Adoption of Information Technology Enabled Innovations by Primary Care Physicians: Model and Questionnaire Development

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A survey instrument was developed based on a model of the substantive factors influencing the adoption of Information Technology (IT) enabled innovations by physicians. The survey was given to all faculty and residents in a Primary Care teaching institution. Computerized literature searching was the IT innovation studied. The results support the role of the perceived ease of use and the perceived usefulness of an innovation as well as the intent to use an innovation as factors important for implementation. The model and survey instruments developed show significant potential to enhance our understanding of the process of implementing IT innovations such that Physicians will adopt them.

INTRODUCTION

Computers are information management tools that can allow a physician to more efficiently manage information from a patient's chart and additional resources. Information technology (IT) also allows a means to easily manipulate information for other uses, such as preventive care and patient education. There are many other ways that IT can enable innovations in the use of information in providing health care.

An American study [1] found possible benefits to hospitals from increased utilization of computers include increased quality of care, decreased transcription errors, decreased reliance on clerical staff, and the possibility of attracting new physicians to hospitals. In one hospital, when a computerized pharmacy reminder system was introduced, they found medication changes were implemented 20 hours sooner than with a traditional paper-based system [2]. Currently there is a low utilization of information systems by physicians [1], although a 1988 study of family (primary care) physicians [3] found that 45% had computers in their office with 17% maintaining partial medical records and 2% maintaining full records on an information system. It is predicted that by the year 2000, 75% of hospitals will have computerized patient lists and facesheets, and 35% will have fully computerized documentation [1]. Unless physicians are willing and prepared to use information technology, it will be difficult to realize these benefits.

Research has been performed investigating the factors affecting individuals' use of innovations, including IT enabled innovations[4], [5]. Some key factors identified are the perceived usefulness of an innovation, as well as the perception of how easy it is to use [6]. Perceived usefulness refers to the perceptions of how useful a skill or technology would be to that person [7], [8]. This can be either a concrete or abstract benefit, or a way to avoid negative outcomes. Perceived ease of use refers to the perceptions of how much effort is involved in learning new skills and putting those new skills to use. The Technological Acceptance Model (TAM) developed by Davis [6], [7] found that perceived usefulness and, to a lesser extent, perceived ease of use both affected a person's attitude to adoption of an IT enabled innovation. The person's attitude leads to behavioral intentions, which in turn lead to actual behavior, such as computer use.

In a self-report survey [11], Smith and Zastrow found that physicians viewing computers as easier to use or more useful were more likely to favour adoption. In another study [12], it was found that computer systems providing value to physicians will have greater utilization. A case study of computerized ambulatory care records performed in the early 1990s [13] found that clinic staff accepted the information technology. They also noted that physician acceptance of the system increased with increased ease of use.

Recent research [9], [10] has found that a person's sophistication will also affect his or her choice to adopt a new technology. End-User Sophistication (EUS) is a measure of how many areas of knowledge a person has, the amount of knowledge in each area, and how well they can apply their knowledge. These characteristics are known, respectively, as breadth, depth, and finesse. It was found that if the fit between the individual's sophistication and the capabilities required by the innovation matched, the individual was likely to have success in adopting the innovation [9], [10].

