Can knowledge management enhance technology adoption in healthcare? A review of the literature

Iestyn Williams and Helen Dickinson

The rate of adoption of new technologies into healthcare systems is considered to be slower than in other settings. A range of knowledge-based facilitators of adoption exist, including: technology specification and assessment; dissemination tools (including electronic decision support tools); networks and facilitated interaction; and skills and leadership development. A review of the evidence relating to each of these is reported in this paper. The authors identify the absence of a single knowledge-related 'magic bullet' before proposing an analytical framework for the future assessment of knowledge-based interventions and their impact on technology adoption.

Introduction

It is frequently suggested that the routine and consistent adoption of innovative and cost-effective technologies is a prerequisite of a high-performing health service (Coyte and Holmes, 2007). Apart from improving the quality of healthcare services, procurement and implementation of technological innovations can play a key role in making patient care more flexible and responsive, and ensuring efficiency in the use of scarce public sector resources (Winkleman and Choo, 2003; Djellal and Gallouj, 2007). However, the rate of adoption of technology into healthcare practice is commonly considered to be poor (Sheldon et al, 2004; Black, 2006).

This paper reports on a review conducted in order to identify facilitators of technology adoption in healthcare. In particular, it addresses the relationship between knowledge-based initiatives and the adoption process, as previous work has suggested that if the knowledge required for an innovation's use can be codified and transferred from one context to another, it will be adopted more easily (O'Neill et al, 2002; Greenhalgh et al, 2004a). Indeed, the ability to effectively manage knowledge is increasingly seen as essential to modern healthcare systems seeking to deliver on both quality and efficiency expectations (Brailer, 1999). Drawing on empirical evidence, the paper therefore examines the evidence on knowledge-related strategies for overcoming barriers to technology adoption. Given the breadth of the field of technology adoption, before setting out the evidence in more detail, the paper begins by defining 'technology adoption' and 'knowledge management' and briefly summarises the main barriers to technology adoption.

Key words knowledge management • technology adoption • literature review • healthcare

Technology adoption

Technologies can take a variety of forms ranging from novel healthcare interventions (eg new products, procedures and pharmaceuticals) to the health-related application of information and communication technology (ICT) systems, to more generic change management prescriptions (eg models of service improvement). For the purposes of this paper, the term 'technology adoption' refers to *the processes involved in the successful introduction, implementation and spread of an innovation within a healthcare setting.*

Taken as a *process* (rather than an *event*), technology adoption can be seen to involve the full spectrum of actors across the commissioning and provision of healthcare including: policy decision makers; professional groups (physicians, nurses etc); managers and administrators; patients; and other stakeholders. Moreover, it takes place in a variety of organisational settings, including public, private and third sectors and the intersections between these. Some technology adoption is compulsory and mandated by central authority, while others are voluntary. Drawing on the concepts of Rogers (2003), Greenhalgh et al (2004a) provide useful distinctions between *diffusion* (passive spread) and *dissemination* (formal efforts to persuade target groups to adopt a technology), and go on to define *implementation* as active efforts to mainstream a technology's use, and *sustainability* as the routinising of use. It is evident in previous work that a variety of barriers can serve to hinder effective technology adoption. These range from characteristics of the technology itself, to organisational and institutional contexts.

Technology type

Although the results of some previous reviews have found little evidence that technology type is a major factor in rates of adoption (eg Heathfield, 2007), others have identified factors such as *usefulness* (in voluntary technology adoption) and *ease of use* (in mandatory technology adoption) as potentially influential in determining levels of adoption (Karsh, 2004). Factors such as the *radicalness* of the technology and the extent to which it possesses demonstrable *relative advantage* over current practices are also suggested as important (Rogers, 2003; Greenhalgh et al, 2004a). The degree of change implied to working roles and practices is also likely to affect patterns of resistance and acceptance (Karsh, 2004). However, these are not immutable technology properties, but rather are a function of the *compatibility* of the technology: that is, its fit with prevailing values, norms and ways of working (Denis et al, 2002).

Adopting individuals

At the level of the individual, cognitive capacities, attitudes and perceptions, and behaviour patterns can all inhibit adoption. The range and volume of information that healthcare professionals are required to manage have increased at a phenomenal rate, leading in some cases to a reported 'overload' (Clancy and Delaney, 2005). Furthermore, 'task uncertainty' (eg due to lack of information about the adoption process and what this entails) is likely to make adopters risk averse (Karsh, 2004). If individuals believe that their work will be adversely affected by the technology, or

if it is perceived to be difficult to implement, there is an increased likelihood that it will be rejected.

