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Refereed paper

Assessing attitudes toward electronic prescribing adoption in primary care: a survey of prescribers and staff

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ABSTRACT

Background Using survey instruments to assess physicians' attitudes toward electronic health record (EHR) adoption has been an ongoing area of research. No instrument has emerged for widespread use.

Objective We used a theoretically-based, 37-question survey instrument to assess attitudes toward electronic (e-) prescribing adoption in the context of an existing EHR. Our objective was to elicit information to inform strategies to maximise adoption.

Methods The instrument assesses attitudes in four domains: finesse, intent to use technology, perceived usefulness and perceived ease of use. Two additional questions ask about computer use at home and self-assessed computer knowledge. We administered the instrument to prescribers and staff at three primary care sites between 2005 and 2007. Each site represented a unique transition from paper-based or partial (Phase 1) to full (Phase 2) e-prescribing use.

Results Fifty-nine prescribers (82% response) and 58 staff (50% response) completed the survey. At the paper-based site, domain scores increased significantly from Phase 1 to Phase 2 for intent to use technology for both prescribers (4.8 to 5; $P<0.04$) and staff (4 to 5; $P<0.03$); and for perceived usefulness for staff (3.7 to 4.6; $P<0.02$). For prescribers, significant associations ($P<0.05$) were found between computer use at home for professional use and each domain score; and between computer knowledge and three of the four domains. Self-assessed computer knowledge was consistently rated as intermediate, vs novice or expert.

Conclusions Domain scores improved. Prescribers' self-assessment of computer use at home and computer knowledge predicted attitudes toward adoption. This instrument may be useful in tailoring strategies for successful adoption.

Keywords: adoption, electronic health records, electronic prescribing, primary care, surveys

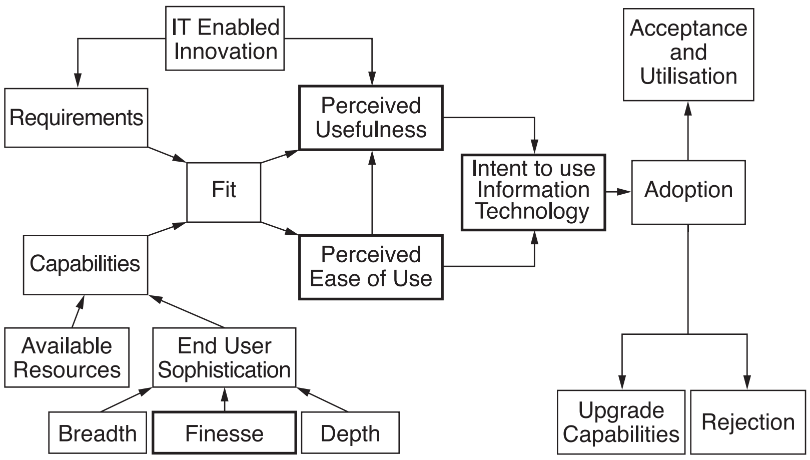
Introduction

For 20 years, the Institute of Medicine has championed electronic health records (EHRs) to achieve quality measures and cost control in health care.[1–3] Despite the benefits of fully-functional EHRs, data from a recently conducted national survey indicate that only 4% of ambulatory care physicians reported using a fully functional EHR.[4] All too often physicians do not invest in technology because of misaligned financial incentives,[5,6] costs,[7,8] the potential for decreased productivity and time-inefficiency.[5,8] In an effort to spur widespread EHR adoption by 2014, the American Recovery and Reinvestment Act of 2009 has allocated $19 billion.[9] Yet legislation alone cannot address major sociotechnical barriers that arise during deployment of systems that critically alter workflow in ambulatory settings. Physicians' negative attitudes and behaviours can fuel resistance to EHR implementations, and even derail the course of deployment.[10]

Assessing physicians' attitudes and behaviours that predict technology adoption has been an area of ongoing research.[11–18] A few studies investigate attitudes toward EHR adoption in inpatient[19] and academic ambulatory care settings.[20] Some have investigated adoption readiness using statewide survey samples of medical practices,[21–24] others have assessed physicians' perceptions of quality of care.[25] We know of no reports describing the attitudes and behaviours that predict EHR adoption, specifically e-prescribing adoption, in the primary care setting of an independent medical group.