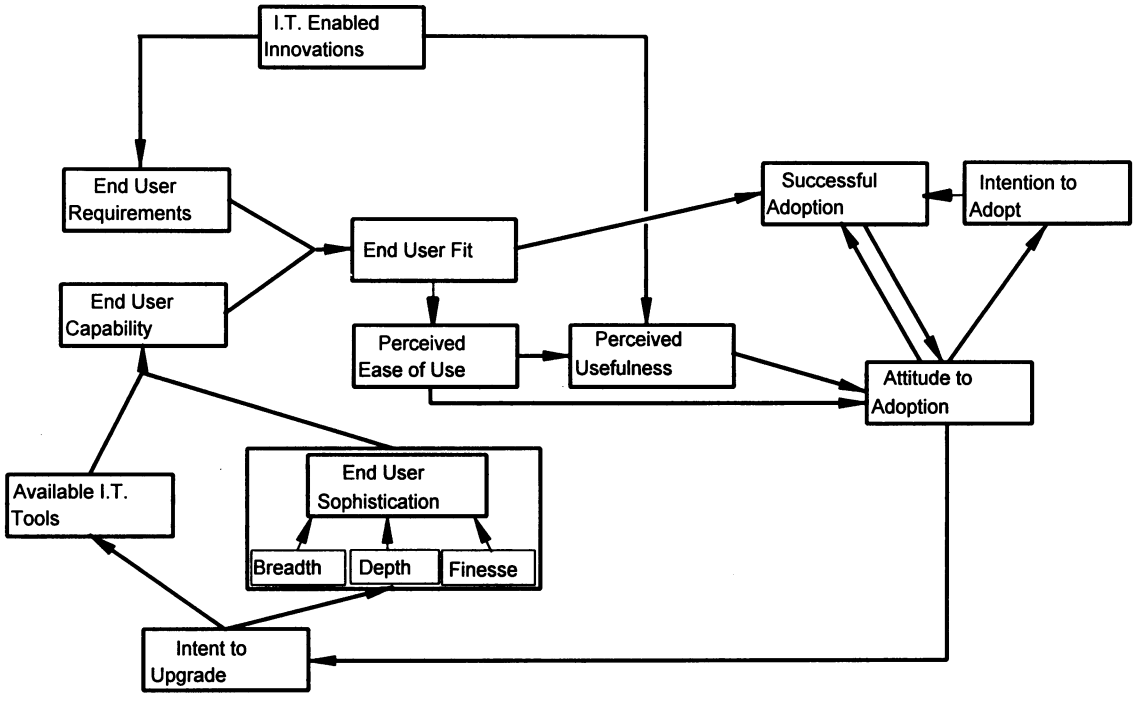

Figure 1: Proposed Model for the Adoption of Information Technology (IT) Enabled Innovations

Building upon the TAM and the EUS research, figure 1 shows the model developed. Each IT enabled innovation, for example a computer application like on-line literature searching, provides benefits and requires resources. The benefits influence the perceived usefulness, while the resources required determines the end user requirements. The end user requirements include the skills and competencies as well as the IT tools needed by the user to use the innovation. The tools and the skills of the user define the user's capabilities. The capabilities, when compared to the requirements determine the fit. If the requirements exceed the capabilities, there will be a decrease in the perceived ease of use of the innovation. As the deficit of a user's capabilities compared to requirements decreases, the fit increases as does the perception that the innovation is easier to use. Perceived usefulness is affected by the perceived ease of use and the characteristics of the innovation. These characteristics are both internal and external to the innovation. Internal factors include the task performed, effort required, and information provided. External factors involve pressures or requirements to adopt, benefits such as promotion or job security gained from adopting, and personal satisfaction.

Both perceived ease of use and perceived usefulness will influence the attitude towards adoption; The more the innovation is perceived as useful and easy to use the attitude towards innovations becomes more favourable. With a positive attitude, an intention is formed to either adopt the innovation or upgrade the skills or tools needed to allow the adoption of the innovation. If the innovation is adopted, success will be enhanced both by a good end user fit, as well as a positive attitude. Successful adoption will also enhance the attitude towards further adoption or upgrading.

End user sophistication is determined by a person's breadth and depth of knowledge as well as their finesse at using that knowledge. Their sophistication can be increased by education, training, and practical experience. Increased sophistication will increase the user's capabilities and ultimately the user's success.

This study was undertaken to develop a survey instrument to test the hypotheses underlying the model presented in Figure 1. We focussed on three hypotheses: 1) perceived usefulness is directly related to favourable intentions to adopt or upgrade skills, 2) perceived ease of use is directly related to favourable intentions, and 3) end user fit is directly related to favourable intentions. The innovation used to test this

model was Computerized Literature Searching.