Systems and organisations

Individual behaviour is only one component of the diffusion of technologies and a number of aspects of organisational context have been found to influence adoption (Meijers et al, 2006). Although organisational context is understood in different ways by different research traditions (or most commonly not defined in a systematic sense at all), most agree that it is central to achieving change in line with best practice or evidence (Dopson, 2007). It is usually suggested that there needs to be a fit between the technology and the prevailing decision-making environment, as well as with: existing technologies; workflow; the environment; and other social systems (Karsh, 2004; Thompson et al, 2005; Williams et al, 2009a). Compatibility is also thought to be required at the systemic level. Greenhalgh et al (2004a: 604) summarise as follows:

> An organization will assimilate innovations more readily if it is large, mature, functionally differentiated (i.e., divided into semi-autonomous departments and units), and specialized, with foci of professional knowledge; if it has slack resources to channel into new projects; and if it has decentralized decision-making structures.… Size is almost certainly a proxy for other determinants, including slack resources and functional differentiation.

Path dependence at both organisational and institutional levels can be a powerful antidote to change. Once the system has 'locked onto' a specific path it is difficult, and potentially expensive, to change direction (Clancy and Delaney, 2005). As such, systems may have a tendency to continue to operate in a particular way, rather than adopting what might rationally seem a useful innovation to adopt.

Knowledge management

The term 'knowledge management', as applied in this paper, refers to any systematic process designed to 'acquire, conserve, organize, retrieve, display and distribute what is known' (Matheson, 1995: 74). Knowledge management interventions can be systems focused or people based, and include: the supply of evidence and information; transfer or dissemination of best practice; networks and communities of practice; development of information systems and decision tools; skills development; and sense making and story telling. Some knowledge management interventions are themselves 'technologies' including IT systems, and decision support software.

Zahra and George (2002) identify four stages (or dimensions) of knowledge management:

1. acquisition
2. assimilation
3. transformation
4. exploitation.

The first two dimensions encapsulate the need to access and interpret knowledge and the third and fourth refer to the process of rearticulating and applying knowledge within the local context. Furthermore, the literature suggests that the distinction between *explicit* and *tacit* knowledge is important to the analysis of change in healthcare organisations and in any prescription for effective knowledge management. Explicit knowledge can be codified in policies, procedures and other materials. However, tacit knowledge is difficult to codify and share because it is made up of the practical and experiential wisdom and expertise of individuals and therefore rarely exists in an externalised and formally articulated form. Moreover, its meaning is context dependent and so some understanding of context is required for tacit knowledge to 'make sense' and to be shared (Greenhalgh et al, 2004a).

Organisational knowledge is expanded and diffused through social interaction between tacit and explicit knowledge. This process involves both the transfer of explicit knowledge (eg through formal information channels and systems) and the sharing of tacit knowledge. Knowledge transfer and knowledge sharing are related but distinct concepts:

> Knowledge sharing is a more subtle concept, and is seen as a dual process of enquiring and contributing to knowledge through activities such as learning-by-observation, listening and asking, sharing ideas, giving advice, recognizing cues, and adopting patterns of behaviour. (Bosua and Scheepers, 2007: 95)

The main implication of the distinction between explicit and tacit knowledge (and between transfer and sharing) is that adoption requires prior recognition of the social nature of knowledge. Tacitly held knowledge can only be passed on through processes such as mentoring, shared experience and story telling. Knowledge transfer and sharing are reciprocally supportive processes and equally important to effective knowledge management (Söderquist, 2006). This implies the need for the presence of formal knowledge transfer systems alongside social relationships and broader organisational cultures that facilitate reciprocity in the exchange of tacit knowledge. This paper therefore sets out to identify the extent to which existing knowledge-related interventions have proven to be – and/or can reasonably be expected to be – successful in overcoming the range of barriers to technology adoption.

Methodology

Given the wide scope of topics for coverage, the authors decided to conduct a 'review of reviews' in the first instance, and then to drill down to the level of individual studies in areas where such reviews of the evidence were not forthcoming. This paper therefore provides a high-level mapping of the evidence, illustrating the main contours of this topic but not detail of the full range of tools that are available. A more detailed case-by-case comparison would require a lengthier and more technical analysis than is possible here. In order of priority, the review sought to identify the following contributions to the literature:

- systematic reviews of evidence in relevant areas;
- other reviews of empirical evidence;
- research studies as reported in peer-reviewed publications;
- selected prescriptive and/or methodological contributions.

General opinion pieces and detailed case studies of disease-specific interventions/devices – for example individual health technology assessments (HTAs) – were excluded. Selected opinion pieces are drawn on, notably in discussion of areas where evidence is in especially short supply – for example leadership development and networks. Any propositions based on this more discursive material are treated as speculative rather than definitive.

