

Doctors On-line: Using Diffusion of Innovations Theory to Understand Internet Use

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Background and Objectives: *Family physicians must be aware of the latest and best evidence for a broad range of clinical and public health topics. The Internet is an important source of this information, but not all family physicians use the Internet. This study used “diffusion of innovations” theory to identify strategies for increasing Internet use by family physicians. Methods:* We conducted a mail survey of 58 family physicians in a midsized Northeastern metropolitan area in the United States to assess Internet use and identify sources from which physicians obtain medical information. We then used diffusion of innovations theory to describe the process by which physicians learn and develop skills at using the Internet. **Results:** *Internet use begins when physicians are not constrained by a heavy patient volume and are able to learn about and observe the benefits of Internet use. When they experience its usefulness, their Internet browsing and searching develop and become more effortless and less time-consuming. Conclusions:* The innovation attributes of diffusion of innovations theory act as predictors of Internet use among family physicians. Internet use by family physicians might be increased by providing them time to learn about how to use it and to experience its benefits. Integration of continuing medical education courses created for the purpose of developing and enhancing Internet usage skills into their schedule may be a workable solution. Demographic factors such as gender and training recency have no influence on Internet use by family physicians.

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Internet technology has enabled health professionals to obtain and share increased amounts of health care information¹⁻² and to track and monitor diseases.³⁻⁵ In addition, the Internet has allowed physicians throughout the world to collaborate, communicate, and interact.⁶⁻¹⁰ Increasingly, physicians use on-line databases to search for the latest information on clinical protocols in different medical specialties and patient management and to consult with specialists and seek continuing medical education.^{11,12} The Internet is of increased importance in the practice of family medicine as a consequence of the efficiency of communications, the accessibility of on-line evidence-based medicine reviews, and the need to assist patients in selecting reliable Internet resources.^{13,14}

As the most credible and most substantive source of medical information for the American public,¹⁵ physicians have a responsibility to keep up with the most current research and applications on topics ranging from

disease screening to bioterrorism threats.¹⁶ The Internet facilitates and enhances this process. Previous studies indicate that many family physicians are unaware of peer-reviewed research evidence on the Internet¹⁷ and consider point-of-care Internet searching relatively time inefficient.¹⁸ However, they recognize the Internet’s potential ability to provide quicker access to accessible and trustworthy information.^{19,20}

A previous study demonstrated that recent medical graduates and younger physicians were more likely to consider the Internet a valuable medical resource and that male physicians were more likely to participate in medical Internet user groups than their female counterparts.²¹ Another study found that younger physicians were only slightly more likely to use clinical information systems.²² In a survey of computing skills, students, junior residents, and faculty were more confident than senior residents in performing computer tasks (such as retrieving patient information or conducting a MEDLINE query).²³ Finally, a third study found that age, gender, or graduation recency had no relationship to information technology adoption by family physicians.²⁴ The present study examines how family physicians currently use and perceive Internet technology by applying “diffusion of innovations” theory. The in-

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formation generated from this approach can help identify strategies to increase family physicians' use of the Internet.

Diffusion of Innovations Theory

Diffusion of innovations theory is "the process by which an innovation is communicated through certain channels over time among members of a social system."²⁵ An innovation's attributes that contribute to its rate of adoption include relative advantage (how much better the innovation is in comparison to the idea it supersedes), compatibility (how consistent it is with existing values and needs of potential adopters), complexity (how difficult it is to understand and use), trialability (degree to which a user may experiment with it on a limited basis), and observability (how visible the results of innovation are to others). Innovations that are perceived as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted more rapidly.

In the context of medical practice, diffusion of innovations theory has been used to describe how physicians accept and prescribe new drugs as well as the adoption of medical technology such as electronic order entry,²⁶ interactive video,²⁷ and rural telemedicine.²⁸ A 1986 study of family physicians profiled the characteristics of early adopters of "end user on-line searching" (the process of using bibliographic and full-text information electronic databases).²⁹ That study found that family physicians were less likely than physicians in other specialties to be early adopters because family physicians spent more time on patient care, which, in turn, was associated with less time for database searching to learn about innovations. Twelve years later, a study comparing information technology use between family physicians and obstetricians showed that both groups used and valued the Internet similarly.²¹

In the study reported here, we postulated that the presence of innovation attributes—relative advantage, compatibility, observability, trialability, and complexity—would predict adoption of Internet usage. In line with other studies assessing medical innovation or technology use, another expectation was that Internet usage would be higher among male physicians and physicians who had completed their medical training within the past 10 years.

