

Investigating healthcare IT innovations: a “conceptual blending” approach

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innovations

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Abstract

Purpose – The purpose of this paper is to better understand how and why adoption and implementation of healthcare IT innovations occur. The authors examine two IT applications, computerised physician order entry (CPOE) and picture archiving and communication systems (PACS) at the meso and micro levels, within the context of the National Programme for IT in the English National Health Service (NHS).

Design/methodology/approach – To analyse these multi-level dynamics, the authors blend Rogers’ diffusion of innovations theory (DoIT) with Webster’s sociological critique of technological innovation in medicine and healthcare systems to illuminate a wider range of interacting factors. Qualitative data collected between 2004 and 2006 uses semi-structured, in-depth interviews with 72 stakeholders across four English NHS hospital trusts.

Findings – Overall, PACS was more successfully implemented (fully or partially in three out of four trusts) than CPOE (implemented in one trust only). Factors such as perceived benefit to users and

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attributes of the application – in particular speed, ease of use, reliability and flexibility and levels of readiness – were highly relevant but their influence was modulated through interaction with complex structural and relational issues.

Practical implications – Results reveal that combining contextual system level theories with DoIT increases understanding of real-life processes underpinning implementation of IT innovations within healthcare. They also highlight important drivers affecting success of implementation, including socio-political factors, the social body of practice and degree of “co-construction” between designers and end-users.

Originality/value – The originality of the study partly rests on its methodological innovativeness and its value on critical insights afforded into understanding complex IT implementation programmes.

Keywords Information technology, Innovation, Healthcare, NHS, Adoption, Social systems theory

Paper type Research paper

Introduction

Over the last decade fully integrated healthcare information technology (IT) has increasingly been seen as a critical lever for improving the quality, safety and efficiency of health systems (Chaudhry *et al.*, 2006).

At the same time evidence is emerging of contradictions and paradoxes regarding the ability of IT innovations to deliver such benefits (Lapointe *et al.*, 2011). While there have been notable achievements in introducing new IT to improve delivery of healthcare interventions and services (Garg *et al.*, 2005), including in the UK the introduction of a national network connecting hospitals to the internet (Barham and Madden, 2007), there have been notable setbacks. The roll out of the ambitious National Programme for IT (NPfIT) of the English National Health Service (NHS) (House of Commons Public Accounts Committee, 2009), subsequently called Connecting for Health, was the biggest, and is still arguably the most troubled, outsourced IT project from the public sector ever undertaken (Dyke, 2003).

By 2011, after expenditure on the programme had totalled £6.4 billion, the National Audit Office (2011) concluded that the English Department of Health had “fundamentally underestimate[ed] the scale and complexity of a major IT-enabled change programme”. Given that the adoption and implementation of IT innovations remains a goal of most healthcare systems, the question remains, “How can we best understand how and why the adoption and implementation of IT innovations occurs?” Specifically, in what ways do certain innovative applications appear problematic to implement? And how can a blending of investigative concepts help to elucidate this problem?

Studying innovations in healthcare

One common way of addressing the first of the above questions has been to apply innovation management theory: for example, concepts of “diffusion” or spread (Greenhalgh *et al.*, 2005) have been used to examine the characteristics of the innovation (as originally proposed by Rogers in 1962), i.e. its “relative advantage”, “compatibility”, “degree of complexity”, “trialability” and “observability”, and its impact on adoption processes. Diffusion of innovation theory (DoIT) has perceived limitations. In the context of IT, “diffusion” is more akin to “technology adoption” (implying some choice) which, in turn, is theoretically different to technology introduction and implementation. The term “diffusion” itself, which entered management theory from the physical sciences via marketing (Rogers, 2003), has been criticised for its potentially misleading emphasis on “saturation” and “resistance” (Czarniawska, 2001).

Although hugely influential, widely taken up, and now in its fifth (2003) edition, Rogers' *Diffusion of Innovations* sets out an approach more aligned to the middle section of an innovation's "journey" (Van de Ven *et al.*, 2008; May and Finch, 2009) in being more focused on the specifics of "early adopters" and "product champions". The focus is on decision-making and persuasion, rather than on the earlier stages of innovation initiation, or the later stages of implementation (Van de Ven *et al.*, 2008; May and Finch, 2009). The unit of analysis within Rogers' work is usually the individual or individual unit/organisation, or the characteristics of the innovation itself. Less attention is paid to different structural and social processes within the whole system that make up the innovation's journey, including professional pressures or processes whereby organisations take up new technologies as a result of economic drivers, legislation, regulatory frameworks or state policy (Lemieux-Charles and Barnsley, 2004; Ferlie and Dopson, 2005; Webster, 2007a, b).

