The application of Technology Acceptance and Diffusion of Innovation models in healthcare informatics.

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Abstract

There have been many attempts to explore models of technology acceptance and the diffusion of innovations; however the models have weaknesses in predicting the behaviour of individuals and organisations, particularly within the complex health domain. The insights recent work on these models offer is relevant to health informatics development and innovation and need to be considered in the development of organisational strategies. This paper analyses the merits of several relevant models and explores their potential significance for the success or otherwise of health related Information Technology projects, highlighting their weaknesses in relation to the lack of differentiation between technological and human factors which limit their applicability in practice.

Introduction

Information Technology (IT) has been proposed for use in healthcare for a variety of reasons; however the primary potential benefit must be for improved patient care and enhanced patient safety. The types of software and hardware being implemented are extremely varied, but whatever the technology involved the vast majority require use by human beings, either staff members or patients. If the systems are poorly designed and do not meet user needs, then the perceived benefits will not be achieved and money will have been spent ineffectively and potentially patients put at risk (1).

Following an extensive systematic review on the impact of ehealth on the quality and safety of health care Black et al found that "human factors" play an important role at individual level and "organisational issues" are critical in influencing adoption. They argue that greater

attention needs to be paid these aspects in understanding the development, deployment and use of ehealth technologies(2). Therefore it is important to examine the factors, particularly socio-technical factors such as individual and organisational characteristics, which lead to the adoption, or rejection, of new technologies and consider these at all stages of the design, implementation and dissemination process.

Extensive data have been collected for many years about the processes by which new technological innovations are adopted and disseminated, from a number of settings internationally and within different academic paradigms(3). Significant models examine individual decision making about whether to adopt new innovations and when. These individual decisions may or may not translate into adoption by wider organisations and networks by a process of diffusion.

The Technology Acceptance Model (TAM) focuses on the factors and decision processes an individual will go through in any decision to accept and use a technology(4). Perceived Usefulness and the Perceived Ease-of-Use are seen as being key determinants. Further studies refined the importance of these and place greater emphasis on attitude and social factors on behavioural intention(4), (5), (6), (7), (8), (9). In 2003 a major paper by Venkatesh *et al* empirically compared eight models. Based on their work in a variety of settings they produced a set of hypotheses to explore and explain the variables which impinge on acceptance and use, which they called the Unified Theory of Acceptance and Use of Technology (UTAUT)(10).

Although these papers tell us that the individual adoption decisions are complex, even more complications arise when trying to examine the factors which influence whether those individual adoption decisions can be shared and disseminated within organisations and between organisations. These diffusion factors are often seen and applied separately from

acceptance models and there is little integration between them. Many of the models that attempt to explain the factors affecting whether an innovation will be shared and adopted by other individuals and organisations have been based on Rogers' Diffusion of Innovation Theory(11). Rogers argued that each adopter's willingness and ability to adopt an innovation would depend on their awareness, interest, evaluation, trial, and adoption (12). In 2005 a major systematic literature review was undertaken, in an attempt to draw together the research on the diffusion of innovations and apply them to health service organisations. A particular emphasis was placed on the relevance of the work to the United Kingdom's National Health Service which funded the work (3).

However, many of the models of innovation acceptance, adoption and diffusion are developed from a limited empirical evidence base and have only been tested by post hoc application to previously published reports and fail to demonstrate predictive capabilities (13). More recently these models have been applied to the introduction of Informatics applications in healthcare; however the components of the models which relate to human and organisational factors are often considered secondary to technological issues when it comes to real world use.

The models of technology acceptance and diffusion have similar components, but each has a different emphasis, and their complexity has increased over recent years, and yet their predictive power is still to be proven in healthcare settings. Despite their limitations the models do provide some insights which can be used to enhance the chance of health informatics innovations being adopted by stakeholders and once adopted shared within organisations and diffused between them.

Technology Acceptance Models

Various attempts have been made to examine the factors which will influence an individual's decision about the use or otherwise of new technologies. Preeminent amongst these is the

Technology Acceptance Model (TAM) which focuses on the factors and decision processes an individual will go through in any decision to accept and use a technology or other innovation (14). The model suggests that when users are presented with a new innovation, two key factors influence their decision about how and when they will use it. Perceived Usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" and the Perceived Ease-of-Use: "the degree to which a person believes that using a particular system would be free from effort"(4) p320. The TAM can be seen as an extension of Ajzen and Fishbein's Theory of Reasoned Action (TRA) (15)(4), which suggests people's voluntary behaviour is predicted by their attitude toward that behaviour and how they think other people would view them if they performed the behaviour. This suggests that people will measure in some logical way the outcomes of accepting a new technology will be for them.