In a brief review of existing survey instruments, Cork *et al* found that some important attributes and attitudes of physicians toward computers have not been explored, including for what purposes health professionals use computers and how much they know about technology.[14] Their review points out that instruments based on theoretical models and studies evaluating the psychometric properties of these are lacking. Dixon and colleagues' instrument[11–13] is one of a few based on a combination of theories – Rogers' innovation diffusion theory[26] and Davis' Technology Acceptance Model (TAM).[27,28] The TAM is related to the theories of reasoned action and planned behaviour.[29–31] Dixon developed his instrument, *Information Technology in Primary Care Practice*, by constructing the Information Technology Adoption Model (ITAM), basing it on a compilation of these theories. He also incorporated constructs from Marcolin *et al* who suggest that end-user sophistication can influence technology adoption.[32,33]

Dixon began development of the ITAM[11–13] (Figure 1) with each user bringing a level of sophistication to the new technology. Sophistication is composed of the user's breadth of knowledge and skills across a number of areas, depth or amount of knowledge and skills within a specific area and finesse, the user's ability to transfer knowledge and skills from one area to another. Sophistication coupled with available resources leads to the capabilities available to use the information technology (IT) innovation. Capabilities coupled with IT system requirements lead to IT–user fit. Rogers' and Davis' theories next come into play with the constructs of perceived usefulness and perceived ease of use. Perceived usefulness is comprised of the sub-domains of relative advantage (e.g. using the IT innovation will increase my productivity and efficiency), subjective norms (e.g. it is appropriate to use the IT innovation in my setting), compatability (e.g. using the IT innovation is a personal priority) and follow-up (e.g. use of the IT innovation will result in favourable outcomes). Perceived usefulness is comprised of the sub-domains of complexity (e.g. it is easy to master this IT innovation), change (e.g. using the IT innovation will result in positive change) and support (e.g. help will be available if needed). Davis found that



Bold boxes represent the domains of the ITAM

Figure 1 Information Technology Acceptance Model (ITAM)[11–13] perceived usefulness of an innovation and, to a lesser extent, perceived ease of use, affect a person's attitude toward adoption and intent to adopt. Behavioural intention, in turn, leads to actual adoption.[27,28] Dixon's ITAM applies these domains to the use of computers in medical care.

Well-constructed, easily-administered instruments may be useful in today's environment of limited resources and rapid deployment. Survey results can reveal what motivates physicians to adopt a technology, and can inform deployment strategies to minimise resistance. Dixon's instrument is intended to provide insights into the purposes for which physicians find computers useful and elicits a self-assessed estimate of computer knowledge. We applied it to gain insights into the use of an e-prescribing system. We administered Dixon's instrument to prescribers (physicians, physician assistants and nurse practitioners) and staff (nurses and medical assistants) in the primary care setting. Our primary purpose was to identify prescriber and staff (together: end-user) characteristics that would predict attitudes and behaviours toward e-prescribing adoption in the context of a pre-existing EHR. Our secondary purpose was to triangulate these results with a companion project we conducted during the same implementation – a systematic recording of 'lessons learned'.[34] To our knowledge, no other instrument has been administered specifically to predict acceptance of an e-prescribing deployment in the primary care setting of an independent medical group.