METHODS

The instrument was developed using questions from several sources. Attitude questions were modified from a scale developed for clinical psychologists [14]. Perceived ease of use and usefulness questions were generated from guidelines found to yield reliable questions [15]. Sophistication was measured across many areas that a family physicians may be exposed to in a standard practice setting. These questions were developed based on Marcolin et al. [9], [10]. Intent questions were created specifically for this questionnaire. Questions were constructed for both computerized literature searching and computers in general. Demographic information was also acquired.

Knowledge endpoints on the scales were defined as novice and expert. Novice "indicates that the person can perform basic functions, but require assistance to perform more advanced functions." Expert "indicates that the practitioner is skilled in basic and advanced functions and is able to provide assistance while uncommonly requiring assistance themselves." To ask about expected knowledge, the respondent was asked to "indicate the level of knowledge that you feel an average general or family practitioner should attempt to acquire in the next few years to most effectively practice medicine." Usage was scaled as yearly, monthly, weekly, more than once per week, daily, and more than once per day. There were no definitions given for the computer applications, although examples of common programs were provided. The survey instrument also contains items addressing a number of different types of IT applications. A copy of the survey instrument is available from the authors.

The survey was directed to residents and full time physician faculty members in the Department of Family Medicine at the University of Western Ontario. All nineteen faculty members and all 69 residents in the family medical centres from January 1993 to August 1993 were surveyed.

RESULTS

There was a response rate of 95% (18/19) for full time physicians on faculty and 84% (58/69) of residents. The total response rate was 86% (76/88). One faculty member and two residents declined to complete the questionnaire. No response was received from the remaining nine residents.

As a measure of scale reliability, Cronbach's alphas were calculated for all scales, and are summarized in Table 1. A scale was judged to have sufficient internal reliability for continued investigation if its reliability coefficient (alpha) was greater than 0.70. Only the attitude scale did not meet these criteria.

Scale Description	Alpha
Attitudes	.68
Perceived Ease of Use - Computers	.83
Perceived Usefulness - Computers	.92
Intent - Computers	.76
Perceived Ease of Use - Lit Search	.76
Perceived Usefulness - Lit Search	.91
Intent - Lit Search	.76
Finesse	.94

Table 1: Scales and reliability coefficients for the instrument.

Figure 2 shows use and knowledge of computerized literature searching. Faculty and residents rated their usage (from yearly (1) to more than once per day (6)) and knowledge (from none (0), and novice (1) to expert (7)). Usage and knowledge, both current and expected were not significantly different between faculty and residents. Faculty showed slightly more usage and knowledge of literature searching systems than residents.

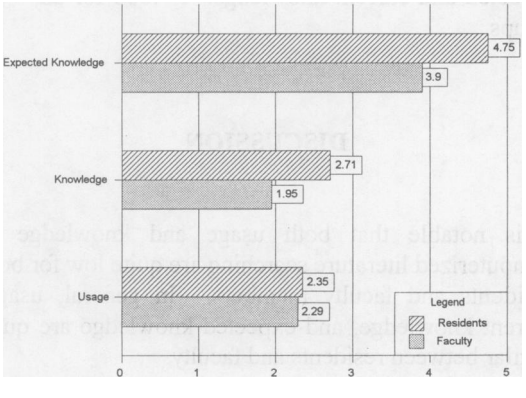

Figure 2: Physician knowledge and usage of computerized literature searching. Usage shown is yearly (1) to more than once per day (6). Knowledge is novice (1) to expert (7).

Figure 3 compares current and expected knowledge of computerized literature searching. The knowledge gap is the difference between what people currently know and what they believe they need to know, their capabilities and requirements respectively. The knowledge gap represents the non-technological component of end-user fit. There is a clear knowledge gap expressed by both residents and faculty with respect to computerized literature searching ($p<.000$).