The review included documents dated 1999–2009 reported in the English language. To identify appropriate literature the research team undertook searches of academic and practitioner literature using health-related databases. HMIC, Medline and Embase were searched using combinations of the following terms:

Technology and ('adoption' or 'coverage' or 'implementation')
OR
Knowledge and ('management' or 'transfer' or 'sharing' or 'diffusion' or 'dissemination' or 'tacit' or 'explicit')
AND
Risk management* or
Research utilisation* or
Evidence-based practice or
Return on investment or
Cost and (effectiveness or benefit) or
Organisations or
Systems or
Culture or
Health care provision or
Health care procurement/commissioning or
Innovation or
Change management*

These terms were derived from an initial scoping of the extant literature. The authors recognise that use of the term 'technology' is more or less common depending on discipline and that, therefore, some areas of the literature may be underrepresented within the review. In-depth hand searching of especially relevant journals (eg *International Journal of Technology Assessment*; *Health Informatics*; *Journal of Healthcare Information Management*) was also undertaken. Finally, once relevant items had been obtained, bibliographies and reference lists were hand searched for any articles that may not have already been identified. Thus, at this point the search strategy took an iterative, snowballing approach.

Results

Initial yield from searches (once duplications had been removed) numbered approximately 3,000. These were sorted by the authors according to relevance and approximately 140 were accessed as full articles. These were categorised according to importance using the criteria set out above. Particular priority was given to reviews of the evidence and to empirical studies in areas where comprehensive reviews were in short supply. The majority of material identified was presented in health-related academic journals (reflecting the databases searched). There was a mixture of UK and international literature, with a noticeably strong current of work from the US. The extent of transferability of research from healthcare systems elsewhere is inevitably partial and this is reflected in claims made for the applicability of evidence throughout this paper. Despite the substantial volume of literature accessed, typically this covered subthemes rather than providing a more general survey of evidence on the relationship between knowledge-based interventions and technology adoption. This is perhaps not surprising given the frequent assertion that 'implementation research in healthcare is still in its infancy' (Fleuren et al, 2004: 120). As such, the literature is dominated by calls for more research and/or better-quality research design (eg Estabrooks et al, 2003; Ellis et al, 2005; Länsisalmi et al, 2006; Mitton et al, 2007).

Knowledge-related interventions

In order to compare findings across a diverse literature base and to facilitate closer analysis of the relative merits of knowledge-based interventions, the authors grouped the latter into five categories (see Box 1). However, it should be noted that this typology is offered for heuristic purposes and is not intended to imply the existence of wholly discrete areas of activity, as these categories of intervention are neither wholly distinct nor mutually exclusive. Indeed, many of these intervention types are designed to be complementary and/or mutually facilitating in their delivery. Other taxonomies of interventions (eg Grimshaw et al, 2004) extend to include 'audit and feedback', 'mass media' and 'marketing'. These are not discussed in detail here.

Box 1: Knowledge-related interventions

Technology specification and assessment: this category refers to the formal evidence base for a given technology. This includes published results of clinical trials, other research reports, systematic reviews of clinical evidence, and cost-effectiveness analysis. In particular, the focus is on *generation* rather than *dissemination* of this evidence.

Dissemination techniques: this category covers the range of non-ICT-based methods for the transfer of information about a given technology. Common examples of such strategies are the development of practice guidelines and the use of conferences or workshops to disseminate best practice in the adoption of technologies.

Electronic decision support tools: as with the previous category, this grouping relates to methods for increasing implementation of best practice in the adoption of interventions. In particular, it refers to ICT-based solutions. Clearly, these can be considered as 'technologies' in their own right. However, they are included here as knowledge-based interventions as their primary function is to impart information and guidance regarding the adoption of evidence-based practice.

Networks and facilitated interaction: this category covers a range of people-based interventions. In particular, it includes formal and informal arrangements for facilitating interaction and knowledge sharing between actors in the adoption process.

Skills and leadership development: this category is linked to the previous one and includes initiatives for increasing leadership, developing adoption 'champions' and the provision of training for implementers in the technology adoption process.

Technology specification and assessment

Technology specification can be generated through techniques such as systematic reviewing in HTA, which enables clinical evidence to be presented as specific solutions to policy problems (Mays et al, 2005). HTAs typically incorporate information relating to the efficacy, safety, ethics and costs of an intervention and can be seen as 'a means of implementing knowledge-based change within the healthcare system' (Lehoux et al, 2005: 609). Such methodologies can help bodies making technology adoption decisions deal with the uncertainties they face, for example in determining what the benefits and risks of a new technology are and what the financial implications for their patient population will be (Gelijns et al, 2005). The use of HTA has been a feature of healthcare systems of countries of the Organisation for Economic Co-operation and Development (OECD) since the 1990s (McDaid, 2001; Sorenson et al, 2008). There is a growing literature that examines the extent to which healthcare practice is informed by such evidence. More specifically, a number of studies and reviews have focused on the influence of HTA and/or economic evaluation on adoption decisions and implementation processes (Williams et al, 2008). Despite caveats, the empirical evidence base is therefore relatively strong in this area.

