 2005	Telehealth in healthcare centres in Quebec, Canada	Telephone-based questionnaire to 32 hospitals, followed by nine case studies based on 24 face-to-face interviews with principal actors involved in telehealth.	To explore the influence of hospitals' organisational characteristics on telehealth adoption. Six structural variables (horizontal specialisation; functional differentiation; size of units; planning and control systems; internal communications; and decentralisation of power) and associated research hypotheses were explored.	A smaller number of sub-units (functional differentiation) was positively associated with telehealth adoption, whereas the number of physicians in administrative positions (planning and control) and the participation of physicians in telehealth decision making (decentralisation) are negatively associated with telehealth adoption. Smaller hospitals and hospitals with less than 10,000 annual admissions (size) were more likely to adopt telehealth. Unexpected finding as most previous research predicted size variable would have provided a statistically significant impact but good example of how specific nature and type of technology can lead to opposite finding
Goes and Park, 1997	15 innovations in Californian acute care hospitals including 6 technical and 11 administrative	Prospective longitudinal study over 10 years; tracked year-to-year changes on 135 items	Hypothesis that (a) size and (b) inter-organisational links affect innovativeness	Positive association was shown between (a) size and (b) inter-organisaitonal links and adoption of both technical and administrative innovations. Hospital exhibiting multiple and extensive inter-organisational links were more likely to be large; large hospitals were consistently more innovative than small hospitals

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
Gosling et al., 2003	Point of Care online evidence system in Australian acute hospital care	Survey of team climate in 18 teams in three hospitals	Team size (<15 or >15); team climate by validated Team Climate Inventory	Positive team climate has no effect on initial adoption decision but is independently associated with effective and sustained use. The climate of the team may be a factor that determines the effectiveness of the localized diffusion. Implementation strategies aimed at clinical teams may be more effective than the standard organisational or professionally based approaches to IT implementation.
Greenberg, 2005	New healthcare technologies in Israeli hospitals	Questionnaire survey to 61 hospital executives in 24 Israeli hospitals. Included asking about decision-making responsibilities of different members of hospital management and opinion as to preferred decision-making mechanism	To map and describe the function of hospital decision-makers within the area of new technology assessment and adoption, and to examine relevant considerations, sources of information, and decision-making processes in the adoption of a new technology	The final decision-making responsibility varied among technologies; the medical director frequently made the final decision when a new device was involved, but this responsibility decreased when a new drug or a new procedure was considered. Suggests support for 'medical individualistic theory' (Greer, 1985). Also suggest that the type of technology considered is linked to the level of responsibility in adoption decisions and suggests that different decision-makers may use different sources of information and processes when making their decisions
Hikmet, 2008	Health information technologies (HIT) in 98 Florida hospitals	Survey	Examines whether specific organisational characteristics, such as hospital size, geographic location (urban versus rural), system membership (standalone versus system-affiliated), and tax status (for-profit versus non-profit), influence adoption of healthcare information technologies (HIT) in hospitals. Hypothesizes that the above organisational characteristics are related to hospitals' adoption of clinical, administrative, and strategic HIT, as well as all HIT in general	Hospital size, system membership, and tax status, but not geographic location, are systematically related to HIT adoption, and that such factors explain about 28–41% of the adoption variance. A mixed pattern of effects emerge for clinical, administrative, and strategic HIT. For instance, hospital size appears to be less relevant for administrative HIT, where its effect is compensated by those of system membership and tax status.
Hillman, 2005	Computerised provider order entry (CPOE)	Postal questionnaire	To examine how hospitals that	Found no statistically significant associations

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
	systems in US hospitals	survey to 1,051 non-federal short-term general and children's general hospitals	reported full implementations of a CPOE system differ from hospitals that have partially implemented CPOE and from hospitals that have no plans to implement a CPOE system	between the non-financial characteristics of hospitals and their stage of CPOE implementation; in particular there was no correlation between bed size and the stage of CPOE implementation. Unexpected finding as most previous research predicted size variable would have provided a statistically significant impact
Hoffman, 1996	'Technological sophistication' in US hospitals	Secondary data analysis of services provided by 189 general, short-term hospitals in Florida (111 not-for-profit and 78 for-profit hospitals)	Not-for–profit hospitals will have a higher level of adoption of medical technological innovations than for-profit hospitals	Not-for –profit hospitals have a higher level of adoption of medical technological innovations than for-profit hospitals ($p<.001$). The difference likely stems from greater influence that key stakeholder groups have on the management of not-for-profit organisations
Jaana, 2006	Clinical IT innovations in US hospitals	Cross-sectional survey nonfederal hospitals in the State of Iowa (n = 116)	Develops and tests a research model for assessing the antecedents of hospital innovativeness with regard to the adoption of clinical IT applications	A significant percentage (45–61%) of the variance in clinical IT sophistication was explained, mostly by leadership and knowledge sharing capacities. In particular, IT tenure and technical knowledge resources were significantly related to clinical IT sophistication.
Kaluzny, 1974	Innovation of selected health services and activities in 23 county and city health departments and 59 general acute hospitals in US (largely focused on programmes as opposed to specific technologies)	Questionnaire sent to all personnel (including administrators) and interviews with administrators	To assess the differential contribution of organisational variables relating to the innovation of selected health services with specific characteristics	Organisational size was a critical factor for high-risk services in hospitals (but not for low-risk services). Excluding size, characteristics of the staff (such as cosmopolitan orientation and training) were prime predictors for low-risk programs in hospitals. The degree of formalization was the primary predictor of innovation of high-risk programs in hospitals.
Kimberly, 1978	12 technologies in area of diagnosis, treatment or prevention of respiratory disease in US hospitals	Questionnaire survey to 489 hospitals in US (completed by hospital administrators and chief medical officers) (same dataset as Moch, 1976 below)	Observed variability in hospital adoption of innovation can be accounted for, at least in part, by variability in the development of structural mechanisms which provide access to information about change in the environment	Received respectable statistical support (indicators such as research activity and hospital allocation of resources to bring in outside speakers and send physicians to meetings proved to be good predictors). Hospitals with a structurally differentiated, formal commitment in the area of respiratory disease are clearly more likely to adopt innovations in this area than those which do not –