Methods

Survey Procedures

A survey was mailed to members of the local chapter of the American Academy of Family Physicians in a midsized metropolitan area in the Northeastern United States during the late spring of 2002. Prenotification cards were mailed out a week earlier. Ninety-eight physicians with working addresses within the designated metropolitan area comprised the study population.

Survey Content

Key questions focused on access, use, and interest in desktop computers (work and home), the Internet, and other computer-based technology. Additional questions were about using the Internet to communicate (get e-mail, respond to e-mail, provide information) with patients and the utility of sources of medical information such as that obtained from colleagues, medical journals, continuing medical education (CME) courses, newsletters, pharmaceutical companies, the Internet, and other sources. We included a specific question on preferred methods for delivering information and updates about bioterrorism and noted whether physicians cited e-mail as a source for this information.

Innovation attributes were operationalized with two statements each (Table 1), which were rated on a 5-point Likert scale that ranged from "strongly disagree" to "strongly agree." Scores for the two statements for each innovation attribute were summed and averaged to create the specific "innovation attribute score." In keeping with Rogers'²⁵ guideline that users' perceptions of an innovation attribute affect adoption, the survey items on attributes were derived from both previous research questions and findings on perceptions about information technology adoption by physicians.^{21-24, 26-28}

An index of professional Internet use was created by summing scores coded "1" for positive responses and zero for negative responses to questions about whether respondents reported (1) Internet use at work, (2) getting patients' e-mail, (3) replying to patients' e-mail, (4) sending patient medical information by e-mail, and (5) selecting e-mail as the best method for getting bioterrorism updates.

Demographic information requested in the survey included gender, training recency (measured by an ordinal scale of 5-year intervals from "within the past 5 years" to "more than 25 years ago"), the number of patients seen daily in practice, the number of years of computer use, and whether the respondent had a teaching hospital affiliation. Training recency was measured instead of age, since one previous study²² demonstrated that age was a minor predictor of Internet use, and another²³ attributed technology competence of younger physicians to their exposure to computers, rather than to their age per se.

Data Analysis

We computed frequencies for all the variables and Spearman's correlations between the paired innovation attribute statements to validate their consistency. *T* tests were performed to assess gender and training recency differences between these individual attributes. Hierarchical regressions were computed to predict Internet usage from the innovation variables of compatibility, complexity, relative advantage, trialability, and observability. Gender, number of years of practice, num-

Table 1

Internet Technology Perceptions Among Family Physicians, Gender Groups, and Training Recency Groups

Innovation Attributes	Percentage Agree and Strongly Agree (n=56)	MEAN (SD)				
		Family Physicians Total (n=56)	Males (n=34)	Females (n=22)	Training Recency <10 years (n=26)	10+ years (n=29)
Relative advantage: r=.65**						
Specific Internet sites are a treasure trove.	62.7	3.61 (0.96)	3.53 (1.04)	3.71 (0.85)	3.65 (0.98)	3.56 (0.96)
I get a lot of useful information from the Internet.	62.5	3.59 (1.02)	3.45 (1.12)	3.78 (0.85)	3.73 (0.96)	3.47 (1.07)
Compatibility: r=.59**						
Searching the Internet takes too much effort. ‡	58.9	3.55 (1.21)	3.64 (1.22)	3.44 (1.20)	3.58 (1.17)	3.53 (1.25)
I don't have time to browse the Internet. ‡	44.6	3.16 (1.42)	3.0 (1.37)	3.41 (1.50)	3.46 (1.42)	2.90 (1.40)
Complexity: r=.35*						
I don't type so I don't use the computer. ‡	91.3	4.51 (0.87)	4.44 (1.02)	4.61 (0.58)	4.73 (0.53)	4.32 (1.05)
My Internet skills are excellent.	44.7	3.23 (1.24)	3.18 (1.26)	3.30 (1.22)	3.46 (1.30)	3.03 (1.16)
Observability: r=.68**						
Some of my colleagues have benefited from Internet use.	79.4	3.91 (0.74)	3.70 ^a (0.84)	4.17 ^a (0.49)	4.04 (0.75)	3.79 (0.73)
Using the Internet has improved clinical practice.	55.8	3.35 (1.03)	3.03 ^b (1.19)	3.77 ^b (0.61)	3.81 ^c (0.69)	2.88 ^c (1.11)
Trialability: r=.56**						
I'd like to see how the Internet can improve my work.	61.8	3.58 (1.01)	3.47 (1.16)	3.74 (0.75)	3.69 (0.97)	3.48 (1.06)
I would take a CME course on Internet navigation.	38.9	3.07 (1.21)	2.97 (1.36)	3.23 (0.97)	3.04 (1.27)	3.10 (1.18)

