Review

Adopting and assimilating new non-pharmaceutical technologies into health care: a systematic review

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Objective: To explore what is known about organizational processes that determine whether (and the extent and rate at which) new non-pharmaceutical technologies are adopted and assimilated into routine health care.

Methods: Electronic searching of four databases, hand searching of six journals and electronic citation tracking searches of three key research papers. A narrative synthesis was conducted.

Results: Ninety-nine empirical studies and seven narrative overviews informed the findings. The majority (62%) of the studies took a deterministic approach (mainly using cross-sectional mailed questionnaires) and typically studied the impact of organizational variables – such as organizational size – on the rate of adoption of technological innovations. The remaining studies were process-based using a single- or multi-case study approach. The organizational processes that determine whether and how technological innovations are adopted and assimilated into routine health care practice are dependent upon the specific innovation concerned, the different actors involved at various points in time, and the particular organizational context in which decisions are made. It is important to see 'adoption' and 'assimilation' as part of an ongoing process rather than discrete events, and as a process that comprises both 'formal' organizational and 'informal' decisions by individual users (the latter often shaped by discussions with their peers and colleagues).

Conclusions: Further process-based studies are needed to provide a clearer evidence base for recommendations on how to facilitate the adoption and assimilation of beneficial new technologies. Three theoretical perspectives could form the basis of such studies and produce practical advice for managers and practitioners.

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Introduction

Policymakers' attempts to improve the efficiency and quality of health care frequently include advocating the need to encourage and reward innovation,[1] and to accelerate the adoption of innovations through, for example, actions to 'simplify the pathway by which they pass from development into wider use, and develop ways to benchmark and monitor uptake'.[2] Concern at the slow adoption and use of beneficial technological innovations in healthcare systems[3] has led to a

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range of policy tools being implemented in different countries, although technological innovation is not in and of itself necessarily beneficial and 'adoption before efficacy has been proven may waste resources and harm patients'.[4]

There is no shortage of high level, policy-focused commentaries relating to technology adoption in health care systems. Broadly similar recommendations emerge from each; for example, specifying ways to strengthen the partnership between the health care systems and health technology industries. In England, this has led to the establishment of an NHS National Innovation Centre and an NHS Technology Adoption Centre whose aims include to increase the uptake of new technology in all areas of the NHS. But such reviews of macro-level policies[5–7] and comparative studies of the 'management' of health technologies[8–10] have not attempted to systematically

explore the processes within health care organizations that influence not only the (often mandated) adoption and implementation of technological innovations but also their assimilation into routine practice.

The aim of this systematic review was to explore in more detail what is known about which organizational factors and processes influence whether (and the extent and rate at which) technological innovations are adopted and assimilated within healthcare organizations in a specific national context (the NHS in England). We define 'technological innovation' as 'a device, procedure or organizational support system that is perceived as new by a proportion of key stakeholders in a healthcare organization, discontinuous with previous practice and which is intentionally introduced and directed at improving health outcomes'. At the request of the funding organization, this review explicitly excludes studies of pharmaceuticals, innovations in organization and delivery, the adoption of guidelines, and the implementation of quality improvement programmes.

A previously published, broader review of the diffusion of innovations in health care organizations has indicated a large, diverse and complex literature.[11] In addition to summarizing earlier work on the influences on individual adoption (e.g. the attributes of the innovation itself and social influence from opinion leaders), our earlier review identified a number of organizational influences, including organization-level antecedents for innovation in general (for example, decentralized decision-making structures), and (b) factors associated with an organization's readiness for a specific innovation (for example, power balances between supporters of an innovation and any opponents). These antecedents and factors encompassed both structural influences (e.g. extent of specialization within the organization) and non-structural ones (e.g. organizational culture, climate for risk-taking and the knowledge and skills base of organizational members). However, the review also found that empirical research has generally been restricted to a single level of analysis (individual or team or organization or inter-organizational); has implicitly or explicitly assumed simple causal relationships between variables; has failed to address important interactions between different levels (for example, how different organizational settings moderate individual behaviour and decision-making); and has failed to take due account of contingent and contextual issues.

Establishing what we know – and do not know – about the formal and informal processes internal to health care organizations that affect the speed and success with which beneficial technological innovations become part of day-to-day clinical practice is the focus of this review.