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
				suggests that the influence of characteristics of the potential adopting system (for example, centralisation) on adoption may be mediated by the relationship between the nature of the innovation and the adopting system
Kimberly and Evanisko, 1981	Technological and administrative innovations in US hospitals in late 1970s	Mixed methodology with questionnaires, described in a separate paper (Moch and Morse, 1977). Number of hospitals not given	(a) characteristics of individuals in authority; (b) organisational characteristics; (c) contextual factors	Size was most significantly and consistently associated with innovation; other organisational variables also impacted on technological, but not administrative, innovations
Knudsen, 2004	15 treatment innovations (including counselling and therapeutic approaches as well as medications) in substance abuse treatment centres (privately funded) in the US	Interviews with administrators and clinical directors in 322 privately funded substance abuse treatment centres	Examines the associations between an additive measure of innovation use ('organisational use of treatment innovations) and 3 measures of absorptive capacity (environmental scanning, collection of satisfaction data and level of workforce professionalism).	Treatment organisations use a greater number of innovations when they engage in more environmental scanning, survey referral sources and third party payers for satisfaction, and have a more professional workforce. Results indicate the importance of absorptive capacity in predicting organisational innovativeness. Views 'absorptive capacity' as an organisational characteristic that can be developed and enhanced by managerial decision-making
Lee, 2007	Radio frequency identification (RFID) in US hospitals	Survey of 126 executives in US hospitals	1. the presence of champions is significantly associated with likelihood of adoption; 2. the performance gap rising from existing inventory tracking and/or patient identification systems is significantly associated with the likelihood of adopting RFID; 3. the level of market uncertainty is significantly associated with the ikelihood of adopting RFID; 4. vendor pressure, or marketing activity, is significantly associated with the likelihood of adopting RFID; 5. perceived benefits are significantly	'Need pull', technology push and the presence of champions successfully explained the motivation of RFID adoption in hospitals. The presence of champions emerged as the most important factor. Authors note that future studies using qualitative research are also needed to help to understand organisational level RFID adoption better … qualitative studies will help to generate ideas and concepts related to the context of … adoption within organisations.

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
			associated with the likelihood of adopting RFID; 6. the relationship between the driving forces of adopting RFID and the likelihood of adopting RFID will be further strengthened in the presence of a higher organisational financial resource	
Moch, 1976	Eleven new respiratory disease technologies in US hospitals	Questionnaire survey to 489 hospitals in US (completed by hospital administrators and chief medical officers)	That increased size, specialization, functional differentiation and decentralisation lead to innovation adoption	Larger and consequently more specialised, differentiated and decentralised organisations are more likely to adopt technical innovations. Suggests that research on large, complex organisations is likely to benefit from including political as well as rational factors in theory construction
Moch, 1977	12 technologies in area of diagnosis, treatment or prevention of respiratory disease in US hospitals	As above	1. size will be positively associated with the frequency of adoption of both compatible and noncompatible innovations; 2. specialization and functional differentiation will be positively associated with the frequency with which compatible innovations are adopted; 3. centralisation will be negatively associated with the adoption frequency of compatible innovations; 4. size and centralisation will interact to affect adoption decisions in such a way that compatible innovations will be adopted more frequently by organisations which are simultaneously large and decentralised	Attributes thought to characterise the generally innovative organisation - specialisation, differentiation and decentralisation - do successfully predict the frequency of adoption of innovations compatible with the interests or perspectives of lower-level decision-makers. Centralisation and the interaction between size and centralisation do not appear to affect adoption of innovations which are not compatible with the interest of lower-level decision-makers. Contrary to expectations, the data indicate that functional differentiation facilitates adoption of this type of innovation. Less compatible innovations (i.e. those which facilitate coordination and control) are likely to be adopted by large and functionally differentiated organisations.
Nathanson, 1980	20 innovations in obstetrics (10 'technological' and 10 'social) in US hospitals	254 Interviews with key informants in 12 US hospitals in same metropolitan area.	1. social innovations are more likely to be adopted by hospitals with a centralised pattern of decision-making 2. social innovations are more likely to	Although main focus of paper is on social innovations, an additional implicit hypothesis has been that the conditions for social and technological innovation would differ. This expectation was supported. The only variable significantly associated