CME—continuing medical education
SD—standard deviation

‡ Reverse coded

* P<.01, ** P<.001

^a t=-.241, P<.019; ^b t=-2.72, P<.009; ^c t=3.60, P<.001

Subjects were asked to rate the above statements on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree). Spearman correlations (r) were computed between the paired innovation attribute statements.

ber of daily patients, and teaching hospital affiliation were included in the regression analyses. Probability levels were set at P<.05.

Results

Demographics

Fifty-eight physicians responded to the survey, for a response rate of 63.7%. Of the respondents, 58.6% were male and 41.4% were female. A majority of the group (55.1%) completed their professional training more than 10 years previously, with 13.8% obtaining their professional credentials 5 to 10 years ago and 31% doing so within the past 5 years. About 45% were undergoing professional training when the Internet came of age in the 1990s. Faculty had a mean of 12 years in practice (range 0.5–35 years). Seventy-one percent had af-

filiations with a major teaching hospital. On the whole, respondents saw about 26.8 patients a day, ranging from a low of 6 to a high of 60 patients.

Computer Availability

More than 9 in 10 (93.1%) of the responding family physicians reported having computers available at work, and 71.9% used them. Seventy-four percent had Internet access at work, while 17.2% did not but would like to add this feature. Nearly 9 in 10 physicians (89.7%) had a computer with Internet access at home. In general, the family physicians had used computers for an average of 4.7 years (range 6 months to 15 years).

Patient Communication

When asked about using Internet technology for patient communication, about one quarter (24.6%) reported receiving e-mail messages from patients, and 21.4% had replied to patients via e-mail. In addition, 14.1% used e-mail to send patients information that was medically important.

Sources of Medical Information

The source of medical information considered most useful was CME courses (mean score of 4.1 on a 1–5 scale, on which 1 was not at all helpful and 5 was very helpful, SD=.75). This was followed by medical journals (3.9 mean, SD=.92), professional colleagues (3.9 mean, SD=.95), and the American Academy of Family Physicians Web site (3.5 mean, SD=1.18). Other sources, including university/medical school/health center health promotion newsletters, bulletins from the Centers for Disease Control, professional association newsletters, pharmaceutical company reports, and health-related foundation reports were all considered less than “somewhat helpful” and were scored between a 3.0 and 2.0 mean. Newspaper reports and television news reports were considered to be only a little helpful and scored 2.1 and 2.0, respectively. E-mail was cited by 38.8% as the best method of obtaining up-to-date information on bioterrorism. Fax (27.7%), other Web sites (25%), and express mail (23.9%) were the other frequently mentioned methods of communication about this topic.

Information Technology Perceptions

A majority (55.8% to 79.4%) agreed that Internet use had advantages, did not take too much effort, had observable benefits, and would like to learn how it could improve their work (Table 1). Nine out of 10 knew how to type and use a computer, a prerequisite for using the Internet. Only a minority (38.9% to 44.7%), however, reported that they had time to browse the Internet, had excellent Internet skills, and would take a CME course on Internet navigation. Moderate to strong Spearman’s correlations ($r=0.35$ to 0.68) between the paired innovation attribute statements demonstrate their construct validity. Female family physicians were more likely than male physicians to observe that the Internet benefited their colleagues (4.17 versus 3.70 , $t=-2.41$, $P<.019$), and improved clinical practice ($t=-2.72$, $P<.009$). Recent graduates were more likely than their more-practiced colleagues to have observed how the Internet has improved clinical practice ($t=3.60$, $P<.001$).