Several researchers have replicated Davis's original study to provide empirical evidence supporting the key assertion that there is a relationship between usefulness, ease of use and system use; (4), (5), (6), (7), (8), (9). Later (16) using newly developed scales, demonstrated that perceived usefulness was 50% more influential than ease of use in determining usage. However this may not apply when the new technology is imposed by managers or organizations even though the attitude of the individual or collective workforce is negative towards the innovation (17).

Malhotra and Galletta (18) criticised the conceptualization, inherent in the TAM, of subjective norm based on the Theory of Reasoned Action. They suggest that it is difficult to distinguish if technology usage behaviour is caused by the influence of outside factors on one's intent or by one's own attitude. They argued for much greater emphasis on social influences, rather than the nature of the technology. In their work social influence is

operationalised in terms of Kelman's processes of internalization, identification and compliance,(19) (20). They developed and tested constructs based around these factors which may be particularly significant in complex healthcare organisations in which many different players are likely to be in a position to influence the success or failure of the innovation, even if they are not involved in adoption decisions.

Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh *et al* empirically tested eight models (including TRA & TAM) in an attempt to develop a model that integrates elements across the eight models (10). Based on their work in a variety of settings they produced a set of hypotheses to explore and explain the variables which impinge on acceptance and use. These related to the effect of gender, age and experience on performance expectancy and effort expectancy. They also showed the influence of attitude and social factors on behavioural intention.

This UTAUT model was found to outperform each of the individual models with four core determinants of intention and usage, and up to four moderators of key relationships. UTAUT was then tested using data from previous studies and found to outperform the individual models and then confirmed with data from two new organizations with similar results.(10) However other studies applying the model to healthcare have found that social influence was not found to be as significant as in other studies from outside the healthcare domain, particularly for physicians (21), (22). Dadayan and Ferro developed a version of the UTAUT model, incorporating the contexts identified by Chau and Hu (22) who added compatibility, social influence and organisational facilitation to the traditional performance expectancy and effort expectancy.(23) Development and testing of the UTAUT model in Greece added further hypotheses related to social influence and facilitating conditions (24). The study conducted in public hospital settings, but largely with administrative rather than clinical staff, rated perceived usefulness as being significantly more important than perceived ease of use.

Application of TAM and its variants in healthcare

Various studies have found that TAM does not fully explain acceptance of IT by health professionals(25), because of its positivistic approach which doesn't fully take into account the qualitative, emotional and cultural components of decision making in healthcare(26).

Chau and Hu (22) applied a model based largely based on TAM to studying the decisions of physicians in Hong Kong, in relation to the implementation of IT, and found that "professionals" subtly differ in their technology acceptance decision-making, as compared with end users and business managers in ordinary business settings. Specifically, physicians appeared to be fairly pragmatic, largely anchoring their acceptance decisions in the usefulness of the technology rather than in its ease of use. Schaper and Pervan(14) suggest that healthcare professionals exhibit fundamental differences in their technology acceptance decisions, from business users and students which have been commonly used in technology acceptance studies. Raitoharju suggests that the stress levels inherent in healthcare work needed to be added to TAM to provide a more predictive model (27). This is supported within wider domains by arguments that greater use of qualitative research methods to understand the significance of people, organisational issues and context in technology acceptance is needed particularly in relation to the public sector (23). Following a literature review Yarborough and Smith found that studies confirmed the appropriateness of TAM amongst physicians but the "perceived ease of use" construct was not fully supported and suggested that in addition to time issues a collaborative organisational culture that emphasises teamwork is needed for successful implementation of IT based systems into physicians practices (28),(29).

The findings from these recent studies suggest that the predictive power of TAM in healthcare may be lower than has been found in other areas. Holden and Karsch suggest that

the problems may lie in the various definitions and interpretations of constructs within TAM in health IT studies, and particularly the way in which attempts have been made to substitute the quality of care for the TAM construct of personal productivity as measure of usefulness(25). England and Stewart found that "that the majority of drivers identified as being significant to organizational and technological innovation are degraded in respect to IT and health" and suggested that health executives, who may be driving the implementation hold different views from clinicians and other front line practitioners(30) p75. This becomes particularly significant as Kelly et al, studying healthcare organisations in Australia; found that systems which meet organisational goals but where the main benefits do not accrue directly to the system user are more likely to meet resistance.(31)

Diffusion of Innovation Models

Following on from the range of approaches examining the ways in which individuals, and potentially groups make adoption decisions, it is also important to consider how innovations are shared and disseminated by individuals and within and between organisations as these will influence wider success. These are often seen and applied separately from acceptance models and there is little integration between them, reducing their usefulness in planning and supporting innovation projects.