Methods

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

Search strategy

The approach to searching was guided by an earlier review of the broader literature on the diffusion of innovations in healthcare organizations which showed that in reviews of complex and heterogeneous evidence (such as the case here) formal protocol-driven search strategies may fail to find important evidence.[11,12] Rather, informal approaches such as browsing and being alert to serendipitous discovery can substantially increase the yield and efficiency of search efforts. Other methods – such as pursuing references of references and electronic citation tracking are especially powerful for identifying high quality sources in obscure locations.[12]

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

Previously the yield from hand searching of biomedical journals for articles relating to the diffusion of innovations was disappointing;[12] we therefore focused on organization and management journals. The lead researcher (GR) hand searched the following six key journals:

- *British Journal of Management*;
- *Journal of Organizational Behaviour*;
- *Organizational Science*;
- *Administrative Sciences Quarterly*;
- *Organizational Studies*;
- *Human Relations*.

In addition, we conducted an on-line search of the *Academy of Management* journals and proceedings database using key search terms.

Electronic citation tracking of papers that had been identified as likely to be 'seminal' had previously provided a significant number of valid and relevant hits.[12] We therefore undertook electronic citation tracking using the ISI Web of Knowledge Citation Indexes to search through articles citing what we identified as three key research papers.[13–15]

Inclusion and exclusion criteria

We used a simple, semi-structured checklist to guide our judgement and exclude references that were unlikely to add value (Boxes 1 and 2). At the first sift we excluded non-relevant primary studies that were: set in the non-healthcare sector; focused on a pharmaceutical technology; focused on an organizational innovation (as opposed to a technological innovation); not about either the process of adoption, implementation and/or assimilation; and only about individual adopter/user characteristics (i.e. non-organizational). Papers that were relevant but that did not go beyond superficial description or commentary were also excluded.
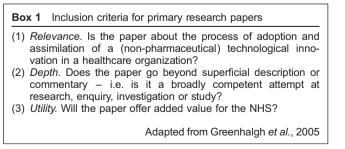
The contribution from different sources to our findings is summarized in Figure 1. Having browsed a total of 817 titles/abstracts we pulled 233 references of which 106 contributed to the findings (i.e. 127 were appraised and then excluded for at least one of the reasons listed above):

Appraisal and synthesis

The data extraction form used for appraising the 106 references in this review is available in the full report of this review.[16] In terms of synthesizing our findings, Slappendel helpfully maps out the literature on innovation in organizations in terms of three theoretical perspectives[17] (Table 1).

These are conventionally referred to in the literature as the individualist perspective, the structuralist perspective, and the interactive process perspective; the first two of these perspectives take a largely deterministic approach. Table 1 provides an overview of the three perspectives (the perspectives are shown in an order that reflects their historical development and relative influence) and provides a framework for understanding the key theoretical and methodological differences that are evident within this field.

Deterministic approaches have been influential in developing knowledge of innovations, adopters (i.e. people who adopt innovations), and diffusion of innovations. However, such approaches have been criticized for being decontextualized and unilevel, focusing on the search for causal relationships between a few variables,

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Box 1 Inclusion criteria for primary research papers

(1) *Relevance.* Is the paper about the process of adoption and assimilation of a (non-pharmaceutical) technological innovation in a healthcare organization?
(2) *Depth.* Does the paper go beyond superficial description or commentary – i.e. is it a broadly competent attempt at research, enquiry, investigation or study?
(3) *Utility.* Will the paper offer added value for the NHS?

Adapted from Greenhalgh *et al.*, 2005

Box 2 Inclusion criteria for theoretical papers and reviews

(1) Is the paper part of a recognized research tradition – i.e. does it draw critically and comprehensively upon an existing body of knowledge and attempt to further that body of knowledge?
(2) Does the paper make an original and scholarly contribution to research into the adoption and assimilation of (non-pharmaceutical) technological innovations in a healthcare organization?
(3) If more than 3 years old, has the paper subsequently been cited as a seminal contribution by respected researchers in that tradition?