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
		Interviews covered 34 issues divided into six issues areas: long-range planning, major changes in allocation of the hospital budget, introduction/elimination of hospital programmes and services, organisation of hospital departments and personnel, hospital/physician relationships, miscellaneous policy issues) A questionnaire to interviewees asked them to rate te amount of influence exercised by individuals in key hospital positions on five types of decisions	be adopted by hospitals where social change values are prevalent if these values are held by individuals in leadership positions 3. social innovations are more likely to be adopted by hospitals with a centralised pattern of decision-making if influential individuals hold values favourable to social change 4. the greater the relative influence of physicians over hospital decision-making, the lower the level of commitment to social innovations	with the adoption of innovations high in 'technology/cost' is the presence of an influential chairman of the hospital's board of trustees (which was not a significant variable for social innovations)
Nystrom., 2002	Medical imaging diagnostic technologies in US hospitals (same dataset as Wilson et al., 1999)	Postal questionnaire survey of 70 hospitals	Organisational size and slack, moderated by aspects of organisational climate (risk orientation and external orientation)	Organisational size and slack promotes innovation, and does so more strongly in organisations with a climate favouring risk taking
Poon, 2004	Computerised Physician Order Entry (CPOE) systems in US hospitals	Semi-structured telephone interviews with 52 senior managers at 26 hospitals at different stages of CPOE implementation.	To identify ways to overcome barriers to adopting and implementing CPOE	The top three barriers were: (1) physician and organisational resistance; (2) high CPOE cost and lack of capital; and (3) product/vendor immaturity. Respective strategies to overcome the each barrier were identified: (1) strong leadership; identifying physician champions; addressing workflow concerns; and leveraging house staff or hospitalists, (2) realign hospital's priorities to focus on patient safety;

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
				leverage external influence; measure CPOE's impact on hospital efficiency; improve system interoperability; and provide third-party payer incentives for implementing CPOE, and (3) vendor must be committed to CPOE market; vendor must be ready to identify hospital workflow issues and adapt its product accordingly; and the vendor must commit to a long-term trusting relationship with the hospital. Note that findings exclude views of hospitals who were not in process of considering implementing CPOE, who may have identified different barriers to adoption.
Poulsen, 1998	Five laparoscopic technologies in 50 hospitals in Denmark	Retrospective postal questionnaires to a single respondent in each hospital	Study of seventeen factors (including some organisational factors) influencing the diffusion of laparoscopic surgery were identified, which were deemed of relevance to the Danish context.	Large and specialized hospitals were the earliest adopters. The factors, nature of technology (minimally invasive versus conventional), training (appropriate training courses), competition (between specialties and between hospitals) and media attention have stimulated the diffusion, whereas three budget factors (budget for investment, budget for operation and public regulation) usually had an impeding effect.
Poulsen, 2001	Laparoscopic cholecystectomy in 59 hospitals in Denmark and 109 hospitals in the Netherlands	Multivariate analysis of secondary data pertaining to three hospital characteristics: size, teaching status and location	To analyse the impact of different hospital characteristics on the hospital adoption of LC	The multivariate analyses showed that increased hospital size was associated with relatively early adoption of LC in Denmark. Neither this nor other hospital characteristics influenced the timing of adoption in The Netherlands. As in other countries studied, hospital size is identified as an important factor in hospital adoption, whereas teaching status and location play a more limited role.
Rapoport, 1978	Radioisotopes in US hospitals	Secondary analysis of American Hospital Association data supplemented with postal questionnaire to 500 hospitals (136 responses)	1. a hospital's decision to adopt a technological innovation is determined in part by inter-hospital rivalry for prestige; 2. the group (teaching or non-teaching) to which a hospital belongs determines to a great extent the time at which a hospital adopts an	Individual hospitals tend to adopt earlier and to acquire more expensive equipment where they are in a competitive environment. In particular, an urban setting with hospitals similar in size and with a large number of hospitals relative to population seems to be associated with competitive adoption behaviour

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
			innovation; 3. variables which influence demand for hospital services will also influence demand for equipment; 4. big hospitals are likely to adopt innovations earlier than smaller ones	
Rappaport, 2004	Liquid-based cervical screening tests in US family physicians and gyanecologists	A mailed survey of 250 family physicians and 250 gynecologists in Maryland in 2000. Additional data were obtained from the AMA Master File of Physicians.	The efforts of Cytyc Corporation to market the ThinPrep Pap test would be an important determinant of its early adoption by physicians. Additionally, examined the effects of physician specialty, patient sociodemographics, practice factors, and financial constraints on laboratory decision making on the adoption of liquid-based cervical cancer screening tests.	Gynecologists were more likely than family physicians to have been early adopters. Part of this variation in adoption was due to aggressive marketing to gynecologists, who were more likely than family physicians to receive information in the mail from the test manufacturer and to have been informed by the manufacturer that a patient had inquired about physicians' use of the test. Concluded that commercial marketing campaigns appear to contribute to the more rapid rate of diffusion of technology among specialists compared with generalists.
Reardon, 2007	EMRs in small physician practices in US	Postal questionnaire survey of 130 practices (23% response rate)	(1) learning-related scale (scale of activities over which learning costs may be spread) is positively related to assimilation stage of EMRs by small physician practices; (2) related knowledge (extent of know-how and skills) is positively related to assimilation stage of EMRs by small physician practices; (3) diversity (degree of heterogeneity of organisational knowledge and activities) is positively related to assimilation stage of EMRs by small physican practices	Learning-related scale, related knowledge and diversity were all positively associated with small physician practice's stage of assimilation of EMR technology. Suggests that some small practices are able to overcome the substantial learning barriers presented by EMRs but that others will require support to develop sufficient learning capacity.
Robertson, 1980	New medical instruments for radiology departments in the US	Questionnaire survey of 209 hospitals. For each hospital respondents were the	To assess the incremental contribution of organisational psychographics (a quantitative research tool intended to place 'consumers' on psychological –	The inclusion of organisational psychographic characteristics improves the predictive efficacy of organisational innovativeness (although notes that the improvement in explained variance is modest).