Rogers Diffusion of Innovation Theory

Many of the models that attempt to explain the factors affecting whether an innovation will be shared and adopted by other individuals and organisations have been based on Rogers' Diffusion of Innovation Theory (11). Rogers argued that each adopter's willingness and ability to adopt an innovation would depend on their awareness, interest, evaluation, trial, and adoption. This led to the proposal of a five stage model for the diffusion of innovation(12):

- Knowledge - learning about the existence and function of the innovation;
- Persuasion - becoming convinced of the value of the innovation;

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- Decision - committing to the adoption of the innovation

- Implementation - putting it to use and

- Confirmation - the ultimate acceptance (or rejection) of the innovation.

Rogers explored the complex social processes involved in decision making and the processes and channels by which it is communicated amongst members of a social system.

Further work has tried to integrate individual and organisational factors. Within complex organisations Rogers (32)[p403] identified three types of innovation decisions:

- Optional – where the decision is left up to individuals.

- Collective – in which collective decisions are arrived at by consensus amongst members of a system.

- Authority – where the decision is made by a relatively small numbers of individuals who possess power, high social status or technological expertise and then all employees must comply.

Each of these decision types has specific benefits and disadvantages which need to be considered in relation to both short term implementation goals and longer term outcomes.

Greenhalgh's model

There have been various attempts to examine the relevance of socio technical factors (where social drivers impact on technology decisions) to health informatics developments over the years, each with different emphasis. In 2005 a major systematic literature review was undertaken, to draw together the research on the diffusion of innovations and apply them to health service organisations, with particular emphasis on the relevance of the work to the United Kingdom's National Health Service which funded the work (3).

The review reaffirmed many of the well-known themes such as the importance of the attributes of the innovation itself, of social networks and organisational cultures, but also

pointed out the lack of empirical evidence demonstrating that work from product-based innovation in companies can be applied to process innovation in service organisations, such as healthcare providers, particularly not for profit and socialised medicine systems. The review attempted to integrate work from a variety of paradigms into a single conceptual model which sought to encompass the whole range of key areas: innovations, adoption by individuals, assimilation by organisations, diffusion and dissemination, the inner context, the outer context and implementation and routinisation.

The topic of innovations covers relative advantage (defined as benefit over existing practice) which may relate to economic terms or social prestige and the convenience or satisfaction it can produce. Greenhalgh et al divide the significant areas into; compatibility, complexity, trialability and observability.(3). Compatibility examines how the innovation fits with existing practices and values and takes into account the needs of potential users and their social systems. Complexity is closely allied to ease of use and describes the degree to which the innovation is perceived as difficult to understand and use. Trialability examines the degree to which an innovation may be experimented with on a limited basis. The term observability is used to represent the degree to which the results of an innovation are visible to others, while reinvention relates to the extent to which the innovation is changed, modified or personalised by the user during the process of adoption and implementation.

Greenhalgh et al's second area explores general and context specific psychological antecedents to, and the nature of, the adoption decision (3). It covers personality traits such as tolerance of ambiguity, prior knowledge, experience, beliefs, attitudes and perceptions and how these impact on the person's motivation and goals which are likely to be affected by their existing skill set and their learning style.

The complexity identified in individual decision making processes relating to adoption and assimilation of new innovations becomes even more complex when this is scaled up to an organisational scale. Greenhalgh et al suggest the influence of each individual will depend on their role within the organisation and within each of the series of decisions which are taken as part of the process (3). "Innovators" is the term given to those who are the first to adopt an innovation. The second category are "Early Adopters" who have a high degree of opinion leadership and are typically younger in age, have a higher social status, advanced education, and are more socially forward than late adopters (12). The next group is known as the "Early Majority" who tend to be slower in the adoption process than early adopters but faster than the "Late Majority" who are typically skeptical about an innovation. The final group is known as "Laggards" who typically have an aversion to change-agents.

Widely accepted characteristics of early adopters such as higher social status and educational achievement are not seen by Greenhalgh et al as fully explaining adoption processes within organisations. They suggest organisations should not be thought of as "rational decision-making machines moving sequentially through an ordered process of awareness –evaluation-adoption-implementation. Rather the adoption process should be recognised as a complex, iterative, organic and untidy."(3) p113.