Interest in more processual approaches to how and why innovations develop over time from concept to sustained implementation has led some theorists to take a different approach to Rogers, for example the work of Timmermans in relation to non-IT innovations in healthcare such as genetic screening (Timmermans and Buchbinder, 2012). Others, however, have integrated Rogers' thinking within a broader framework of processes, sequences and paths (e.g. May and Finch, 2009). Unlike many other management theories (cf. Bartunek and Egri, 2012), one clear advantage of Rogers' theory is its simplicity of description and apparent organisational "actionability", reflected in its widespread use and application, including in the area of IT implementation (e.g. Peasupap and Walker, 2007; Zanaboni and Wootton, 2012).

As with the study of other types of innovations, with IT innovations in healthcare the complexity of context is hard to ignore, context here being interpreted in terms of the landscape at different levels of various scale – ranging from the small (micro) to medium size (meso) to large (macro) (House *et al.*, 1995). In a publicly funded health system, such as the English NHS, the interplay between policymaking (macro level), healthcare organisations (meso level) and the clinical encounter and technical procedures (micro level) assumes particular significance (Greenhalgh and Stones, 2010). Each of these levels is "shaped by a set of specific interests, rules and norms of a given field of action and thought" (MacVaugh and Schiavone, 2010, p. 321) and the ways in which interests mesh or collide within and across levels help to determine the course of an innovation's adoption (Lee, 2011). Models that simplify these relational processes may provide limited insight into the dynamic interactions between internal and external processes at different levels and at the boundaries between these (House *et al.*, 1995).

A number of studies both within and outside healthcare indicate that implementing innovations comprises a set of complex social and organisational processes (Feldman, 2000, 2003; Barley, 1986; Lehoux *et al.*, 2002). Robert *et al.* (2010) have also emphasised the value of using a range of sociologically informed theories to enhance innovation strategies in healthcare, including routinisation theory, technology structuration theory and actor-network theory.

Routinisation theory (Feldman, 2003) highlights the process of embedding innovation and explores links between micro- and macro-level actions and interactions; this theory has been applied to the study of healthcare organisations to identify emerging patterns of collaborative routines that help or hinder diffusion and assimilation of technological innovations (Edmondson *et al.*, 2001). Technology structuration theory, drawing on the work of Giddens (1984), looks at the role of social systems, structures and practices in the adoption of technologies; since the 1980s

researchers have applied this theory to healthcare settings to explain how the same technological innovation may have similar or different impacts in different organisations and even between different departments within an organisation (Barley, 1986; Lehoux *et al.*, 2002; Goh *et al.*, 2011). Actor-network theory (Latour, 1992) focuses on interactions between people, ideas and technologies, and sees the resulting networks as being in a state of continual flux and conflict. As with structuration theory, this has been used to explain variations in the impact of innovations in different settings (Cresswell *et al.*, 2010). Together with sociotechnical studies generally, actor-network theory has been used to further problematise the notion that the success of technological innovations in healthcare can be predicted from the outset and has called attention to the significance of unintended consequences of such innovations (Attieh *et al.*, 2014), including computerised physician order entry (CPOE) (Harrison *et al.*, 2007).

A further theoretical candidate is normalisation process theory (NPT) (May *et al.*, 2009). This proposes that implementation and embedding of new technologies occurs through four generative mechanisms: coherence (ideas about meaning, use and utility); cognitive participation (how actors are implicated in a practice); collective action (organising and enacting a practice); and reflexive monitoring (procedures for monitoring and assessing the impact of a new practice within an organisational setting). As with actor-network theory, NPT sees actors enroled across social and socio-technical networks but differs from it by not insisting on the agency of non-human actors. While NPT has been applied mainly to technological advances in healthcare its proponents argue that it can be used to explain, and not just describe, how technologies generally are integrated into evidence-based practices (May and Finch, 2009; Johnson *et al.*, 2014).