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
		administrator, the chief radiologist and at least one staff radiologist.	as distinguished from demographic – dimensions) to the explanation of organisational innovativeness (the number of medical innovations adopted by the hospital).	Further improvement in predictive ability is achieved when the degree of consensus between radiologist and administrator is added.
Robertson, 1983 [subset of above]	Seven radiology innovations in US	Questionnaire survey of 209 hospitals. For each hospital respondents were the administrator, the chief radiologist and at least one staff radiologist. This analysis based on subset of 182 hospitals with complete data on all variables in question	1. organisations with a cosmopolitan consensus will be innovative; 2. organisations with a local orientation will be late adopters of innovations; 3. organisational innovativeness will be more pronounced under conditions in which the professional component is cosmopolitan and the bureaucratic component local, than the reverse	The highest innovativeness is exhibited by hospitals characterised by a cosmopolitan professional and a local administrator, and the lowest innovativeness is exhibited by hospitals with a local professional and a local administrator. Predicting the hospital's level of innovation is improved by redefining organisational cosmopolitanism as the pattern of cosmopolitanism among relevant members of the 'buying' centre (and not on a single organisational respondent)
Schaper, 2007	ICTs in occupational therapy setting in Australia	Questionnaire survey of 1,605 occupational therapists to test socio-technical model for explaining behavioural intentions towards, and acceptance of, ICTs	The model theorises that technology acceptance has three dimensions (1) characteristics of the individual, (2) characteristics of the technology, and (3) characteristics of the implementation context. The implementation context was theorised to have the predominant influence on user acceptance	Model explained 63% of variance in behavioural intentions. 'Performance expectancy' (a determinant of dimension (2)), 'computer attitude' (1) and 'compatibility' (3) had a more substantial influence on behavioural intention than 'effort expectancy' (2) or 'social influence' (3). Did not study technology acceptance over time but confirms complexity of (socio-technical) factors influencing technology acceptance in healthcare
Shields, 2007	Health information technology in US community health centres	Postal survey of 673 health centres	To assess current health IT capacity and EHR adoption rates and identify key barriers to EHR adoption	Primary barriers to adoption were: lack of capital; the inability to integrate the EHR with the centres current billing system; and concerns about the loss of productivity or income during the transition. An organisational barrier to note was that 56% of respondents rated their inability to evaluate, compare and select the appropriate EHR system as 'important' or 'very important'

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
Simon, 2005	Electronic medical records in US primary medical groups	Postal survey of 738 medical groups that asked about seven organisational and market-related characteristics that may affect adoption	To determine the characteristics of primary care medical groups that distinguish EMR adopter from non-adopter organisations	Large organisations with relatively fewer practice locations were more likely to adopt an EMR. Authors suggest that larger medical groups may have more staff and other infrastructure resources to overcome these barriers (for example, more change management expertise, leadership and IT support staff).
Sloan, 1986	Five surgical procedures: hip arthroplasty, coronary bypass surgery, morbid obesity surgery, retina repair and cataract surgery in US	Time series cross-section of 521 hospitals based on discharge data	To examine the role of payer mix, regulatory policies, physician diffusion, competition among hospitals and various hospital characteristics (for example, size), and the spread of technologies	The results are more consistent with a framework that has been applied by economists to study diffusion in a variety of industries than with the view that hospitals and their surgical staff can decide about innovations without regard to market influences Some patterns are consistent with non-economic theories. For example, innovation is typically more likely to occur in larger cities; the authors hypothesis is that this reflects the larger pool of patient candidate for the procedures but not alternative hypothesis that metropolitan physicians may belong to networks through which information about the new technology is transmitted first
Snyder-Halpern, 2001	Clinical information technologies/systems	Two round Delphi study with 34 experts from US-based healthcare organisations with direct involvement with clinical information systems and applications	To achieve consensus on (a) dimensions of organisational readiness for innovation (as included in existing innovation model – the 'Organisational information technology/systems innovation model' (OITIM)); and (b) indicators for assessing the dimensions	Delphi study identified eight innovation readiness sub-dimensions: resources, staffing and skills, technology, knowledge, processes, values and goals, operations and administrative support. 316 indicators were identified for the sub-dimensions. Results used to inform development of *Organisational Information Technology/Systems Innovation Readiness Scale (OITIRS)*
Tabak, 1999	(a)Digital radiography, (b) stereotactic breast biopsy, and (c) spiral acquisition computed tomography in US hospitals of 100-199 beds	Postal questionnaire to 4,625 CEOs, CFOs, COOs and VPs of non-federally owned hospitals exploring	(1) top managers' risk propensity and self-efficacy will be positively related to their intentions to decide in favour of adopting potential technological innovations; (2) top managers'	Found that, separately, individual and organisational variables each explained some variance in intention to adopt new technology. With regard to the organisational context, hospital strategy, information processing capacity and resource availability

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
		their 'intent to adopt' the 3 technologies. 1,096 responses (24%)	cognitive complexity will be positively related to their intentions to adopt potential technological innovations; (3) top manangers' age will be negatively, successful past experiences and education level will be positively, related to their intentions to decide in favour of adopting potential technological innovations; (4) top managers' perceptions of a domain-offensive strategy will be positively related to their intentions to decide in favour of adopting potential technological innovations; (5) top managers' perceptions of information processing capability will be positively related to their intentions to decide in favour of adopting potential technological innovations; (6) top managers' perceptions of organisational resource availability will be positively related to their intentions to decide in favour of adopting potential technological innovations; (7) organisational specialization will be positively related to top managers' intentions to decide in favour of adopting potential technological innovations	appeared as significant determinants of intentions to adopt potential innovations. The results did not support the hypotheses that hospital specialization would be positively related to intentions to adopt. Studies investigating organisational phenomena should include effects of both individual and organisational contexts to obtain a broader explanation of innovation decision making at the top management level. However, study limited to hospitals with 100-199 beds (result may be different in larger hospitals where resource availability not as a big a constraint) and focus on intent to adopt (not actual adoption).
Tabak, 2000	21 new imaging technologies in hospitals in US	Postal questionnaires to executives in 1181 medium-sized community hospitals (605, 51% response rate)	To explore the practical implications following hospital managers' innovation decisions that may be congruent or incongruent with the current organisational context. Hypothesises that: (1) perceived strategy and perceived resource availability will interact in such a way	A fit between hospital structure, strategy and resource availability will result in greater hospital innovative behaviour than the direct effects of any of these variables alone.