Predicting the Use of the Internet in the Practice of Medicine

Regression analyses revealed that there were paths between the innovation attributes and Internet use. Table 2 reports the results of four regression equations predicting Internet use, relative advantage, trailability,

observability, and compatibility. It lists the semi-partial correlation (sr^2) or unique proportion of variance explained by a specific independent variable, its beta weight (Beta), the correlation (R), and variance (R^2) for each of the final equations.

The first regression predicting Internet use (Table 2) produced two significant variables: relative advantage ($\text{beta}=.48$) and trialability ($\text{beta}=.31$), which accounted for a combined 31% adjusted variance ($P<.001$). In the second regression, observability ($\text{beta}=.53$) and compatibility ($\text{beta}=.46$) were significant predictors of relative advantage, accounting for 63% of the combined variance ($P<.001$). In the third regression, trialability was predicted by observability, which in turn was af-

Table 2

Hierarchical Regression Coefficients Predicting Internet Usage and Four Innovation Attributes (n=56)

Predictor Variables	sr^2	Beta	P Value
Internet Usage			
Relative advantage	.25	.48	.001
Trialability	.09	.31	.024
R ²	.31		
r	.59***		
Relative Advantage			
Observability	.45	.53	.001
Compatibility	.19	.46	.001
R ²	.62		
r	.80***		
Trialability			
Observability	.11	.34	.05
R ²	.09		
r	.34*		
Observability			
Number of daily patients	.11	-.33	.05
R ²	.09		
r	.33*		
Compatibility			
Complexity	.34	.60	.001
R ²	.35		
r	.60***		

* $P<.05$, ** $P<.01$, *** $P<.001$.

r—correlation coefficient or a number between -1 to +1 indicates the degree to which two variables are related.

R²—coefficient of determination indicates how much the variance in one variable is explained by one or more variables.

sr^2 —semi-partial correlation measures the unique proportion of variance explained by a specific independent variable.

beta weights—standardized regression coefficients enable the comparison of the relative importance of independent variables measured with different metrics or scales of measurement.

ected by the number of daily patients. In the regression predicting compatibility, complexity accounted for 60% of the variance. No other significant relationships including the influence of gender or training recency were found. The linkages are profiled in Figure 1.

Discussion

Our study reveals two “pathways” that describe how family physicians incorporate the Internet into their practice. The first pathway begins when family physicians are not constrained by the number of patients they have to see. When there is less pressure to see patients, they observe their colleagues benefiting from Internet use (observability). At this point, they will be able to investigate Web sites and obtain useful information from the Internet (relative advantage). With practice, they will be sufficiently facile with the Internet to use it as the means of getting the latest clinical information. An additional approach after observing the benefits of the Internet is to try it out through a demonstration or a CME course (trialability).

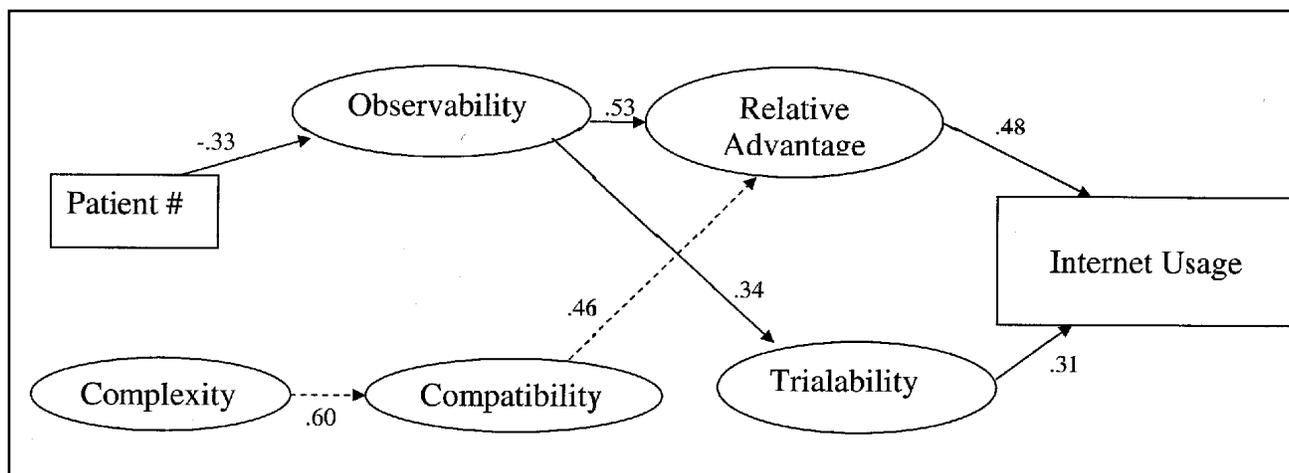
The second pathway begins when the family physician attains a sufficient level of Internet skill (low complexity) and finds that there is time to browse the Internet and not consider it an effort (compatibility). When this happens, using the Internet will lead to helpful Web sites and useful information (relative advantage) that enhance the clinician’s medical practice.