Despite adding to our thinking, relatively few of these studies apply a pluralistic approach or seek to explore more fully the interaction of different levels that affect implementation. While there is increasing interest in the analysis of macro, meso and micro levels, macro-level determinants of implementation outcomes are less likely to be assessed (Chaudoir *et al.*, 2013). Greenhalgh and Stones (2010), for example, explore the implementation of IT in healthcare through the micro-detail of clinical work, bringing structuration theory and actor-network theory to bear (see also Greenhalgh *et al.*, 2014). Callen *et al.* (2008) study the implementation of CPOE through a multi-level model which excludes the macro as external. Other work uses Rogers' theory to focus on one or more levels, but omits consideration of dynamic interactions between levels (see MacVaugh and Schiavone, 2010).

Our approach aims to address this deficit, by combining the particular focus and clarity, and organisational "actionability" gained from Rogers' perspective with insights from a more sociologically informed perspective which directs attention to interconnections between levels, including the influence of the macro in shaping perceptions and behaviours of actors at other levels. In the "conceptual blending" (Cornelissen and Durand, 2012) of these two approaches we aim to provide new insights into the adoption of IT innovations in healthcare, the focus being not on a single time point or snapshot of an innovation decision but on the innovation "journey" from adoption to implementation (cf. Van de Ven *et al.*, 2008).

Theoretical perspectives: a conceptual blending

"Conceptual blending" refers to the intentional combining of "domains" or approaches to prompt alternative insights (Cornelissen and Durand, 2012). Critically, in taking

this approach it is not the similarity or dissimilarity between these “domains” that is key (cf. Oswick *et al.*, 2011) but producing a blend at the intersection of “within-domains” similarity and “between-domains” distance that may result in novel thinking (Cornelissen and Durand, 2012).

In attempting to more fully address interconnections across different innovation participants and organisational levels we found concepts discussed in the work of Webster (2007a, b), including the “social matrix”, to be particularly insightful. In relation to NPfIT, Webster argues for the need to understand innovation not in terms of a technical, rational set of issues mobilised by any one group, but of requiring co-construction by “a range of technologies, social actors, their networks and organisations [which] have to be recruited to make the system in any way workable” (Webster, 2007a, p. 115).

The processes by which new technologies in healthcare are adopted and implemented is thus one of interaction and co-construction – of the material and the social – between various relevant actors and networks; they create a “social matrix” that is “only as strong as the network of relations that hold it together” (Webster, 2007a, p. 116). For example, in Webster’s assessment, clinicians have been largely displaced as drivers of innovation. While agreeing that clinicians continue to shape new developments in medical technology, and crucially act as gatekeepers to innovations, he states that their role “as drivers of new technology has been overtaken by the state and the private sector” (p. 49). In relation to NPfIT specifically, the value of perspectives which take into account socially and politically informed processes that were pivotal to its original vision and subsequent outcome of implementation is clear (Cresswell *et al.*, 2011). The vision underpinning NPfIT, to allow patients’ health information to be shared by NHS care providers throughout the country, was set by the then Prime Minister. From its inception, the management structure of NPfIT included endorsement and sponsorship by the Secretary of State for Health, with day-to-day oversight provided by ministers in the Department of Health (National Audit Office, 2006). In 2002, a manager with experience of procurement and delivery of large scale IT programmes in the private sector was appointed to run NPfIT. Implementation in acute trusts was to be through one of five geographic partnerships with the private sector. However, previous work has highlighted the difficulties in implementing this programme at the meso, organisational level in relation to unrealistic timescales and insufficient engagement of end-users, particularly clinicians (Hendy *et al.*, 2005, 2007).

The concept of the “social matrix” highlights the complexities of managing and governing new health technologies. As with Rogers’ (2003) concept of “diffusion network”, this points to the importance of studying the adoption and implementation as the precursor to creating “critical mass” (see “Meso- and micro-level negotiations”). The social matrix differs from the diffusion network in the greater attention paid to networks of relations which exist at multiple levels (macro, meso, micro), and the dynamics between these levels. While diffusion of innovations theory has been used as a lens through which to assess health-specific models of innovation (Byambaa *et al.*, 2015), theories have not been explicitly “blended” to seek the intersection of similarity and distance between theories in order to generate new insights. For Rogers, the diffusion or movement of innovation is mainly a matter of spread across levels, while for Webster it is a matter of spread across and between levels. In this paper, therefore, we analyse the implementation of two IT innovations, in terms of the interactions between macro and meso levels and negotiations between meso and micro levels, where the intersection of the blending of Rogers’ (2003) and Webster’s (2007a, b) concepts is

most apparent. Our interest in blending was restricted to its explanatory power rather than its value as a predictive tool or in modelling causality (see “Discussion”).