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
			that hospitals will be more innovative when top managers perceive their hospitals to have a domain-offence style and abundant resources; (2) perceived strategy and perceived top management information processing structure will interact in such a way that hospitals will be more innovative when top managers perceive their hospitals to have a domain-offence strategic style and high top management information processing capacity; and (3) perceived strategy, perceived top management team information processing structure, and perceived resource availability will interact in such a way that hospitals will be most innovative when top managers perceive their hospitals to have a domain-offence strategic style, high top management team information processing capacity, and abundant resources	
Teplensky, 1995	MRI in 637 US hospitals	Two telephone surveys of 507 hospitals with MRI plus a stratified sample of non-adopters. The first survey was of members of radiology departments relating to the technology itself and then second survey was of hospital CEOs asking about the organisations decision-making	To examine the factors affecting whether and when a hospital acquires a specific new capital-intensive medical technology (MRI)	The importance a hospital attached to being a technological leader, together with an emphasis on clinical services that required MRI and the change in revenues it believed to be associated with the adoption of MRI, were the major determinants of adoption behaviour. Changing the level of medical staff involvement in the decision-making to above the median also increased the odds of adoption. Larger hospitals were more likely to adopt MRI early; teaching hospitals were not more likely to adopt

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
		process. In the second survey non-adopters were asked about factors that might cause them to consider adoption of an MRI		
Wang, 2005	Health Information Systems (HIS) in 1441 US hospitals	A cross-sectional analysis was performed with 1441 hospitals selected from metropolitan statistical areas in the United States. Multiple data sources were merged. Six hypotheses were empirically tested by multiple regression analysis.	(1) hospitals operating in markets with greater managed care pressure will be positively associated with HIS adoption; (2) hospitals operating in competitive environments will be positively associated with HIS adoption; (3) hospital size will be positively associated with HIS adoption; (4) hospital information processing needs will be positively associated with HIS adoption; (5) participation in a strategic hospital alliance will be positively associated with HIS adoption; and (6) hospitals' financial status will be positively associated with HIS adoption	HIS adoption was influenced by the hospital market, organisational, and financial factors. Larger, system-affiliated, and for-profit hospitals with more preferred provider organisation contracts are more likely to adopt managerial information systems than their counterparts. Operating revenue is positively associated with HIS adoption. From an organisational perspective, this study suggests that organisational slack in large hospitals may be more predictive of hospital adoption of information systems. The empirical findings of this study show that large size, system-affiliated, and for-profit hospitals with more preferred provider organisation contracts were likely to adopt more administrative information systems.
Weingart, 1993	'Advanced medical equipment' in 12 academic medical centres in US	16 open-ended interviews with self-selecting respondents	To describe decision-making regarding the acquisition of technology including the clinical, economic and strategic considerations that informed the decision	Most of the centres had no distinct and recognisable technology assessment process in place; decisions about the acquisition of technology were often described as 'political', 'informal', or 'ad hoc'; the capital budgeting process was the primary vehicle at most centres for rationalising technology acquisition; uniformly, proposals for new technology percolate up from the clinical departments. At some of the centres various committees had been established on occasion to address decision about acquisition of technology (although a much more common strategy was to employ existing organisational entities - such

First author / year	Technological innovation and context	Study design and size	Aims/Hypothesis tested	Main findings relevant to this review
				as the capital budgeting system - to deal with decisions about advanced technology). Highlights informal, political nature of technology adoption decision-making processes
Wilson et al., 1999 (related analysis to Nystrom et al, 1992)	Medical imaging diagnostic technologies in US hospitals	Postal survey of 70 hospitals	Organisations with a greater risk-oriented climate are likely to (a) adopt innovations that are more radical and (b) adopt innovations with higher relative advantage	Risk-oriented organisations tend to adopt more radical innovations ($r=0.22$, $p<.06$) and innovations that provide greater relative advantage ($r=0.23$, $p<0.05$)
Wu, 2008	Adverse event reporting system in Taiwan	290 questionnaires from staff at hospitals that had actually or partially implemented reporting systems	1. management support has a direct effect on perceived usefulness of reporting system; 2. management support has a direct effect on perceived ease of use of reporting systems; 3. management support has a direct effect on subjective norm of reporting systems	The data showed that the management support had a direct effect on perceived usefulness, perceived ease of use and subjective norm. Extends the TAM by integrating variables connoting trust and management support into the model
Yetton et al., 1999	IT system for human resource management in Australian public healthcare system	Survey (133 potential users; 67 usable replies) of managers	Innovation attributes (task relevance, task usefulness) plus adopter characteristics and organisational variables	Only 3 factors were significant in the final model: task relevance, task usefulness, and physical access to the innovation. Conclude that innovation attributes dominate for innovations whose impact is on the individual; but organisational variables dominate at team level

Appendix 10 Examples of empirical studies in the technology-in-practice traditions