A number of clear messages can be distilled from this literature. Although clearly necessary, the generation of reports and evaluations is not sufficient in itself to promote adoption and is generally evaluated as having an unsatisfactory impact on healthcare organisation and practice (Drummond and Weatherly, 2000; Haines et al, 2004; Williams et al, 2008). Initiatives such as the Cochrane Collaboration have helped to compile a strong evidence base but, given the modest impact on practice, increased activity in this area cannot plausibly be seen as a solution to the problems of technology adoption. The literature suggests a number of reasons for this gap between evidence and practice. First, in a context of information overload, generation of more analyses can have an additive rather than a moderating effect on complexity and those involved in adoption (decision makers, clinicians, allied professionals and

patients) are unlikely to have sufficient data-processing and analysis skills to make full use of such analyses. Furthermore, studies suggest that research, as reported in journal publications, rarely provides the range of information required by adopters and implementers (Leeman et al, 2006). For example, formal reports of evidence and analysis are not traditionally accompanied by implementation guides and are not designed to draw on tacit as well as explicit knowledge. In other words, the model is one of knowledge *transfer* rather than knowledge *exchange*, and is subject to potentially inhibiting individual, organisational and system-level barriers. The establishment of the Cochrane Collaboration's Effective Practice and Organisation of Care (EPOC) group is a direct response to the lack of impact of such passive models of evidence dissemination (www.epoc.cochrane.org).

The call for evidence-based approaches in itself does not therefore constitute a blueprint for the way forward (Glasby and Beresford, 2006). Approaches to evidence-based technology adoption run the risk of being dominated by traditional research hierarchies at the expense of locally specific research, the tacit knowledge of frontline practitioners and the lived experience of people using services. These latter considerations are crucial to relevant and rigorous technology adoption practices (Williams et al, 2009). Overall, it is clear that proliferation of evidence alone is unlikely to yield positive results in the facilitation of technology adoption. In the words of Swinglehurst (2005: 199), 'The mere existence of evidence is not sufficient. To be effective, information needs must be translated into information seeking behaviour and then into information use, connecting information to real action which matters to patients'.

It has been suggested that less instrumentalist, top-down models of how to drive change are required that acknowledge the necessary reconstruction of evidence within the organisational context (Dopson, 2007). In as much as this category of intervention is valuable, therefore, it is likely to be so at the formal decision to adopt stage and less so in subsequent decision implementation phases.

Dissemination techniques

A number of reviews have addressed the broad topic of how to get evidence into practice (Innvaer et al, 2002; Lavis et al, 2003; Grimshaw et al, 2004, 2006; Mitton et al, 2007). Each of these emphasises the limitations or inconclusiveness of the evidence and as a result makes only tentative claims about the respective merits of interventions such as guidelines, information repositories, reminders, conferences and workshops, and educational outreach. Some support is offered by commentators for a more multifaceted approach incorporating combinations of these interventions (Solberg et al, 2000; Lavis et al, 2003; Chaillet et al, 2006) although this is disputed elsewhere (Grimshaw et al, 2004). However, the trade-off between extra benefit and additional cost is not well understood and it is not known which components of multifaceted interventions are the most effective (Davies, 2002). Within these options there is little support for either conferences, workshops, or educational outreach applied in isolation (Chaillet et al, 2006). Equivocal but more encouraging evidence exists of the benefits of clinical guidelines (Brailer, 1999; Cabana et al, 1999, Grimshaw et al, 2004). These

can be moderately effective in facilitating behaviour change among professional groups although return on investment is again rarely explored or demonstrated in the literature. However, the variation in reported impact on practice (and by deduction, practice in the area of technology adoption) suggests that positive results cannot be predicted irrespective of context.

Overall, then, the evidence of impact of dissemination techniques on adoption is weak. Such evidence as there is generally suggests only modest gains, although some evidence of increased impact of multiple over single dissemination tools is present. By focusing on practice, the advantages of guidelines and educational programmes over mere production of evidence are clear, if assisting with adoption is the primary aim. However, the literature suggests a number of possible explanations for the modest outputs. First, there is little facility for the exchange of tacit knowledge that may make a difference in encouraging technology adoption and addressing concerns over risk. Second, the development of dissemination tools does not in itself create incentives for adherence to these. This means that the success or otherwise of dissemination strategies remains dependent to a large extent on the receptiveness of individuals, organisations and broader systems (Solberg et al, 2000) as well as their ability to 'replicate' knowledge developed elsewhere so that it is relevant to local context (Landry et al, 2006). To be more effective, dissemination tools – notably guidelines – should reflect these factors in both their design and their implementation. They are therefore a potentially useful, but in themselves insufficient, driver of technology adoption (Grol, 2001).

Electronic decision support tools

ICT has been used to develop many aspects of knowledge management and dissemination. The range of electronic support for technology adoption includes electronic guidelines, medical informatics, decision support and reminder systems, and computer-based record keeping. Again, it is worth noting that these are ultimately overlapping categories. For example, decision tools have been defined as 'an active knowledge resource that uses patient data to generate case-specific advice which supports decision making about individual patients by health professionals, the patients themselves or others concerned about them' (Liu et al, 2006: screen 3).