Methods, data collection and analysis

We chose to focus on the implementation of two healthcare IT innovations which had preceded NPfIT and were positioned by the programme as pivotal to the modernisation of healthcare (Barham and Madden, 2007): CPOE and picture archiving and communications system (PACS). CPOE, as implemented in this study, is a networked computer system that allows web-based test ordering (with automated form filling, order sets and warnings of possible test duplication) and access to the results of previous tests by a number of authorised users from different terminals connected to the network. PACS is a networked computer system that allows web-based test ordering (with automated form filling), electronic filing of images and viewing of new and archived images by a number of authorised users from different terminals connected to the network in a similar way to conventional light boxes (Royal College of Radiologists, 2011). NPfIT planned to implement a national broadband network whereby, for example, digitised X-rays from PACs could be relayed when needed (Webster, 2007a).

Implementation processes relating to these two innovations were studied in four case study NHS acute hospital trusts that reflected a range of different organisational characteristics, differing in size, number of sites, financial situation and the existing level of implementation of electronic functions (see Table I and Figure 1). Qualitative data for the study presented here were collected over a two-year period (2004-2006) through semi-structured in-depth interviews with a range of staff. The interviews were carried out across two levels and three time points, with level 1 focused on senior staff and their perceptions of macro-level influences (34 participants) and level 2 with 38 participants specifically using and implementing the innovations under study, PACS and CPOE.

Findings and methods from level 1 data have been reported elsewhere (Hendy *et al.*, 2005, 2007). These data were also analysed for this paper, but the framework and data analysis were distinct from the earlier work (which focused on the overall progress of NPfIT). Level 2 data have not previously been analysed or reported. Given that discussion and analysis of the lessons afforded by NPfIT continue (Greenhalgh and Keen, 2013; Jones, 2013) we felt there was particular value in bringing these rich data sets together to offer further critical insights for policy makers, researchers managers and practitioners.

Trust 1	Trust 2	Trust 3	Trust 4
Merger of 2 district general hospitals (DGH), 1999. Hospitals had very different IT platforms: Site 1 had advanced system, user-focused in terms of what clinicians valued (e.g. test ordering, results reporting) Site 2 had basic system Took until 2003 to achieve same system across both hospitals	Merger of 2 DGHs, 1999 Site 1 – new build public funding initiative (PFI) Site 2 – old site, basic IT PFI partnership between two companies. Partnership broke up because one bought competitor off the other Major performance challenges – access, targets, finance	Single site Long-standing financial deficit Had good basic IT systems “on the cheap” Serious performance challenges – attention focused on turnaround	Single site DGH, no major organisational change Management very receptive to implementation of IT systems Seen as an IT innovator: acted as pilot hospital for e-booking