Authors / date	Context	Research question	Theoretical basis	Study design and scope	Main findings	Conclusion/ comment
Barley 1986[45]	US hospital radiology	Why did the introduction of the 'same' technology (CT scanner) play out differently in two different settings?	Structuration theory	Qualitative comparative case study (using ethnography and interviews)	The embedding of the CT scanner in a radiology department was shaped and constrained by pre-existing social structures via interpretive frames, power and influence, and professional codes of conduct. The technologies offered new opportunities for acting differently, and as a result, new patterns of action and interaction emerged.	The 'same' technology, when introduced in different contexts, will have different impacts (and be used differently and support different roles) because of complex and subtle differences in historical, contextual and social factors
Edmondson 2001[74]	US cardiac surgery	What accounts for the successful introduction (or not) of the technology for minimally invasive cardiac surgery?	Organisational sensemaking, routinisation theory	Qualitative (ethnographic) comparative case study in 16 hospitals, in which the 7 most successful teams were compared with the 7 least successful	Successful teams were characterised by a leader who framed the project as one of developing wider routines (as opposed to individuals learning to use a plug-in technology	Complex technology-supported innovations should not be viewed as plug-in technologies but as opportunities for teams to develop new routines
Lehoux 2002[75]	Canada, telemedicine in primary / secondary care	To what extent can tele-consultations be integrated into the routines of different medical specialties, and why?	Structuraiton theory, routinisation theory	Qualitative study (mainly interviews but some ethnography) on six different specialties in one hospital	Teleconsultation was seen as highly compatible with routines and work practices in specialities that primarily used images or numerical data, and much less compatible in specialties needing extensive physical examination or discussion with the patient. Perceived enabling properties of teleconsultation increased with distance separating patient and specialist, and decreased with the centrality of 'subjective' information in the clinical decision.	The development of teleconsultation should be consolidated around applications whose theory of use is compatible with existing clinical routines, or offers opportunities to restructure clinical work appropriately
Novek 2005[66]	Canada, hospital medicine	What explains the failure and abandonment of an	Actor-network theory, feminist theory	13 in-depth qualitative interviews to key actors; 158 questionnaires to all	Different groups of actors had different goals and sought to mobilise people and technologies in pursuit of these goals. The new technology, which	New technologies have unintended consequences; their 'success' cannot be predicted from the outset.

Authors / date	Context	Research question	Theoretical basis	Study design and scope	Main findings	Conclusion/ comment
		automated drug delivery technology in hospital care?		nurses	had been designed around an abstracted, 'professionalised' view of nursing work failed to gel with the practice of front-line nurses.	

Appendix 11 Application of the model to the five case studies

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
THE INNOVATION					
Key attributes of the innovation as perceived by intended user: (a) relative advantage (b) compatibility (c) complexity (d) trialability (e) observability (f) reinvention	(a) Relative advantage was considered to be high but new evidence about long-term complications (restenosis) has recently cast doubt on this. (b) Compatible with many professional values (e.g. evidence based practice) *and* administrative ones (efficiency). (c) Simple to develop and, once technique has been mastered, simple to use. (d) Highly trialable (e) Highly observable. (f) Low potential for reinvention.	(a) Relative advantage is very high – connecting different diagnostic technologies and departments, providing paperless images and records has high relative advantage. (b) Compatible with the values of all clinicians although some change in skill set required. (c) Technically complex but later versions very user-friendly. (d) Easily trialable. (e) Observable. (f) High potential for reinvention if central communication system (DICOM) is maintained.	(a) Relative advantage high in certain contexts e.g. poor and geographically remote areas. (b) Compatible with some values but does not align with values and expectations for 'high technology' solutions. (c/d/e) Very simple, trialable, and observable. (f) High potential for reinvention.	(a) Relative advantage differs for different professional groups (high for managers but low for nurses and ambiguous for pharmacists). (b) Compatible with the values of some (managers) but fundamentally challenges some nursing values. (c) Complex. (d/e) moderately trialable and observable. (f) Low potential for reinvention – offered as a largely fixed technology.	(a) Relative advantage very high but there is a major capital and revenue cost associated with an organisation's investment in the technology. (b) Highly compatible with values of modern medicine. (c) Extremely complex; requires a whole new skill set and a new role (CT / MRI technician). (d) Not locally trialable before investment. (e) Impact readily observable. (f) Very little potential for reinvention
Key operational attributes	(a-c) High task relevance, specificity, usefulness, and is	(a-b) Relevance and usefulness was not contested.	(a-c) High relevance usefulness and feasibility (d)	(a-b) Relevance and usefulness was contested	(a-b) Very high task relevance and usefulness. (c) Feasibility

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
(a) task relevance (b) task usefulness (c) feasibility (d) implementation complexity (e) divisibility (f) nature of knowledge needed	feasible. (d) After initial training will be simple for surgeons to implement. (e) Not divisible but since it is a small and simple innovation, this attribute is not necessary. (f) Knowledge codifiable and hence transferable.	(c) Variable feasibility because of high investment needed in IT infrastructure (d) Very high implementation complexity. (e) Divisible (can introduce PACS for some types of image e.g. CT scans before others e.g. MRI. (f) Knowledge largely codifiable and transferable.	Implementation complexity very low. (e) Not divisible nor is this needed. (f) Very low knowledge needed and this is codifiable. (barriers to adoption lie elsewhere – see above)	between groups, but in terms of the actual task (drug administration) the innovation proved counterproductive. (c) Variable feasibility because of high investment needed in infrastructure (d) Very high implementation complexity. (e) Not divisible. (f) Codifiable knowledge needed by pharmacists but ignores tacit knowledge of nursing staff.	low in resource-poor settings or where insurers do not cover its use (d) High implementation complexity. (e) Not divisible. (f) Knowledge partially codifiable but tacit knowledge by technicians hard to transmit in codified form.
ADOPTERS AND ADOPTION					
Who are the adopters and what are their characteristics and needs?	Cardiologists who seek to improve patients' survival after angioplasty.	Diagnostic radiologists who seek to store and share complex images (typically within a hospital) and reduce the problem of films getting lost. Requires simultaneous adoption by all in an organisation.	Clinicians in remote rural areas looking for an inexpensive solution to heat loss for premature babies.	Managers seeking to reduce error and waste in drug distribution. Pharmacists seeking to free themselves from tasks that could be automated. Nurses who sought to meet their patients' needs.	Diagnostic radiologists and clinicians who would order these tesst. Requires simultaneous adoption by all in an organisation.
What is the meaning of the innovation to intended adopters?	Evidence-based intervention for improving survival (though	An efficient and cost effective way of storing and sharing	To some, a cost-effective way of saving babies' lives. To	To managers, a way of making the delivery of drugs in a ward	A major step forward in diagnostic imaging ('the ability