As with the other interventions discussed in this paper, it is difficult to measure the impact of such tools given the complexity of organisational systems in which they are introduced. Despite this, there is some support for the claims that ICT-based systems offer improvements on previous paper-based systems (Tang et al, 1999) although Grimshaw et al (2004) found the impact of reminders to be moderate overall. There remains little evidence regarding return on investment beyond a general underperformance against manufacturer projections and a similar lack of measurement of patient benefit (Georgiou et al, 2007). What the evidence does indicate is that electronic access to clinical information has been found to save time and reminder systems have been shown to increase compliance with best practice in some instances. However, concerns remain over the quality and scope of information that can be disseminated in such ways (Erstad, 2003). As with traditional dissemination techniques, the literature consists of contrasting findings, which suggests that much depends on

the context into which electronic guidelines are introduced (Butzlaff et al, 2003), and again it is not clear that such interventions provide any additional support for the exchange of tacit knowledge.

There have been numerous instances of reportedly poor 'task-technology fit' in the application of electronic systems although it appears that newer designs are becoming more aligned to complex organisational settings (Kukafka, 2003; Clancy and Delaney, 2005; Liu et al, 2006, Yusof et al, 2007). It seems likely that use of ICT will expand in healthcare although, in the implementation phase, technological solutions to technology adoption will come up against many of the barriers they are designed to remove – as they are themselves of course technological innovations (Kukafka et al, 2003). For this reason, technical system changes cannot be designed in isolation of the social and professional environment in which they are to be implemented (Karsh, 2004). Determining the optimal scale and scope of introduction and ensuring sufficient technological infrastructure remain key challenges to the successful use of these interventions and, in themselves, they do not overcome issues of incentives, organisational culture and inter-professional divisions. Until better information can be obtained, concerns also remain over issues of cost-effectiveness and data protection. However, electronic support for decision makers and implementers is likely to be crucial in facilitating a range of other resources, including 'virtual communities', e-libraries and in-house information access (Akesson et al, 2007).

Networks and facilitated interaction

An area that is relatively unexplored in the literature is the use of facilitated interaction outside of traditional organisational structures (Grimshaw et al, 2004). This is despite the observation by Greenhalgh et al (2004a: 601) that 'interpersonal influence through social networks … is the dominant mechanism for diffusion'. For the purposes of this discussion, the term 'networks' is used to encompass a substantial range of types, including clinical networks, inter-organisational networks, and networks of technology producers, researchers and users. Network approaches are based on a relationship model of translation, which assumes that the 'key … processes are interpersonal and involve social relationships; and that translation partnerships are most successful if they are collaborative' (Estabrooks and Glasgow, 2006: 51). Thus, the focus is on the ways in which people work together in pursuit of common aims through networks or 'communities of practice' (Lave and Wenger, 1991). Greenhalgh et al (2004a, 2004b) note that inter-professional and inter-organisational networks can help to facilitate the development of shared meanings in relation to technology innovations. Decisions to actively adopt technologies can be triggered by the knowledge that similar organisations have previously done so (although the converse is also true and such processes may impede adoption). The more 'cosmopolitan' (externally networked) an organisation is, the more likely this influence will take place across organisational boundaries.

A number of studies have indicated that social interaction is a key catalyst of change management and best practice dissemination (eg Fitzgerald et al, 2002; Grol and Wensing, 2004). Direct interaction permits 'exchange' as well as 'transfer' of

knowledge and opens up the possibility of internalisation of explicit knowledge and the sharing of tacit knowledge. Direct interaction can also facilitate other knowledge management interventions (such as traditional knowledge transfer, team building and sharing best practice). An interactive approach acknowledges the need for evidence to be reconstructed into usable information in the implementation environment and for the meaning of the technology to be discussed and understood (Bate, 2004). This form of sense making within a specific organisational context promotes the importance of sufficiency and plausibility alongside traditional notions of scientific accuracy and formal evidence of benefit. From this perspective, successful adoption depends on individuals' capacity to buy into a changed organisational narrative with each innovation that is introduced (Peck and Dickinson, 2008).

Interaction within and across formal boundaries is dependent on compatible performance management structures and incentives. Evidence suggests that it also requires a prior history of collaboration and the presence of leaders/champions to enable formal hierarchies and professional divisions to be circumvented (Greenhalgh et al, 2004b).

One key distinction made in network types is between horizontal and vertical forms. Different professional groups are associated with different network types, with doctors more likely to inhabit horizontal networks and nurses more often subject to formal, vertical networks (Williams et al, 2009). While vertical networks are likely to be relatively effective for transferring explicit, codified knowledge about technologies, horizontal networks are more effective in 'spreading peer influence and supporting the construction and reframing of meaning' (Greenhalgh et al, 2004a: 18). However, this is not the only distinction made in terms of network types; Goodwin et al (2004) identify a range of different types of networks, each of which have their own characteristics in terms of goals, management structures and ideals. Of those identified by Goodwin et al, the types most pertinent to this review are learning and problem-solving networks. Learning networks seem to be of obvious interest given that learning is likely to be a key driver of technology adoption through the ongoing incorporation of shared tacit and explicit knowledge into practice. Problem solving is differentiated from learning as this refers to addressing time-limited issues as they arise. Problem-solving and learning networks are linked predominantly by their institutions, which have a vested interest in a particular area. This is important because it is not only individual ties between people that sustain such networks, which means that in theory they should be less vulnerable to collapse when key individuals move on.