Table I.
Characteristics of case study trusts

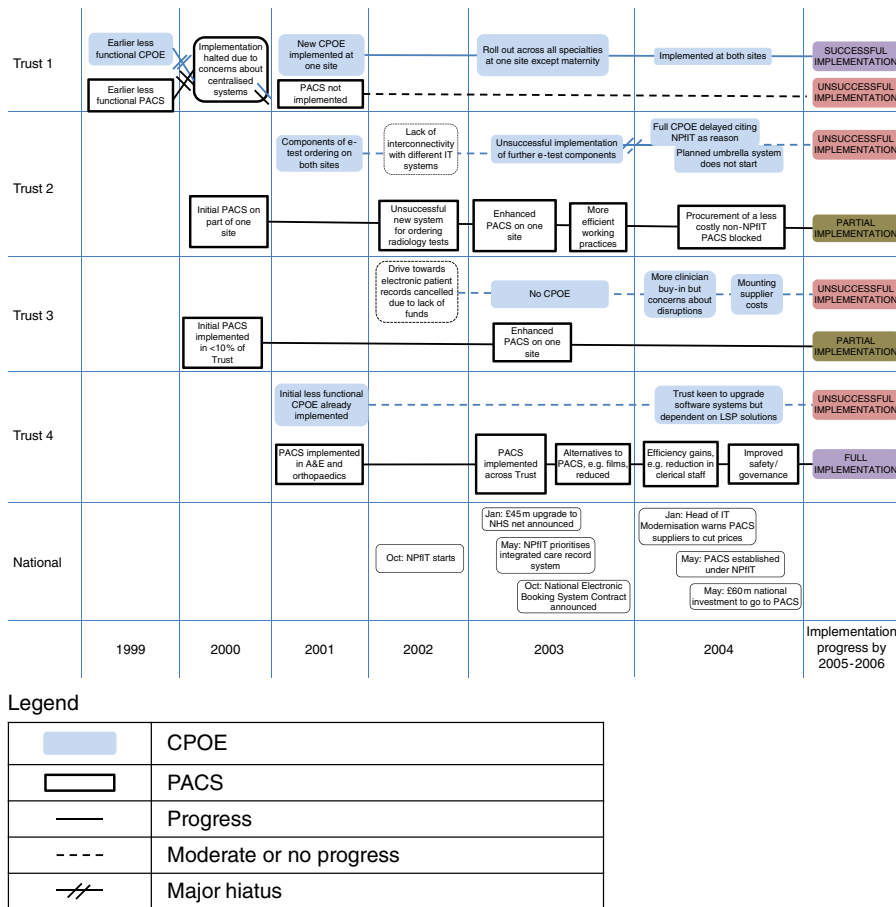


Figure 1. Timeline of implementation of IT innovations

Interviewees were recruited through purposive sampling and interviews focused on the experiences of implementing and using these specific IT innovations. Participating staff included senior and middle managers, clinicians (doctors, nurses, radiographers, pharmacists, pathologists, allied professional staff), administrative staff and IT project managers and trainers (Table II).

Ethical approval was granted by NHS Trent Multicentre Research Ethics Committee (MREC/03/4/017) and NHS Trust Local Research Ethics Committees.

Number of participants	Trust 1	Trust 2	Trust 3	Trust 4	Total
Senior managers/clinicians	8	9	8	9	34
PACS	7	0 ^a	3	7	17
CPOE	10	11	0 ^a	0 ^a	21
Total	25	20	11	16	72

Note: ^aZero indicates that the application was not implemented in study site

Table II. Interviewees

Three researchers (SCr, JH, NF) independently read interview transcripts. A combination of inductive and deductive methods was used to analyse processes over time (Langley, 1999). Our original analysis took a DoIT perspective to explore innovation characteristics, individual communication and decision-making that affected implementation, and their role in diffusion activities. Subsequently, we applied Webster's perspective to analyse context and dynamics operating within and between levels of the system. The resulting "conceptual blending" (Cornelissen and Durand, 2012) sought to prompt alternative insights not generated by one perspective alone.

Results

The adoption and implementation journey of the two IT innovations in each trust is summarised in Figure 1, together with key developments of NPfIT specifically as they interacted with these local journeys. Overall, PACS was more successfully implemented (fully or partially in three out of four trusts) than CPOE (implemented in one trust only). To understand implementation processes, findings are presented in terms of the dynamics within and between levels of the system (macro, meso and micro). Here the macro is represented by government and its political agenda, the meso by individual trusts (and the enactment of senior-/strategic-level management) and the micro by front-line staff.

Macro-meso level dynamics

We analysed how, within each trust, the national policy agenda was interpreted according to each trust's organisational agenda, aims and goals. In addition, we examined organisational adaptability – how each trust was able (or not) to interpret and modify national policy to fit locally. Before NPfIT each trust had IT implementation plans (see Figure 1 and Table I). Some of these plans were more devolved than others – which made fitting into the national timetable and obtaining national support (including funding) an imperative but also a tension. Added to the practicalities of strategic fit was the high political profile and perceived tight state control:

Because it's such a high profile and costly investment for the government [...] the government [...] seem to want it to be very tightly controlled because there's so much at risk (Information Management and Technology Project Manager and NPfIT Project Manager, Trust 1).

Politicians with a big "P" have got to stop changing the rules every five minutes or, if they do change the rules every five minutes to be quite clear how they want it [...] reams from big "P" politicians are not the way to design your healthcare processes (R and D Director and Clinical Director, Trust 4).

Despite these reservations there was support across all Trusts for the idea of centralised support to achieve IT modernisation:

I absolutely support a centralised approach. I think for too many decades we've been reinventing the wheel locally with all the costs attached to that (Information Management and Technology Project Manager, Trust 3).

Different meso-level organisational contexts and existing strategic priorities were important factors in explaining implementation variation among trusts (Table I). Salient factors included the creation of multiple sites following merger (Trusts 1 and 2), financial deficits (especially Trust 3) and the need to meet performance targets (especially Trusts 2 and 3). However, the most important factor was the macro-level promise of financial support from NPfIT: trusts did not want to pay for local CPOE or

PACS solutions if these could be supplied nationally (see Figure 1 for a breakdown of the timings and delays across the four sites).