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
	later evidence challenged this).	images within the hospital.	others, a low-tech, somewhat unhygienic and second-best technology.	setting more efficient and accountable. To nurses, a threat to their professionalism.	to see inside the body in 3D slices').
What is the nature of the adoption decision?	Usually individual by the cardiac surgeon.	The decision to install PACS is corporate; once it has replaced film all must use it.	Usually individual by the paediatrician.	The decision to install the system is corporate; once installed all must use it.	The decision to install CT or MRI is corporate. Once installed clinicians may choose whether to use it but radiologists must interpret the images. Insurers must be prepared to pay for it.
What are the concerns of adopters at (a) pre-adoption stage; (b) early use stage; (c) experienced user stage, and to what extent are they met?	(a) Will the drug-eluting stent reduce acute complications? Will it prevent later heart attack or stroke? (b) How do I insert one? (c) How can we overcome the restenosis? How can we improve the stent?	(a) Will this system work? How reliable is the technology? (b) How can we operationalise this across all departments? How can we get user terminals to where they are needed? How do we protect against system crashes? (c) How can we extend the service?	(a) Does the box prevent heat loss in premature babies? Is it safe? (b) How can we overcome the perceived low social value of the box? (c) How can we spread this innovation to other regions?	(a) Is this feasible and will it work in practice on a busy ward? (b) How do we align the unpredictability and messiness of clinical work with the rigid timescales inscribed in the technology? (c) Not applicable – was abandoned.	(a) How much will this cost and will insurers reimburse its use? (b) Technology and logistical issues. Can we get the staff to run and maintain this technology? (c) what new indications can we use a CT / MRI scan for? What research can we do?
COMMUNICATION AND INFLUENCE					
What is the nature of the networks through which	Surgical innovations generally arise spontaneously at local	PACS originally developed in University-linked hospitals and	Mainly, local spread via interpersonal influence of	A centrally led, management-driven innovation that is being	Originally developed by large IT companies working in

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
influence about the innovation is likely to spread?	level and spread via horizontal networks of professionals. Spread via conferences, journal publications as well as manufacturers ('reps').	spread via informal horizontal networks of professionals. Spread occurred via manufacturers (IT companies) and to some extent through conferences and journals.	paediatricians; some impact of formal professional networks	spread mainly via vertical networks	partnership with academics; spread to university-linked hospitals via horizontal networks of professionals. Also manufacturers and academic outlets
Who are the main agents of social influence and what are they doing?	Expert opinion leaders – mainly academic cardiac surgeons.	Expert opinion leaders – mainly technical experts and leading radiologists.	Mostly, peer opinion leaders (front-line paediatricians who champion the technology).	To some extent, experts in 'evidence-based' and 'cost effective' practice who champion this technology as a route to safer, better practice.	Mainly, peer opinion leaders.
THE INNER CONTEXT					
What are the key structural features of the organisation? Size / maturity Complexity / differentiation Decentralisation Slack resources	The crucial structural feature is whether the cardiologists have autonomy to choose to adopt this innovation and adopt improvements as they emerge.	Because of high financial investment, large size and slack resources needed.	No special organisational features needed as this is a low-cost, low-tech innovation adopted at an individual level.	Relatively high capital investment needed (for infrastructure and training), hence slack resources important.	Very high capital investment needed so these technologies tended to be introduced first in regional referral centres and then other large hospitals..
What is the organisation's absorptive capacity for this type of knowledge?	Depends on specialist cardiology skills and an	Requires substantial investment in skills and	No special absorptive capacity needed as this is largely taken	Meditrol requires a strong investment in logistics as well	Requires strong investment in radiological diagnostic skills

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
Skill mix Knowledge base Transferable know-how Ability to evaluate the innovation	effective system of monitoring and audit	knowledge, plus IT support since a functioning ICT infrastructure is now 'mission critical'.	up at individual level.	as some training for front-line staff in running the distribution technology.	(now given as part of the normal training of a radiologist/radiographer) as well as technical support to run complicated diagnostic imaging equipment.
What is the organisation's receptive context for this type of change? Leadership and vision Values and goals Risk-taking climate Internal and external networks?	No formal data but anecdotal reports suggest that it was the innovative, risk-taking hospitals who first tried out stents, and that these initiatives were led by pioneer clinicians who were widely networked externally.	No formal data but anecdotal reports suggest that it was the innovative, risk-taking hospitals who first tried out PACS, and that these initiatives were led by pioneer clinicians who were widely networked externally.	No special receptive context needed as this was a simple technology adopted on an individual basis	No formal data but the innovation appears to have been implemented in hospitals engaged in a 'modernisation' programme and who led the filed in other ICT innovations.	Data suggest that it was the innovative, risk-taking hospitals who first tried out CT Scanners, and that these initiatives were led by pioneer clinicians who were widely networked externally particularly those with links to the university sector and industry.
What is the organisation's readiness for this specific innovation? Organisational fit Assessment of implications Dedicated time/resources Broad based support	Not applicable as this was largely a clinical decision.	In general, PACS has been embraced enthusiastically and given appropriate support from top management (perhaps because relative advantage is clear to most players even though the initial capital costs are fairly high).	Not applicable as this was largely a clinical decision.	'Fit' was assumed rather than formally assessed. Its introduction was well resourced but support was lacking in key sectors (especially front-line nurses)	In general, CT and MRI scanners have been embraced enthusiastically and given appropriate support from top management (perhaps because high relative advantage was clear).