Depending on how clearly the 'problem' of technology adoption can be defined, it is conceivable that a community of implementers can be brought together with the specific aim of facilitating an individual instance of adoption. Similarly, such networks might lie dormant until such time as an adoption challenge is faced and then be reactivated in order that the relevant experience, information and expertise can be brought to bear. However, networks for technology adoption also benefit from an ongoing commitment to shared learning through iterative interaction of both facilitated and informal varieties. In the English National Health Service (NHS), numerous 'collaboratives' have been established over the past 10 years in order to facilitate service improvement. However, it has transpired that this model

is vulnerable in several key respects. Bate et al (2002) conclude that these networks are too bureaucratic in their design and do not enable communities of practice to arise who would have been more adept at sharing tacit knowledge. McLeod (2005: 264) points to 'the consequences of the model's short timescale, explicitly aiming to promote change rapidly by attempting to create the initial "tension for change" (or "tipping point") without recourse to potentially time-consuming activity to establish "proof" of the need for change'.

The collaboratives example also illustrates another important lesson: networks will not be successful if they are presented as purely structural solutions to the problems of technology adoption. Hierarchical models for the implementation of technology adoption are insufficient and the rationale for a networked community approach is that participation is to some extent voluntary – raising the question of incentives to involvement. In the long run, it is hoped that professional groups engage as they see that the costs of not being involved could potentially outweigh the costs of being involved. However, even where issues of incentives are addressed, professional and cultural barriers still need to be overcome.

Another form of network identified by Goodwin et al (2004) is the information-sharing network. Unlike problem-solving and learning networks, information-sharing networks are linked by their members, which means that there is usually some incentive for involvement but this does not necessarily make them easy to maintain. Sermeus et al (2001) examine the network of hospitals known as the Belgian–Dutch Clinical Pathway Network where membership had to be sustained by continuous efforts in persuasion. Similarly, a study on Project CHAIN (Community Health Alliances through Integrated Networks), a university-supported information network around improving quality of life for older people in South Wales, suggests that without mandatory membership and lacking any well pre-defined output, even developing protocols for coordination in community-based medication required extensive work to stabilise the membership and negotiate with powerful and sometimes mutually suspicious professions (Warner et al, 2003).

Peck and Dickinson (2008) suggest that it is imperative that the purpose of the proposed network is established at the outset. Once this is clarified, informed decisions about membership and involvement can be addressed. Of potentially crucial importance to networks for technology adoption is the involvement of a combination of the following: experienced 'adopters'; those involved in production of technological innovation; and those responsible for generating an evidence base around new and existing technologies. For more complex innovations it is likely that an inter-organisational network will be helpful for successful adoption (Williams et al, 2009a) but collaboration is more difficult to sustain when crossing organisational boundaries (Burnett et al, 2005; Kümpers et al, 2006). The constraints on collaborative working should be taken into account when considering membership of networks: there is an inevitable trade-off between ambition and pragmatism and the challenge of building and sustaining networks increases as membership becomes more multilayered and diffuse.

Skills and leadership development

The concept of leadership as a driver of improvement is presently proving very popular within policy-making circles. The UK government's Performance and Innovation Unit (PIU, 2001: 11) has not been alone in calling for 'highly effective leadership and a requirement for new leadership skills' within the public sector. In the UK NHS, the concept of effective leadership has predominantly taken the form of transformational leadership. Thus, as Lawler (2004) suggests, the assumption is often made that leadership is desirable, that people will welcome it and that it is unequivocally a 'good thing' and an interest in leadership is also reflected throughout much of the network literature. For example, Bardach's (1998) analysis of a number of case studies led him to suggest that 'effective' leadership is important for network success and such claims are also made in a range of other areas of this literature. Much of the technology adoption literature similarly makes strong claims for the role of leaders or 'champions' to be involved in the process of technology adoption (Shapiro and Devlin, 2000; Leeman et al, 2006; Bodenheimer, 2007). However, Bardach is not able to demonstrate the different conditions within networks for the efficacy of using each type of his identified approaches to leadership. Moreover, it is not always clear from the literature what the ideal forms of leadership should be within different network types (eg dispersed or centralised).