While at meso level some managers welcomed or pragmatically accepted political drivers and delays, especially on grounds of financial efficiency, many were aware that macro-level political sponsorship was likely to incur increased scrutiny and pressure to deliver because political reputations were at stake:

I see this as a very politically driven process with a very clear leader who feels very tied to ministerial accountability to ensure that things are delivered: “A lot of money has gone into this, I must deliver, you must all deliver” (Research and Development Director, Trust 2).

Concerns were expressed during initial interviews by several senior managers about whether the immediate, observable benefits of the new IT, an important factor outlined by Rogers, and in this case promulgated by macro-level rhetoric and support, would be enough to persuade micro-level front-line staff. At meso and micro levels there was a sense of unease that the macro-level programme was being used for short-term political bargaining:

After the general election is this [PACS] going to be on the back burner? Are we in now for two or three months of hyping up of what PACS can do, for the electorate? (General Manager/ Chief Radiographer, Trust 3).

This is where Webster’s argument that IT innovation requires co-construction, a network of relations which strive forward together, is relevant. From the beginning, the macro-level timetable for implementation was perceived at meso level as completely unrealistic. Trust managers were aware that it would take much longer to implement systems of this complexity than the national timetable allowed for. This disconnect between macro and meso levels reflects Webster’s focus on the socio-political context of implementation. It also demonstrates how this lack of alignment can spin out to create micro-level clinical displacement, with front-line staff expressing dissatisfaction at the lack of macro-level interest in meso- and micro-level challenges:

As a tax-payer I’m furious, as a clinician who’s dedicated time speaking on behalf of other professionals who’ve spent hours of unpaid time trying to make this work they feel devalued, marginalized and ignored (Medical Director, Trust 1).

Overall, we found no evidence that meso- or micro-level contextual issues had any impact on macro-level policy or communications. The strong macro-level political backdrop appeared an anathema to any form of cross-level co-construction: the NPfIT was perceived as arising from macro-level policy largely divorced from concerns at other levels – “Politicians have fixed their flag to the mast” (Medical Director, Trust 1).

Meso- and micro-level negotiations

As discussed, local implementation processes differed between trusts and reflected different micro- and meso-level dynamics. At meso and micro levels local contextual factors could not be ignored; here Rogers’ theory enabled us to examine these in more detail. In examining meso-micro dynamics we explored the utility of Rogers’ notion of “critical mass” (“I’ll do it because everyone else is”). Webster (2007a) also argues that the notion of critical mass is especially true of information and communication or media technologies because they require many users if they are to be efficient.

“Critical mass” was exemplified by Trust 4’s strategy of ensuring simultaneous roll-out of PACS in orthopaedic clinics and operating theatres. One of the most potent factors

for securing critical mass was the benefit for end-users, in terms of the patient experience. Where PACS and CPOE were implemented fully, many positive improvements were reported, for example, fewer lost (and hence fewer unnecessary repeat) X-rays, reduced waiting times and increased information for patients (see Figure 1):

PACS is something that has moved from being an innovation toy to critical to the pathway of evaluation of a patient [...] Many patients actually like the concept of seeing what's wrong with them and they can understand [...] It's much less remote [...] [patients can] sit there side by side with their clinician and discuss various things (Radiologist and PACS Lead, Trust 2).

In all four trusts end-user (micro-level) consultation drove implementation, regarding the quality of training and IT support as levels of readiness of those adopting the application varied. It was a challenge to engage some end-users unfamiliar with IT during early implementation. Strong project management team skills with high-level management support were seen as essential to progress:

If it's not supported by someone from the top there's no point in doing it [...] if it's a task handed to a junior project manager or somebody like that it's got no authority to make people use the system (IT Implementation Manager, Trust 1).

Not all implementation went well due to the complexity of the IT. Some physicians reported spending more time interacting with a computer than the patient during a consultation. The importance of complexity of use is strongly highlighted by Rogers but often overlooked (Plsek, 2003).

Co-construction and engagement processes

In studying meso- and micro-level negotiations, we also drew on Webster's ideas of co-construction and clinical displacement to analyse how engagement (or lack of it) aided or hindered local progress. While implementation plans across trusts were underpinned by the rhetoric of co-construction and user empowerment in reality these were rare:

The clinicians [...] they've said it is such a complicated screen [for e-test ordering]. They said "Change it." I said, "Well I don't have that power, this is what the Trust bought (Pathology Operations Manager, Trust 3).