Correlations were calculated between the knowledge gap and usefulness, showing significant positive correlations for computerized literature searching ($r=.41$, $p<.001$). There was no significant correlation found between knowledge gap and perceived ease of use ($r=-.09$). Intentions of adopting computerized literature searching were significantly correlated with perceived usefulness ($r=.26$, $p<.05$) and perceived ease of use ($r=.32$, $p<.01$).

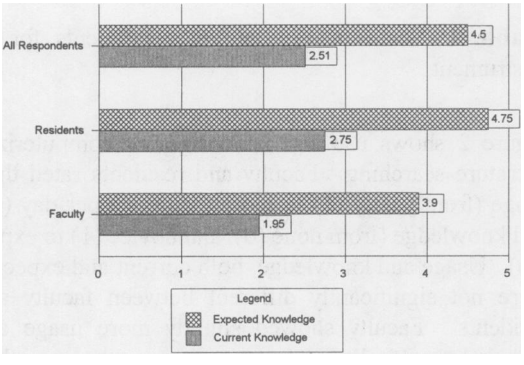

Figure 3: Knowledge gap for computerized literature searching - the difference between expected and current knowledge. $P<.000$ for all groups.

DISCUSSION

It is notable that both usage and knowledge of computerized literature searching are quite low for both residents and faculty members. In general, usage, current knowledge, and expected knowledge are quite similar between residents and faculty.

The most striking differences are seen in Figure 3. This shows the knowledge gap that currently exists. Faculty and residents feel they need more knowledge about computerized literature searching than they currently have. As expected, the knowledge gap was strongly correlated to the perceived usefulness of literature searching. Computerized literature searching appears to be an ideal area to focus on implementation at present. There is a significant knowledge gap identified by both faculty and residents, and computerized literature searching is readily available, and relatively easy to use. Also, many physicians have had occasion to use paper-based literature searching facilities, which require much of the same knowledge. Eventually, this gap will decrease with successful implementation and other innovations will be the focus of our research.

The model presented in Figure 1 is generally supported by the results from this study. It is unclear why the knowledge gap did not correlate with the measures for perceived ease of use, although it was correlated with perceived usefulness. Possibly, end user fit acts directly on perceived usefulness. The small sample size precludes the use of advanced statistical techniques like structural modelling (e.g., LISREL) needed to adequately test this model. Another limitation of the current research is the use of self-report measures of usage. Methods to objectively capture use were not available, but are being developed.

The contribution of this model to Medical Informatics research is to develop tools to provide insight into the implementation of IT innovations, specifically how to entice physicians to use computers. From figure 1, the key areas are perceived usefulness, perceived ease of use, and sophistication. Sophistication is build partially by experience, and partially by education. Perceived usefulness is affected by education as to the costs and benefits of a computer innovation, sophistication, and the persons own needs. Perceived ease of use is affected by a person's capabilities, which is related to their sophistication, and the tools available to them. As people gain experience, their sophistication should increase, leading to an increased perception of the ease of using other related innovations. Education can increase both a person's sophistication and their perceptions of the usefulness of a new program, leading to a more successful adoption. Also, by adding rewards or requiring behaviours, the usefulness of an innovation will increase to gain the reward or satisfy the requirements.

Future Research Directions

As this survey is further validated and refined, it can be sent to community physicians to allow a rational development of continuing medical education programs and computer resources to facilitate the implementation of information technology in physicians' offices. This survey can also be used to examine the needs of

undergraduate medical students. It may provide a basis for integrating computer instruction in the undergraduate curriculum and training in the Department of Family Medicine.

The underlying causal relationships in the model are better explored using a longitudinal research design. Using these scales as pre- and post- intervention measures during an IT implementation will provide a significant opportunity to test the model's hypotheses further. The similarity of our results obtained in a medical setting to the results obtained in Management Information Systems research, where the components of this model have been drawn from, provide the support to pursue our research agenda further.

The role of IT in health care is increasing dramatically, and understanding how physicians develop their attitudes towards IT is critical to successful implementations. We believe that this survey instrument, and the model upon which it is based, is a useful tool to gain insight about implementing IT innovations.

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