Given the importance ascribed to leadership processes, however, and the current popularity of the concept of 'dispersed leadership' through networks, leadership development programmes have been seen as a potential way in which to facilitate technology adoption. What network approaches suggest is that not only executive leaders are important in the process of decision making for technology adoption. Thinking in terms of networks for technology adoption, rather than hierarchies, requires the involvement of a large number of people at all levels of the organisation, not just those in formal positions of authority (Woolnough and Faugier, 2002; Hewison and Griffiths, 2004). This is further reinforced by Ferlie and Shortell (2001: 291–2) who state: 'we believe that sole reliance on the charismatic individual as a source of leadership is a mistake, especially in multiple-stakeholder-based systems such as healthcare, where different groups may expect different management styles'.

Notions of collective leadership and team leadership seem to be crucial to engagement in change programmes. It is suggested that by acting together, formal and informal leaders work to engage all members of healthcare teams in ongoing improvement processes. Therefore, networks are thought to be effective where they are able to engage a range of staff members at all levels through a process of collective leadership. Research into 'clinical microsystems' suggests that in most high-performing units within organisations there is not a single leader, but two or three co-leaders (Batalden et al, 2003; Williams et al, 2009a). For example, this coalition may take the form of a physician leader, a nurse leader and/or an administrative leader. Leadership at the very top level is not sufficient and middle managers and clinical managers specifically are imperative in leading reform through social processes.

As suggested above, the evidence underpinning the contribution that leadership makes to processes such as technology adoption is not fully understood (Peck and Dickinson, 2008) yet it is frequently identified as a crucial factor within the literature.

This may potentially reinforce Gemmill and Oakley's (1992) argument that leadership might, in fact, be a 'social fiction'; that is, because leadership is increasingly seen as unquestionably crucial to effective adoption, then one of the causal factors of effective adoption must be leadership.

Furthermore, as much of the evidence presented in this paper has suggested, technology adoption is a social and relational process, rather than being associated solely with individual behaviour. Thus, leadership development programmes for technology adoption should incorporate this facet. Yet, Day (2000) suggests that leadership development has traditionally been conceptualised as the nurturance of individual skill. This is problematic as it fails to take into account 50 years of research, which illustrates that leadership is a complex interaction between a particular designated leader and the social and organisational environment (eg Fiedler, 1996). Day suggests that given this focus on the individual level, much leadership training and development has actually, in fact, been *leader* development. That is, it has invested in the human capital of particular individuals but has failed to develop the leader*ship* capacity of an organisation – or, its social capital. Day suggests that while leadership development is orientated towards such social capital and emphasises reciprocity, trust and respect, leader development is orientated towards human capital and emphasises the development of 'individual capabilities such as those related to self-awareness, self-regulation, and self-motivation that serve as the foundation of intrapersonal competence' (Day, 2000: 605). Given this focus, leadership development programmes may not be entirely successful in enhancing technology adoption processes. However, it is difficult to be unequivocal about the efficacy of such programmes as there is very little empirical evidence linking leadership development programmes and outcomes generally – let alone in this area specifically. Thus, while leadership might act as a significant trigger for tacit knowledge exchange – thereby increasing absorptive capacity – this requires a clearer understanding of optimal leadership forms than is currently available within the technology adoption literature.

A related intervention is the formal development of adoption-specific roles through training and education. Again there is little published evidence of the benefits of such interventions despite some support in small-scale studies (Burnett et al, 2005). Although it seems likely that improving the information capacity of implementing organisations will help to overcome some of the current barriers to information access, interpretation and evaluation of technology outputs, this has yet to be fully demonstrated. However, well-designed training programmes have been shown to promote end user acceptance of technology through both improved understanding and increased feeling of involvement in decision making (Karsh, 2004). Davidoff and Florance (2000) argue for the 'informationist' – a professional with an understanding of both information science and clinical work in supporting decisions around adoption of specific interventions.

Discussion and conclusions

The evidence base

As demonstrated throughout this paper, the authors experienced a number of difficulties in conducting the review reported here. Although the literature contains some insights into the topic, very little focuses explicitly on the relationship between knowledge management and technology adoption. Therefore, while there is some direct evidence relating to the influence of technology assessment and clinical guidelines on technology adoption, there are major gaps with regard to the impact of networks and leadership development. These sections of the paper have thus relied to a greater extent on extrapolation from related research fields. The review therefore supports the argument for ongoing empirical investigation in these areas.

Overall, there is a particular shortage of data relating to the *efficiency* of knowledge management interventions. The tenuous link between intervention and observed outcomes makes return on investment difficult to measure and this is compounded by an absence of explicit incorporation of cost-effectiveness considerations within implementation studies. The related issue of disinvestment in, or disengagement of, existing technologies is also relatively under-investigated. Typically, newly introduced technologies do not replace older technologies at a ratio of 1:1 (Clancy and Delaney, 2005). This means that introduction of new technologies adds to both complexity and cost. There is a similar lack of clarity regarding knowledge management and risk, and the benefits of knowledge management in reducing perceptions of risk tend to be assumed rather than demonstrated in the literature.