There's some tests that have got certain rules attached to them that prevent you from ordering them or if it's inappropriate or that come up with warnings saying that, you know "This needs to be discussed with a haematology consultant before it actually can be analysed" (Consultant Haematologist, Trust 2).

However, many end-users at micro level developed a practical sense of integrating IT into their daily work, which suggests they found ways to make rule-based, rather inflexible systems work for them. It was less a case of demystifying technical competence as taking into account the various interplays of professional knowledge and practice, indicating ways in which the distinctive responsibilities and remits of actors could at times effectively negotiate power differentials and vested interests (McLaughlin and Webster, 1998).

User experiences at micro level

The value of conceptually blending Rogers and Webster became particularly salient when analysing user experiences at micro level. Attributes significant for adoption were mainly relative speed, ease of use and reliability of the technology and ability to customise or

make it compatible with existing practices. PACS was perceived by many users as fast, easy to use and reliable. This contrasted with differing experiences between two Trusts in their use of different CPOE systems. In Trust 1 systems were perceived as easy to use and time-saving; in Trust 2 there was a slower rate of adoption and this was directly attributed to the system being hard to use and incompatible with existing practices:

for new members of staff [...] even with the best will in the world, for the first couple of weeks they are functioning at about fifty per cent of what somebody else is (Senior Clinician, Trust 2).

Even if the IT application had positive attributes there was resistance reported in the initial implementation stage. Some managers regarded clinical leaders as IT laggards:

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

However, this perception risked dismissing concerns expressed by some clinicians, discussed above, about the negative impact of IT applications on the quality of the clinician-patient relationship and clinician workloads (see de Pires *et al.*, 2012):

We'd still like to let that activity [test ordering] happen outside of the consulting room [...] Because we may be involved with [...] not only the patient, there's family members, there's sometimes a medical student or two in the room, you can be acting in a lot of levels and, you know, the consultation process can be a teaching process as well and it's not absolutely essential to take that time out to be doing this process (Consultant Physician, Trust 2).

This perception may point to a wider impact on working practices that merits further exploration, given that the workflow arising from the interface of clinician, patient and computer is of a unique complexity that calls for "deep customization" (Mandl and Kohane, 2012).

Clinicians were also apprehensive about the quality of digital vs plain film, for example in the imaging of bone injuries which had to date relied on the use of high resolution plain film. A PACS project manager (Trust 2) complained that orthopaedic consultants were being "awkward" and "traditional" in their preferences for plain film in such circumstances. Subsequent studies confirmed that digital imaging provides equally good grey-scale and image resolution as conventional radiography (Steinmetz *et al.*, 2009). Yet it would be an oversight to regard these consultants as "Luddites". Concerns need to be contextualised to be understood. Characteristics of adopters were not static but changed over time as IT innovations were implemented:

More recently [...] I really do value the place of information technology in the delivery of my care, but lots of clinicians regard it as an imposition because it makes them change the way they work (Medical Director, Trust 1).

Attributes of the application influenced how potential adopters perceived it and how willing they were to use the application (see also Pynoo *et al.*, 2012). Implementation at micro level was thus an interactive process (see also Fitzgerald *et al.*, 2002). Webster's attention to ways in which the micro level of practice is inscribed within the wider world provides insights into ways of further understanding how complexity, interdependence and fragmentation impacts within and between levels of a system. This is an instance where Webster's attention to discontinuities, as indicated in our study by four major hiatuses in implementation in Trusts 1 and 2 (Figure 1), in Trust 2 attributed to pressures from the centre, is a useful corrective to more conventional interpretations of events using Rogers.

Discussion

Our study sought to bring fresh insights to the analysis of implementation of IT innovations in healthcare at meso and micro levels, and of the dynamic interplay between these (see Robert *et al.*, 2010). It also sought to analyse the impact of the macro level, in this case a powerful influence on how implementation played out within the organisations studied. To achieve this, we decided to “blend” two theoretical approaches: DoIT (Rogers) and a sociological critique (Webster).