In their chapter on diffusion and dissemination Greenhalgh et al's focus on the role of opinion leaders and champions and their characteristics which enable them to influence others (3). They also examine network structures, and the effectiveness of formal dissemination programmes within organisations and "boundary spanners" who have a significant role in transferring innovations from one organisation to another. Greenhalgh et al develop these ideas by looking at what they call the inner context addressing organisational antecedents, readiness for innovation, and the receptive and absorptive capacity they have for

change.(3) Under the heading of the outer context they examine external factors such as inter-organisational networks and collaboration and external pressures such as statutory requirements. In addition they discussed how structure, leadership and management, human resources, funding and communication issues influence implementation and routinisation.

Greenhalgh et al. sought to test the model with four case studies; integrated care pathways, General Practitioner fundholding, telemedicine and the electronic patient record (3). Telemedicine is subtitled "the maverick initiative" and was selected partly because it had previously been studied from a diffusion of innovations perspective (e.g. (33) and (34)). It was highlighted as being an initiative that tends to be introduced by individual enthusiasts rather than as part of an organisational process. The evidence for the effectiveness and cost-effectiveness of telemedicine is inconclusive and barriers to adoption are extensive, however small teams of enthusiasts, have devoted time and personal resources to development, often in the face of institutional indifference and made the projects successful. May et al used telemedicine as a case study in their examination of the processes surrounding health technology assessment (35),(33). They suggest that although the technology is attractive to policy makers as a "technological fix" for some structural problems that affect access to health care, it is unstable in clinical practice, not widely used and there are doubts about its efficacy, acceptability to patients and cost effectiveness. The evaluation of these sorts of technological developments involves debates about evaluation methodology and professional dynamics that conceal more fundamental difficulties in conceptualising a technology in play, and which are difficult to resolve in practice. May et al produced a set of terminology about how these innovations are adopted including; Ideation, Mobilisation, Clinical Specification and Specific Application which are not dissimilar to the stages originally set out by Rogers in his diffusion model. This approach aimed to make them more applicable to clinical settings, (35) and could therefore be integrated with Greenhalgh et al's model.

The other case study by Greenhalgh et al. [Greenhalgh et al, 2005] with direct relevance to Informatics is their review of the electronic health record which they dub "the big roll-out". This major national initiative is seen in the context of the UK's National Health Service which is fragmented across multiple sites and sectors posing obstacles to clinical care, administration, research and public health initiatives. The strong "external mandate" from UK government and the Department of Health is seen as being in conflict with the response from staff, because of "high complexity, questionable relative advantage and low ease of use" (3)p208-210. These problems are identified as being significant because of the critical dependence on simultaneous adoption by multiple users, and low absorptive capacity of many parts of the system. These findings are further reflected by the independent evaluation of the summary care record early adopter programme, which identified positive mediators, including organisational readiness and aspects of the implementation, and negative mediators including the concerns of the potential adopters of the innovation (3).

Criticism of model application

The Greenhalgh et al model highlights the importance of human actors and the processes between them as being more important than the hardware and software of the technologies concerned, but argues that it is not possible to make "formulaic, universally applicable recommendations for practice and policy" based on the model(3). This makes it very difficult to use to predict behaviours and outcomes. It also becomes difficult to test or use it in implementation projects.

Although a wide range of potential factors are identified the model avoids ranking the importance of the various which reduces the ability of the model to assist in identifying those areas which are most significant.

The research team also postulated that power relations were critical to successful implementation, but suggested they were very difficult to explore systematically, which seems to be a central question when trying to apply them in real life settings. They also bemoaned the lack of research on the complexities in spreading and sustaining innovation in service organisations as opposed to initial innovation, however they failed to suggest how this could be done. The general complexities of identifying the factors that contribute to the diffusion of innovations are complicated within specific organisational contexts and interpersonal relations and the model needs to be further developed to take these into account.

Other researchers such as Westbrook et al (36) argued that the approaches to IT implementation used in other industries may not be applicable in the healthcare sector, partly because of the organisational and workforce characteristics, with major professional groups having high levels of autonomy, while operating in hierarchical structures and exhibiting "tribal behaviour". The work they undertake is highly specialised and work processes non-linear, however effective outcomes are dependent on interprofessional collaborations, which fall outside the parameters suggested by Greenhalgh et al (3).