Adapted from Greenhalgh *et al.*, 2005

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playing down relationships between different variables at micro and macro levels and – in endeavouring to achieve generalizability – usually stripping away important contingent influences.[11]

The predominant description of the adoption and assimilation of a new technology as a rational-linear process has been the subject of criticism for some decades.[18] Wolfe, for example, argued back in 1994 that highly generic and linear models of diffusion lack empirical validity;[19] Dopson *et al.* showed that innovation in healthcare organizations in relation to evidence-based practice occurs via a series of 'interlocking interactions',[20] and Van de Ven demonstrated that large-scale innovation in organizations is a non-linear process characterized by shocks, setbacks and surprises.[21] These earlier critiques alluded to technological innovations, but did not focus specifically on these. Arguably, the challenge to contemporary researchers of technology-based innovation remains that of exploring further the complex, context-sensitive nature of the innovation process in much greater depth.[22] Importantly, scholars favouring a more processual view of innovation have sought to reframe the notion of 'causality':

Using qualitative investigative or process-type methods may appear to be taking a wrecking ball to the edifice of
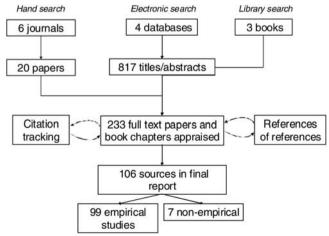

Figure 1 Result of literature search

Table 1 Three theoretical perspectives on innovation in organizations

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

Adapted from Slappendel, 1996

scientifically rigorous academic intervention research. In some academic circles, the premium placed on being 'right' appears so high that there is little room for speculation and imagination. It would be a mistake for academic . . . health researchers to be so focused on technique that they miss key variables and relationships related to effective implementation of new treatments . . . . The process of implementation is rarely linear, and understanding it involves more than administering a survey pre- and post-implementation interventions.[23]

We drew on the distinction between determinist and processual perspectives in the framework in Table 1 above to help synthesize the results of our review in the next section. Our rationale for presenting the findings in this way is twofold. Firstly, although large numbers of deterministic studies have helped to generate hypotheses relating to the adoption and assimilation of technological innovations in healthcare organizations, if we are to seek to make detailed recommendations to policy makers and practitioners as to how to facilitate the introduction of beneficial technologies – the explicit purpose of this review – then we must look mainly to the relatively limited number of rich, in-depth case studies for guidance. Of particular relevance to this review is the increasing attention being paid to the political, social and cultural characteristics of organizations as important forces shaping the adoption and assimilation of innovations. Secondly, of particular value in developing such guidance is the evidence-base derived from studies undertaken in the specific national context to which the findings will be applied. Our justification for prioritizing NHS-based studies is that research evidence shows that there are obstacles in translating practices from one system to another when there are important factors (for

example, the extent to which the locus of decision-making is centralized, or the nature and extent of 'insurance' coverage) that operate differently in each system.[24,25] Comparative studies of technology diffusion in different health care systems suggest that there is a high likelihood of national differences in the processes by which adoption and assimilation of technological innovations occur.[26]

Results

Nature of the evidence

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

Summary of findings

None of the five meta-analyses[27–31] we reviewed were exclusively focused on the adoption of technological innovations in health care organizations and most made no specific reference to the healthcare context at all. These studies are included in our full report[16] as their findings raised hypotheses which have informed

later, more qualitative and process-based, research undertaken in the healthcare sector.

Of the seven systematic reviews[32–33] relevant to our research objective, two were particularly wide-ranging in scope and applied to healthcare organizations,[32–38] albeit with significant differences in focus to this review. Both confirmed the importance of paying attention not only to (a) pre-existing conditions that encourage innovation adoption generally, but also to (b) interventions and conditions that facilitate the adoption and assimilation of specific innovations into an organization at a certain point in time. These two reviews also confirm the largely atheoretical nature of the vast majority of adoption research in healthcare to date; research which has also largely taken the 'adoption' decision as a discrete event and the primary outcome measure of interest, ignoring how and why 'adopted' innovations are thereafter assimilated into routine clinical practice.