Despite these limitations, calls for improvements to the evidence base should be tempered by an acknowledgement of the difficulties that this involves. As illustrated in this paper, gaps in knowledge reflect the difficulty of generating an evidence base in this area and it is likely that this is not simply reflective of the fact that knowledge-based interventions are not effective (this is not an uncommon observation when seeking to evaluate healthcare interventions – see Dickinson, 2008). The review supports the argument that healthcare settings are characterised by complex systems with 'nonlinear interactive components, emergent phenomena, continuous and discontinuous change, and unpredictable outcomes' (Zimmerman et al, 1998: 263), and that therefore the impact of interventions cannot be fully predicted and will not be the same in different settings. As Dopson (2007: 75) suggests, 'acknowledging that unplanned outcomes always occur is important in understanding the process of knowledge translation'. This requires implementation to include adaption (as well as adoption) to local circumstances and suggests that linear models of evidence-based practice are of limited value.

Connecting knowledge and adoption

The review also suggests the need for theoretical development, including:

- further specification of the categories (or types) of knowledge intervention – the typology developed here is descriptive and, as such, may not survive incorporation and scrutiny of the full range of possible knowledge-related activity;
- mapping of Zahra and George's (2002) stages of knowledge management (acquisition, assimilation, transformation and exploitation) against the subcategories of adoption (decision, implementation and routinisation);
- structured assessment of interventions according to their facilitation of both tacit and explicit knowledge exchange.

Table 1 considers the potential of each of the four intervention types to address these multiple dimensions of both knowledge management and technology adoption. The assessments included here are subject to the disclaimers relating to gaps in the evidence described above. Therefore, such value as this framework has may lie predominantly in helping to develop a more theoretically robust framework for categorising and analysing knowledge-based facilitators of technology adoption.

Useful knowledge

Although this paper is partial in its conclusions, it nevertheless confirms a number of specific implications for those responsible for technology production and adoption. For example, the formal evidence base for technologies could usefully incorporate implementation concerns and the provision of tools for adopters could be embedded into the technology design process. The review also underlines the importance of involving end users (taken to include practitioners, service users and the public) in technology design and implementation and the encouragement of sense making. The latter can be facilitated by making available multiple opportunities for reflection and learning at all levels of the organisation and system (Williams et al, 2009). Key questions to ask prior to the introduction of new technologies are: What is the 'value added' of the innovation? Is it easily evident to those who carry it out as well as to those for whose benefit the innovations have been introduced? Can the added value be demonstrated? (Luo et al, 2006). Overall, investment should be targeted towards multi-level tools and frameworks for technology adoption thatinclude enhancing 'absorptive capacity' and the exchange of tacit knowledge within their primary focus.

An overwhelming message from the literature relating to knowledge management interventions is that 'it is the interaction among the innovation, the intended adopter(s), and a particular context that determines the adoption rate' (Greenhalgh et al, 2004a: 598). In relation to knowledge-based interventions, this requires organisations to give primacy to the context of implementation and in particular its 'absorptive capacity' – that is, the extent to which it is able to identify, assimilate, share, re-codify and act on new knowledge (Zahra and George, 2002). The review suggests that facilitated interaction – perhaps via networks and specific forms of leadership development – can aid this process. Alongside the development of technology adoption training and

programmes for nurturing adoption champions, such arrangements appear to offer the potential for greater exchange of tacit knowledge. Overall, interventions to improve knowledge adoption must start from the premise that there is no single knowledge-related 'magic bullet' and that receptive contexts are a prerequisite of effective practice.

Table 1: Assessing knowledge-related facilitators of adoption

	Explicit and tacit knowledge	Acquisition/ assimilation	Transformation/ exploitation	Adoption phase supported
Technology specification	Adds to bank of codified knowledge without addressing tacit knowledge exchange	Aids access to formal evidence base	Adds little to application of knowledge to local context	Formal decision to adopt
Dissemination techniques	Tend to adopt a knowledge transfer (as opposed to exchange) model	Designed to increase acquisition and assimilation of knowledge but without sensitivity to implementation context	Modest contribution to the application of knowledge to local contexts	Implementation
Electronic decision support tools	Adopt a knowledge transfer (as opposed to exchange) model	Designed to increase acquisition and assimilation of knowledge but without sensitivity to implementation context	To date, modest contribution to the application of knowledge to local contexts	Implementation
Networks and facilitated interaction	When effective, can promote exchange of tacit knowledge	Can be tools for the dissemination and rearticulation of evidence in local contexts	May be important in bringing change and improvement into being	Implementation and routinisation
Skills and leadership development	Some leadership forms may facilitate network development, thereby increasing tacit knowledge exchange	Adoption champions and 'informationists' can help facilitate access to (and interpretation of) knowledge	As 'sense makers', leaders can be important in facilitating organisational change	Implementation and routinisation

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Iestyn Williams (i.p.williams@bham.ac.uk),
Helen Dickinson,
Health Services Management Centre, University of Birmingham, UK