Methods

Setting

We conducted our study at The Everett Clinic, the largest independent medical group in Washington State. Physician owners and staff care for 275 000 patients in 16 locations in the northern Puget Sound region. Providers log 660 000 ambulatory care visits and write 2.7 million prescriptions annually. The clinic began internal development of the EHR in 1995, through an initiative led by its solely-owned IT subsidiary. The e-prescribing software was developed and implemented between 2003 and 2005. The e-prescribing system interfaces with EHR-based laboratory and radiology services and chart notes. It is web-based and uses point-and-click functionality. The system makes use of the drug database from Multum™ (Cerner, Denver, CO). It generates new and renewed prescriptions. Prescribers select medications from pull-down menus or from 'favourites' lists. Directions can be selected or typed as free text. During the study the e-prescribing system included only basic dosing guidance, duplicate therapy checks and, when the clinician entered a child's weight, a weight-based, paediatric dosing of drug, strength and bottle size (if liquid medication). Allergy, drug–drug interaction, drug–disease interaction, and laboratory monitoring alerts were added after completion of data collection. Clinic staff can queue prescriptions, but only licensed prescribers can sign and release them. Prescriptions can then be printed or electronically faxed to a pharmacy of the patient's choice.

Study design

We employed a quasi-experimental study design and administered Dixon's survey at three primary care sites: Silver Lake (SL), Harbour Pointe (HP) and Snohomish (Sno). We captured information at two time points. Phase 1 represented a hardware configuration and a stage of e-prescribing implementation unique to each site. SL was the only site at which e-prescribing had not yet been implemented. During Phase 2, all sites had been e-prescribing for two years, recently from desktops in examination rooms (Table 1). Interested readers can read about iterations of computer hardware and e-prescribing software configurations in one of our previous publications.[35]

Survey administration

We invited end-users to voluntarily complete one survey during each phase. Two reminders encouraging completion were sent via broadcast email. Prescriber responses were coded, with their written consent, so that investigators could pair them between phases. Because staff employment status is less stable, staff completed the survey under a waiver of consent; their responses were anonymised. The University of Washington Human Subjects Committee approved all study activities.

Information Technology in Primary Care Practice is comprised of 38 questions that cover the four domains of the ITAM: finesse, intent to use IT, perceived usefulness and perceived ease of use.[11–13] The 38th question addresses ease of installing a computer system; it was dropped because the system had already been installed. Responses to each question are recorded on a five-point Likert scale that ranges from 1 (strongly disagree) to 5 (strongly agree). The survey queries for age, gender, degree and type of primary care practice (family practice, internal medicine, paediatrics or walk-in clinic). Two questions elicit information about computer use at home – for professional or personal use; each coded dichotomously. A final question asks respondents to rate their self-assessed computer

Table 1 Hardware and software configurations, and characteristics of prescribers and staff

	Silver Lake (SL)		Harbour Pointe (HP)		Snohomish (Sno)	
Hardware and software configurations	Phase 1 (Winter/ Spring 2005)	Phase 2 (Spring 2007)	Phase 1 (Summer 2005)	Phase 2 (Winter/ Spring 2007)	Phase 1 (Fall/ Winter 2005)	Phase 2 (Fall/ Winter 2006)
Hardware availability and configuration (exposure time)	Basic (>5 yrs)	Final (2 months)	Basic (>5 yrs)	Final (1 week)	Basic (>5 yrs); plus prescriber laptops (4 months)	Final (1 month)
e-prescribing software (exposure time)	Absent	Present (>24 months)	Present (11 months)	Present (> 24 months)	Present (15 months)	Present (>24 months)
Type of e-prescriptions	N/A	New and refills	Refills	New and refills	Refills	New and refills
Basic = All sites used desktops in prescriber offices and clinic workstations Final = All sites used desktops in patient exam rooms						
Characteristics of prescribers and staff						
Prescribers						
Consented/employed (%)	8/10 (80%)	10/14 (71%)	12/15 (80%)	12/16 (75%)	8/8 (100%)	9/9 (100%)
Specialty						
Internal medicine	2	3	3	2	2	3
Family practice	3	3	5	6	4	4
Paediatrics	1	1	4	4	1	1
Walk-in clinic	2	3	0	0	1	1
Degree						
Medical doctor	7	10	8	8	8	9
Doctor of osteopathy	1	0	2	2	0	0
Nurse practitioner	0	0	2	2	0	0
Females/total consented (%)	3/8 (38%)	5/10 (50%)	5/12 (42%)	5/12 (42%)	5/8 (63%)	5/9 (56%)
Age, mean (range)	45 (38–50)	45 (34–52)	46 (35–55)	46 (37–57)	46 (35–60)	48 (36–61)
Staff (nurses and medical assistants)						
Consented/employed (%)	7/18 (39%)	8/19 (42%)	16/ 26 (62%)	17/28 (61%)	6/14 (43%)	4/11 (36%)
Females/total consented (%)	7/7 (100%)	7/8 (88%)	16/16 (100%)	17/17 (100%)	6/6 (100%)	4/4 (100%)
Age, mean (range)	44 (31–53)	47 (31–62)	37 (27–52)	41 (26–64)	49 (30–58)	51 (44–59)
Prescribers and staff, combined	15	18	28	29	14	13