The 10 NHS-based processual studies[22,39–47] are important to increasing our understanding of why and how technological innovations are adopted and assimilated in the specific context of NHS healthcare organizations. As one of the studies[22] suggests, in a healthcare context characterized by complexity with multiple stakeholders and decision 'points', a far greater importance needs to be placed in the interactions between groups than previous (largely non-healthcare based) literature predicts. The overall findings of these 10 studies highlight:

- That there is often no single adoption decision;
- The importance of the history, culture and quality of interprofessional relationships;
- The vital role of power and politics in determining the outcome of decision-making processes relating to innovation adoption and assimilation;
- The impact of different types of formal and informal decision-making processes (and that a short-term perspective typically predominates);
- That social influence on potential adopters of technologies within an organization is generally more complex and dynamic than the effect of one or two 'opinion leaders' or 'boundary spanners';
- That professionalism can be a negative influence (i.e. the existence of many different professional groups in healthcare – each with a different perspective, evidence and knowledge base, and skill set – can act as a barrier to the rapid and widespread adoption and assimilation of a beneficial innovation).

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

We also reviewed 54 studies whose approach was broadly deterministic – that is, which assumed the existence of 'determinants' and set out to characterize these (2 in the NHS and 52 from other healthcare systems). Typically, such studies undertake a large scale (usually postal) questionnaire survey of 2–4 key decision-makers in health care organizations. The focus of the studies varies but is most commonly placed on establishing which organizational factors influence adoption (for example, size or extent of decentralization of decision-making), although a small minority take a more practice-oriented perspective and seek to develop tools and frameworks for practitioners to apply in their organizational settings. Relevant findings for this review are that:

- Senior clinicians are key decision-makers, thus supporting the relative importance of the 'medical-individualistic' system of decision-making[13] along with the political nature of these processes;
- The dynamics between the internal decision-making structures of an organization and its relationships with its external environment (for example, external networks).

Two key messages emerge from the findings from the 99 empirical studies we included in our review:

- The different influences on innovation adoption and assimilation interact in a complex way and the importance of these interactions varies depending upon the specific innovation concerned, the different actors involved in the various stages of an innovations adoption and assimilation into routine practice, and the particular organizational context, systems and processes in which 'formal' and 'informal' adoption decisions are made;
- In order to realize (and study) the potential benefits to patient care of technological innovations it is important to see 'adoption' as a process rather than as a discrete event, and as a process that comprises both 'formal' organizational decisions and a series of 'informal' decisions by individual users – shaped by discussions with their peers and colleagues – which ultimately leads to the assimilation of the innovation into routine practice (or not).

Discussion

Recognizing the limitations of much of the existing empirical literature for making recommendations to practitioners, we note the promising but, as yet, relatively untested, normalization process model[48] which

is closely related to the concept of assimilation used in this review. This model comprises four components: interactional workability (which in terms of this review asks: does the innovation fit with the micro-environment of the clinical encounter?); relational integration (does it fit with the network of relationships within which the clinical encounter sits, and especially, how does it impact on issues such as interpersonal trust?); skill set workability (does it fit with the formal and informal division of labour between staff?) and contextual integration (does the organization understand the innovation and agree to allocate material and human resources to its implementation?).

Below we also offer three examples of a 'technology-in-practice' approach to the assimilation (or 'normalization') of new technologies which if applied in future innovation studies could also potentially offer further insights into the process of innovation adoption and assimilation in healthcare organizations, both in the NHS and other health care systems. They have in common the use of naturalistic, ethnographic methods to study practice, and an interpretive, reflexive approach to analysis. All originated in the 1980s or early 1990s and have developed rapidly in the past five years. Although others have suggested that these approaches – while helpful at engaging with complexity at a systems level – may be limited in terms of accounting for everyday micro level practice and assisting with practical problem-solving,[49] we believe such approaches should be explored further and adaptations of these used to underpin new programmes of research in the healthcare field. The three related approaches are:

- *Routinization theory*: considers how organizational routines emerge and are shaped through the production and reproduction of patterns of activity by interacting individuals in a particular organizational context;
- *Technology structuration theory:* explores how in adopting (or choosing not to adopt, or finding that they are unable to adopt) a specific technology, human actors are influenced by a pre-existing organizational context ('meso') and by wider social structures ('macro') which include norms, symbolic meanings and the availability of resources, and their behaviours and actions in turn feed back on these external structures;
- *Actor-network theory:* describes the interactions between human and non-human elements in a specific organization and wider social context and argues that it is more helpful to consider the relations and generative power of the socio-technical network as a whole than to focus on any human or technological 'actor' in isolation.