The inverse relationship of patient load to Internet use is supported by previous research.²⁹ It is certainly possible that with more practice, Internet use may provide timely assistance to the family physician. Likewise, the first step in the second pathway involves getting better Internet skills so that using the Internet will not take too much time or effort. This would be best accomplished outside of the work environment so that equipped with basic Internet operating skills, the family physician can obtain useful information for clinical practice.

Unlike previous research, however, no relationship was found between demographics (gender and training recency) and Internet use when other factors were considered in the regression analyses. This suggests that in contrast to those older studies, family physicians currently realize that the Internet represents an asset, and they are open to developing the requisite skills to use it. Getting from basic skills to advanced skills is the challenge. Toward this end, CME could constitute the optimal means for family physicians to learn how to navigate the Internet. Courses that are integrated into physicians’ schedules could be a workable solution. Until basic technical skills are in place, attempting to build an advanced skill lexicon will be difficult and met with resistance.

Figure 1

Predictors of Internet Usage, Relative Advantage, Trialability, Observability, and Compatibility



→ Pathway 1. The first pathway begins when family physicians are not constrained by the number of patients they have to see and observe their colleagues benefitting from Internet use (observability). At this point, they will be able to investigate Web sites and obtain useful information from the Internet (relative advantage). An additional approach after observing the benefits of the Internet is to try it out through a demonstration or a CME course (trialability).

- -> Pathway 2. The second pathway begins when the family physician attains a sufficient level of Internet skill (low complexity) and finds that there is time to browse the Internet and not consider it an effort (compatibility). When this happens, using the Internet will lead to helpful Web sites and useful information (relative advantage) that enhance the clinician’s medical practice.

The numbers represent beta weights.

Limitations

Study limitations include the fact that the metropolitan area in which the survey was conducted (Syracuse, NY) has a higher rate of Internet connectivity than most other mid-sized cities. It is possible that because of this environment, the subjects in our study were more technologically sophisticated than average physicians. This possibility is supported by the high proportion of family physicians in our study who had computers at work and at home. In addition, most had a teaching hospital affiliation, and this could result in more exposure to computer technology. Additionally, the small number of physicians participating in the study threatens the validity of our results, which should be validated with a larger sample distributed throughout a wider geographic area.

Future research should also explore other aspects of the diffusion of innovations theory, focusing on communications, the social system, and the diffusion time. In addition, other innovation dynamics should be explored, such as the tension between voluntariness and system-mandated adoption, incentives for integrating the innovation, social networks, and characteristics of the agents of change/opinion leaders. None of these factors were considered in our study.

Conclusions

Our study reveals that innovation attributes of diffusion of innovation theory do act as predictors of Internet use among family physicians. We identified two pathways that describe how family physicians incorporate the Internet into their practice.

Internet use by family physicians might be increased by providing them time to learn about how to use it and to experience its benefits. Integration of CME courses created for the purpose of developing and enhancing Internet usage skills into their schedule may be a workable solution. Demographic factors like gender and training recency have no influence on Internet use among family physicians.

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