knowledge on a 7-point visual analogue scale with anchors at 1 (novice) and 7 (expert). The survey instrument is available from the Survey Compendium website of the Agency for Healthcare Research and Quality.[36]

Statistical analysis

To ensure accuracy, two investigators entered survey data into a database. Prior to conducting the analysis, we assessed instrument performance by calculating internal consistency reliability, employing Cronbach's coefficient alpha.[37] We then answered five research questions. First, using Wilcoxon rank–sum tests, we evaluated whether responses to each of the domain scores changed between Phase 1 and Phase 2. Second, using chi-squared (χ^2) tests, we evaluated whether the proportion of end-users who used a computer at home for professional or personal use changed between Phase 1 and Phase 2. Third, using χ^2 tests, we assessed whether self-assessed computer knowledge changed between Phase 1 and Phase 2. To do so, we collapsed the 7-point visual analogue scale into three categories, representing *novice* (scores 1, 2 or 3), *intermediate* (4 or 5) or *expert* (6 or 7) computer knowledge. Fourth, using modelling techniques, we evaluated whether answers to the questions of computer use at home for professional or personal use predicted each domain score. For prescribers, we used a linear mixed model that accounted for the correlation within each prescriber who completed the survey during both phases. For staff, we used an ordinary least squares model. In both models we controlled for site and phase of implementation. Finally, using these same regression models, we evaluated whether scores on the question about self-assessed computer knowledge predicted each domain score. We stratified all analyses by type of end-user. To answer the first thee questions we also stratified by site. We used a *P*-value of 0.05 to establish significance throughout. All data were analysed using Stata 10.1 (StataCorp LP, College Station, TX).

Results

One-hundred-and-seventeen surveys were completed, out of a total possible number of 188 opportunities if each end-user had completed one survey in each phase. This represents a 62% response rate, overall; 82% for prescribers and 50% for staff. Fifty-nine surveys were completed by prescribers, 28 in Phase 1 and 31 in Phase 2. Fifty-eight surveys were completed by staff, 29 in each phase. Twenty-four prescribers completed a survey during each phase (Table 1). Cronbach's alpha reliability coefficients were 0.90 (finesse), 0.90 (intent to use IT), 0.92 (perceived usefulness) and 0.92 (perceived ease of use).