Routinization theory offers a relatively new way of thinking about the embedding of innovation. The empirical literature on its application in healthcare is currently sparse. Edmondson *et al.*'s study[50] of the introduction of minimally invasive cardiac surgery by 16 teams in US hospitals is a good example of how this theoretical perspective can link human action and interaction at the micro level with of the development of recurrent patterns of activity at organizational level. This theory could help with questions such as: how do collaborative routines emerge in healthcare organizations, and how does their emergence link to the adoption and assimilation of complex innovations?

Technology structuration theory was first proposed in Barley's study[51] of the adoption and use of CT scanners. Using ethnographic methods, he found that introducing the same technological innovation into two different US hospitals had very different impacts in terms of the patterns of interaction between clinicians and technicians. In one site, the social order of the department changed radically while in the other, it hardly changed at all. Various historical, cultural and social factors probably created subtle but important differences in the contextual preconditions for human action and interaction. A technology structuration perspective could help explore issues such as: how do teams collaborating around common tasks (e.g. multi-disciplinary care of a patient) negotiate how their respective roles and practices will be shaped and aligned, and how do the material properties and constraints of the technologies impact on this in different settings?

Actor-network theory views 'networks' as made up of both people and technologies. It is a largely descriptive approach with some affinity to complexity theory, and its main driving question is 'what is the network, and what is emerging from it?' The contributions of this theoretical perspective to the study of technological innovation are: firstly, as a mapping tool to describe the multiple interacting 'actors' and influences in a complex case study; secondly, to help consider why innovations appear to 'behave' differently in different settings or at different times and; thirdly, to draw attention to the unintended consequences of innovation adoption and assimilation (as well as the anticipated ones). Novek's study[52] of the attempted introduction of an automated medication distribution system in a long stay care facility in Canada found that this innovation was never assimilated into routine practice. Using actor-network theory, the study showed that this was at least partly because the abstracted roles and rigid time-bound procedures that had been built into the technology aligned so poorly with the reality of front-line nursing work; the nurses and pharmacists reverted to previous ways of working.

Technology structuration theory and actor-network theory share much philosophical common ground and offer particular potential for studying the introduction of complex technologies (such as electronic patient records) in complex settings such as national-level IT programmes.[53,54]

This systematic review has updated and extended previous systematic reviews on related subjects and confirmed previous findings that there is no simple, fully predictable model for ensuring the adoption and assimilation of – in this case – technological innovations in the context of NHS organizations. A limited number of studies of processual models point to the highly political, contested and variable nature of adoption decision-making processes. Sociologically-informed theories – including May's normalization process theory and Pentland and Feldman's routinization theory – emphasize that where technologies are concerned, innovation is closely tied to the micro detail of work practice and the social relationships which support it, and that explanations of both 'success' and 'failure' must include a detailed analysis of both these micro issues and the wider organizational environment in which they play out. In short, the adoption, implementation and assimilation of technological innovations comprise both social and organizational processes, and outcomes are largely determined by the dynamics within and between these.

Given that the process by which health care organizations adopt certain technological innovations – and how or why such innovations are then successfully implemented and assimilated into routine practice – is not clear from existing studies, there is a need for rigorous, longitudinal and qualitative studies in order to develop better explanatory, and context-specific, models. Such models will provide a better understanding of the organizational processes that shape the rate of use of beneficial innovations, and enable the design of organizational interventions aimed at improving decision-making and implementation strategies. Importantly, such models should take full account of significant contextual variables as they pertain to the organizations under study (rather than ignoring or attempting to simplify them as deterministic research tends to do).

Given the importance placed by policy makers on the need for innovation to be encouraged and rewarded, and for the widespread adoption of new beneficial technologies to be speeded up, the findings of this review highlight an important gap in our knowledge relating to one of the key strands of national healthcare policy in many countries. However, policy tools that seek to encourage technology adoption should be used carefully since the benefits of a new technology are often difficult to predict.[9] Our current lack of a sophisticated understanding of what actually happens when healthcare managers, clinicians and other staff seek (or are instructed) to adopt and assimilate technological innovations into the local teams, departments and organizations in which they work will continue to undermine national attempts to reduce the time such technologies take to move successfully from 'bench to bedside'.

Acknowledgements

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