West showed how, in the UK, the networking behaviours of senior nurses and medical staff, and their cliques, were different (37)(25). The differences influenced the way in which they gained and shared information with colleagues, and suggested that these were a result of the occupational socialisation within the different professions, which had led to the development of subcultures (38). Similar work in the USA examining the implementation of an electronic medical record system found that the new working practices which were inherent in the electronic system required "clarification of clinical roles and responsibilities which was traumatic for some individuals" and that "no single leadership style was optimal – a participatory consensus-building style may lead to more effective adoption decisions,

whereas decisive leadership could help resolve barriers and resistance during implementations: the process fostered a counter climate of conflict" (39) p1313.

These professional variations and the wide variety of roles played by individuals militate against finding models which can encompass all the myriad influences of adoption and dissemination of technologies within the healthcare domain (25). It is also complicated by a lack of clarity or shared understanding of the relationship between knowledge and clinical work. Greenhalgh et al suggest there is a tension between definitions about "clinical work as decision-making" versus "clinical work as situated practice" and between "knowledge as transferable facts" versus "knowledge as information in context", suggesting that a positivist view of clinical work as being reducible to a series of decisions is challenged by a view that clinical work is better characterised as "addressing the ongoing local question, what to do next" (40) p16.

The lack of empirically tested models looking at the changes in work processes and structures caused by IT in healthcare means that an evidence based approach cannot be adopted. Many of those studies which have been carried out tend to focus on those institutions which developed their own IT systems rather than those purchased from commercial suppliers (36). The models are also so varied that no two models test exactly the same constructs (25). In a systematic review of the impact of IT use in health, nearly 25% of studies were conducted in one of four US medical centres, all with home grown systems and in only 9% of 257 studies examined were commercial systems examined demonstrating the need for further studies of this approach (13).

There is a need for clarity in looking at the "fit" between the technology and the task it is intended to support, which is not be met by the technology acceptance and diffusion of innovation models described above. System design methodologies developed by those who

work in the IT industry do not match well with objectives and values of clinical staff (41). The degree to which a "one size fits all" solution can cause local resistance in organisations and individuals who have been used to "locally grown" systems which have high degrees of customization and localization was also highlighted by Hendy et al (42) and Gillies and Patel (43). They found this factor was a significant driver in the development of resistance to new systems by clinicians. The fit concept is about more than the design of the user interface but the way in which the whole systems integrate with work practices and cultures (1). Another term for this is the 'Design-reality gap' which has been given as a label to identify some of the factors which may influence the outcome of eHealth systems taking into account the situation specific factors which are relevant(41).

Applying the models

Various studies suggest that different factors will have influence on particular sections of the healthcare workforce. For example if younger, predominately male, doctors are more task focused than older female nurses or allied health professions, who are more influenced by social factors, the attitudes towards the adoption of IT innovation of large sections of the workforce are likely to be at odds with each other, If the cooperation of all these different groups is needed for the innovation to be adopted then a unified approach is unlikely to be successful. A collaborative organisational culture that emphasises teamwork is needed for successful implementation of IT based systems, particularly in physician's practice (28).

Implementation models which accept the importance of involving users require consultation with individuals who will be affected by the change, both on an individual basis and through representative organisations. These require recognition of professional autonomy and an understanding of the different values and assumptions which may be held by different groups

such as managers and clinicians. The "human factors" need to be taken into account at all stages of the design, implementation and use phases of informatics implementations, however this has higher development and implementation costs, but may turn out to be cheaper and more effective in the long run. A variety of strategy and policy documents for at least the last twenty years have stated that socio technical factors need to be taken into account when planning new IT systems for use in the NHS. The list of those which have failed, at least partly because they failed to do this, stretches back just as far. The lessons learnt from IT systems implementation in real life healthcare systems must be used in future planning, not just of the IT systems but within the wider socio-technical context. (Aarts, 2012)

Conclusion

Despite their limitations Technology Acceptance and Diffusion of Innovation Models do have something useful to offer in considering the socio-technical issues factors in health informatics implementations. A focus on perceived usefulness is more likely to influence clinicians than ease of use issues, and individual and organisational attitude and culture is likely to be significant in both initial adoption and subsequent diffusion of the innovation. However an early stage of an implementation plan should be to identify which are the factors are most significant for each specific organisation as the models have so far failed to find universal solutions.

Further work is needed to refine and test the models weighing the relative importance of the different components within socialised medicine contexts. In addition attention should be paid to those aspects of the model which are common to both acceptance and diffusion and how these can be developed to meet the specific communication and professional codes of different professional groups. From these one or more predictive hypothesis are needed which can be prospectively tested in real world settings.

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