The median score for each of the domains is presented in Table 2. We combined the scores for HP and Sno, the two sites where e-prescribing had already been implemented in Phase 1, because the results for each domain and phase did not differ significantly between these sites. All scores but one (finesse for SL in Phase 1) were higher than the neutral score of 3. Median scores did not differ markedly across sites. Intent to use IT received the highest median scores, followed by perceived usefulness, perceived ease of use and finesse. SL scores increased from Phase 1 to Phase 2, and were significant for both prescribers and staff in terms of intent to use IT, and for perceived usefulness for staff. Table 3 illustrates that a higher proportion of prescribers than staff used a computer at home for professional use; proportions for personal use were also somewhat higher for prescribers than staff. There were no significant differences between phases in either type of computer use at home, although there was a significant difference between prescribers and staff in the number who used computers at home for professional use (SL, P=0.03; HP-Sno, P=0.002). There were no significant differences between phases in self-assessed computer knowledge (Figure 2). With the exception of SL staff in Phase 1, a greater proportion of prescribers and staff at each site considered themselves to possess an intermediate level of computer knowledge, rather than a novice or expert level. At both sites a greater proportion of prescribers and staff rated their computer knowledge as intermediate in Phase 2 than in Phase 1.

Because there were no differences between Phase 1 and Phase 2 in computer use at home for professional or personal use, or for self-assessed computer knowledge, to answer research questions four and five we included responses for both phases, and controlled for phase in each model. The results reveal that, for prescribers (but not staff), the use of a computer at home for professional use predicted improved scores on each of the four domains (Table 4). The most significant impact was seen for perceived usefulness. For example, the mean score on the Likert scale for the perceived usefulness domain was 0.68 points higher for prescribers who used a computer at home for professional use, compared with those who did not. Self-assessed computer knowledge predicted significantly improved scores on three of the four domains for prescribers, and on one domain for staff. For example, prescribers who rated their self-assessed computer knowledge as intermediate scored 0.99 points higher on the finesse domain than prescribers who rated themselves as novices. There was no association between computer use at home for personal use and domain scores.

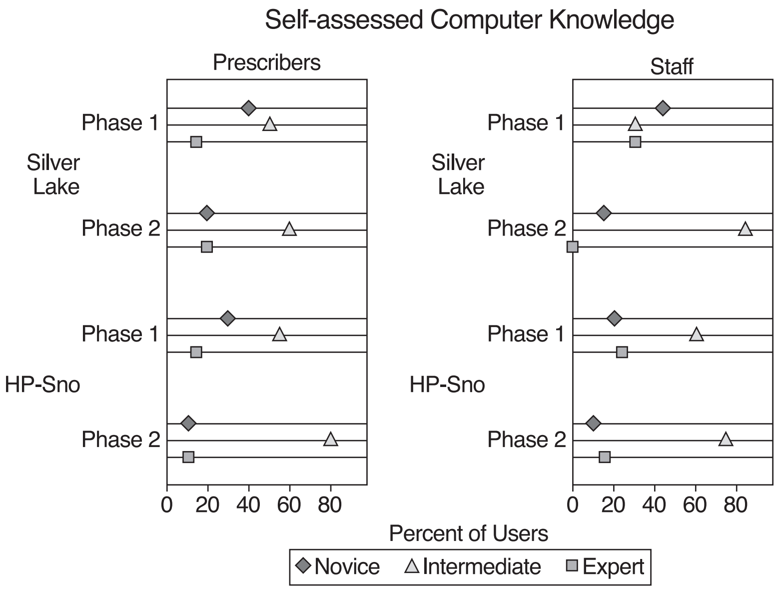
Table 2 Median domain scores, by site and professional role

	Silver Lake (SL)		Harbour Pointe and Snohomish (HP-Sno)	
	Phase 1 Median (range)	Phase 2 Median (range)	Phase 1 Median (range)	Phase 2 Median (range)
Prescribers	*n*=8	*n*=10	*n*=20	*n*=21
Finesse	2.8 (1.8–4.2)	3.1 (1.8–5)	3.1 (1.4–5)	3 (1.4–4.6)
Intent to use	4.8 (1–5)	5[a] (4.8–5)	4.8 (3–5)	4.8 (3.2–5)
Perceived usefulness	4.1 (1.7–4.9)	4.4 (3.4–5)	4.2 (2.7–4.9)	3.9 (2.1–4.8)
Perceived ease of use	3.2 (1.8–4.4)	3.8 (2–4.9)	3.5 (1.7–4.5)	3.5 (1.9–4.3)
Staff	*n*=7	*n*=8	*n*=22	*n*=21
Finesse	3 (1–3.8)	4 (2–5)	3.7 (2.6–5)	3.4 (1.8–5)
Intent to use	4 (1.8–4.6)	5[b] (3.6–5)	5 (3.6–5)	5 (4–5)
Perceived usefulness	3.7 (1.9–4.1)	4.6[c] (2.9–4.9)	4.7 (3.2–5)	4.5 (3.7–4.9)
Perceived ease of use	3.3 (1.8–4)	3.7 (2.5–4.8)	4 (2.1–4.9)	3.9 (3–4.7)