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
THE OUTER CONTEXT					
What is the nature and influence of the socio-political context?	Positive towards evidence based practice and technical solutions which improve patient outcomes.	Strong support for networked IT solutions which were explicitly linked in UK and USA to the modernisation and patient safety agendas.	Not especially favourable – 'appropriate technology' was less popular than branded, high-tech solutions.	Strong support for networked IT solutions – perhaps led to over-adoption of technologies that were poorly aligned with clinical practice	Positive towards evidence based practice and technical solutions which improve patient outcomes.
Are there any external Incentives and mandates?	No	Introduction of PACS was government-funded in the UK	No	No	Various incentives (e.g. in the UK through Private Finance Initiative and modernisation funds, and through insurers in the USA).
What are the prevailing norms from other comparable ('opinion leader') organisations?	Strong norms for evidence-based practice which broadly support innovations in stents.	PACS is now established as an organisational norm.	Limited inter-organisational influence. Spread has been mainly at an individual level through observation and word of mouth.	Meditrol was used in some but not all organisations and seen by some but not all as a leading in innovation.	CT scanners rapidly became an organisational norm.
IMPLEMENTATION AND SUSTAINABILITY					
What are the features of the implementation process in	In general, implementation of stents (a) requires no new roles or staffing; (b) requires specific equipment and	Implementation requires a strong investment (a) basic IT skills and some technical skills for the staff maintaining the	Implementation of he incubator (a) requires no new roles or staffing; (b) requires no specific equipment and	Implementation requires a strong investment (a) in training pharmacy staff who need to prepare the	Implementation requires a strong investment (a) diagnostic imaging skills for radiologists and radiographers

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
terms of (a) Human resources (b) Involvement of key staff (c) Project management	training; (c) is inherently a clinical skill development rather than a project management initiative	system (b) clinicians reading the initial images and those retrieving the images also need training and support (c) procurement of the IT system needs careful project management	training; (c) is inherently an individual clinical decision rather than a project management initiative	medication for the distribution system (b) nursing staff are given a swipe card to access this system and will need to develop skills in implementing the delivery of these drugs. (c) procurement of the system needs careful project management	and technical skills for the staff maintaining the system (b) clinician involvement and support is key (c) procurement of the system needs careful project management
What measures are in place to capture and respond to the consequences of the innovation (e.g. audit and feedback)?	Covered by routine clinical audit	As a networked ICT innovation, PACS includes the facility for audit but the application of these depends on local initiative/priorities	Generally, limited since use is restricted to resource-poor settings.	Quantitative audit data probably readily available but no the impact of the change in roles and management of unpredictability is not systematically captured.	Covered by routine clinical audit
What measures enable organisations to develop, adapt and reinvent the innovation (e.g. inter-organisational networks and collaboratives)?	Covered by standard clinical practice developments	Re-invention likely to be IT industry led with new generations of software and upgrades becoming available from time to time.	Limited.	No published evidence of these.	Covered by standard clinical practice developments
THE ROLE OF EXTERNAL AGENCIES					
Are the developers linked with potential users of the	Not applicable (not developed centrally)	Some highly productive links between commercial IT	Not applicable (not developed centrally)	Developers are technical and the users of the system are	Some 'sentinel' sites work with developers but these may not

	Drug eluting stent	PACS	Thermacol incubator box	Networked drug distribution system	CT and MRI scanners
innovation at the development stage, and do they share value systems, language and meanings?		companies and users of the system. Potential mismatch between technical expertise in the IT companies and clinical priorities.		clinical. There are major differences between the two groups' value systems, language and meaning.	be representative of all users. Much of the development is lab-based within high tech electronics industry.
What is the capacity and role of the external change agency (if any) to help organisations with operational aspects of assimilation?	Not applicable	Because PACS is a government priority in UK, support may be available to organisations seeking to introduce it.	Not applicable, though there is potential for (e.g.) non-governmental organisations to facilitate wider adoption of this innovation	No central change agency officially devoted to this innovation.	No central change agency officially devoted to this innovation.

Disclaimer:

This report presents independent research commissioned by the National Institute for Health Research (NIHR). The views and opinions expressed by authors in this publication are those of the authors and do not necessarily reflect those of the NHS, the NIHR, the NIHR SDO programme or the Department of Health. The views and opinions expressed by the interviewees in this publication are those of the interviewees and do not necessarily reflect those of the authors, those of the NHS, the NIHR, the NIHR SDO programme or the Department of Health"

Addendum:

This document is an output from a research project that was commissioned by the Service Delivery and Organisation (SDO) programme, and managed by the National Coordinating Centre for the Service Delivery and Organisation (NCCSDO), based at the London School of Hygiene & Tropical Medicine.

The management of the SDO programme has now transferred to the National Institute for Health Research Evaluations, Trials and Studies Coordinating Centre (NETSCC) based at the University of Southampton. Although NETSCC, SDO has conducted the editorial review of this document, we had no involvement in the commissioning, and therefore may not be able to comment on the background of this document. Should you have any queries please contact sdo@southampton.ac.uk.