Systematic evaluation of Rogers’ DoIT shows that complexity, together with relative advantage and compatibility, is one of the three innovation attributes that are statistically significant in terms of their correlation with adoption (Kapoor *et al.*, 2014). The extent to which an innovation is more or less complex is a powerful determinant of adoption or non-adoption. Rogers (2003) defines complexity in technical terms, as “the degree to which an innovation is perceived as difficult to understand and use” (p. 250). If, however, we take into account organisational size and a corresponding environmental and systemic complexity then the situation may become less clear cut. Rogers contends that the larger the organisation the greater the putative impact on innovation adoption (see Terlaak and King, 2007), but evidence in relation to IT innovation adoption is mixed and inconsistent (Lee and Xia, 2006).

In our original analysis, we found that DoIT was useful only at certain levels of the system, and we needed to blend this with another concept, in this case Webster’s, to understand in particular the influence of the macro level. For example, applying DoIT concepts to the data indicated that the drive from the centre was highly effective in the initial “push” stages of adoption, in establishing awareness of IT innovation among potential adopters, persuading key players and promoting its relative advantage. On closer inspection, opinion differed about the value of a top-down, centralised approach in relation to implementation within organisations. Here, the application of Webster’s perspective offered finer-grained insights.

In our analysis of other levels and of dynamics between them we needed to look beyond DoIT concepts of attributes of innovation and decision-making of individuals; NPfIT was not just about adoption of specific technologies (like PACS) but was embedded into system-level dynamics. By applying Webster’s social matrix we sought to develop new theoretical depth, implicit in his approach.

DoIT enabled us to see why, overall, PACS was more successfully implemented in the trusts studied than CPOE, with those at meso level failing to engage those at micro level. PACS was more successful because its relative advantage at micro level was strong, overriding (except in Trust 2) any difficulties that arose in the fit between macro, meso and micro levels. This advantage was due in part to the technology for PACS being more “standalone” than CPOE, which has to become embedded in a much wider range of hospital practices and routines. Webster’s emphasis on the integration of technological innovation into the wider social body of practice might add depth to our understanding of the extent to which IT innovations co-evolved with professional practice, but it would not supplant a DoIT analysis entirely.

Our analysis lends support to the argument that DoIT remains a valuable framework for research when considering more finite and less “fuzzy” technologies, in terms of the clarity of both the system and its boundaries. Such an approach has been applied to healthcare, for example with magnetic resonance imaging scanning (Grigsby *et al.*, 2002) and polio vaccine (Nelson *et al.*, 2004). Common features of such innovations are their trialability and observability which lend them to rapid assessment of their

benefits, with early feedback available to potential adopters, so that adoption and implementation can be driven by this strong advantage. However, this type of scenario is often exceptional in the context of healthcare IT innovation, where innovations are often “fuzzy” and unbounded (Dopson and Fitzgerald, 2005); moving forward such innovations may be less commonplace, with any strong advantage hard to judge in advance. Moreover, our findings regarding CPOE implementation suggest that complex large-scale IT innovations in organisations subject to intense political scrutiny may be better understood through a blending of theoretical approaches of the type discussed here.

Webster’s (2007b) concepts were more helpful in critically understanding innovation adoption and implementation as co-constructed by a range of actors, institutions and policies, and the importance of studying their relative roles and relationships. He has cautioned that, while responsibility for new healthcare technologies can be to an extent shared across actors and networks, “co-construction is [...] never an equal process” (p. 465), given the power differentials, vested interests, distinctive responsibilities and remits of actors involved. The implementation (or not) of the innovations analysed here took place in a highly complex policy, regulatory and financial context. The interactions between the innovation and its attributes, adopter characteristics and contextual factors all influenced implementation outcomes (see Ferlie *et al.*, 2005).

Studying implementation of healthcare IT applications presents a number of challenges. Complicating factors include differing scales of programmes and multiple research traditions with diverse theoretical approaches and methodologies (Greenhalgh *et al.*, 2009). A single-perspective analytic tool, such as Rogers’, may be adequate for small-scale implementation programmes but misses critical properties when studying the implementation of innovations within larger, complex systems (Dattée and Barlow, 2010). Indeed, the observation of influences underpinning implementation may depend entirely on getting the level of scale correct, with clarity achieved only by including the broader meso or macro levels, and studying interactions over time. Theories may be needed that pay attention to all these levels, and by blending different theoretical approaches we can provide a better analysis of “technology in practice” (Timmermans and Berg, 2003). In response to our original research questions about understanding the how and the why of adoption and implementation of healthcare IT innovations, and the contribution of theory in elucidating the problems arising, we argue that the way forward may lie in blending useful tenets of DoIT with alternative, system-level approaches.

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