[a] $P<0.04$ for difference between Phase 1 and Phase 2 for SL prescribers
[b] $P<0.03$ for difference between Phase 1 and Phase 2 for SL staff
[c] $P<0.02$ for difference between Phase 1 and Phase 2 for SL staff

Table 3 Computer use at home, by site and professional role

	Silver Lake (SL)		Harbour Pointe and Snohomish (HP-Sno)	
	Phase 1 *n* (%)	Phase 2 *n* (%)	Phase 1 *n* (%)	Phase 2 *n* (%)
Prescribers	*n*=8	*n*=10	*n*=20	*n*=21
Computer use at home, professional use	5 (63)	8 (80)	14 (70)	16 (76)
Computer use at home, personal use	8 (100)	10 (100)	20 (100)	21 (100)
Staff	*n*=7	*n*=8	*n*=22	*n*=21
Computer use at home, professional use	2 (29)	3 (38)	8 (36)	9 (43)
Computer use at home, personal use	6 (86)	8 (100)	22 (100)	18 (86)



HP-Sno = Harbour Pointe-Snohomish sites

Figure 2 Self-assessed computer knowledge

Discussion

Box 1 What this paper adds

- A limited number of survey instruments designed to assess physicians' attitudes toward EHR adoption in medical practice have been developed. A few are based on theoretical constructs, some are lengthy; most have been used in the setting of academic medical centres. None has been embraced for widespread use.
- A brief survey instrument, based on theoretical constructs, that assesses attitudes toward adoption of EHRs and e-prescribing may be useful in informing strategies for successful adoption. We used a theoretically-based, 37-item instrument covering four domains (finesse, intent to use, perceived usefulness, perceived ease of use) to assess prescribers and staff attitudes toward e-prescribing implementation in a primary care setting; the instrument elicits information about computer use at home and self-assessed computer knowledge.
- Computer use at home for professional purposes and self-assessed computer knowledge were associated with higher domain scores.
- These findings suggest the instrument may be useful in identifying characteristics of users and in tailoring implementation strategies that will optimise adoption.

Principal findings

The results of our research suggest that *Information Technology in Primary Care Practice* can provide meaningful results in today's environment, in the context of e-prescribing implementation, for both prescribers and staff. Our reliability coefficients were high. The responses suggest the instrument has both face and content validity in our setting. That all but one median domain score was higher than neutral throughout the study suggests end-users in this setting were willing to embrace adoption. That respondents most strongly agreed with the intent to use information technology could be due to the fact that, despite adoption initially being voluntary, clinic leadership made clear that all sites would eventually adopt e-prescribing. Respondents at all sites felt e-prescribing would be useful. The lower scores for finesse suggest that respondents were more reserved in their perceived skill level. That the domain scores improved between Phase 1 and Phase 2 only for respondents at SL suggests that the initial hurdle had already been overcome by those who were already e-prescribing in Phase 1 (HP-Sno). The lower scores in Phase 1 at SL could be due to 'computer anxiety', that is, apprehension, hesitation and confusion around using computers – a concept previously measured by others.[14] It is encouraging that the scores for intent to use IT and for perceived usefulness significantly improved after implementation at SL. That a larger proportion of prescribers than staff used a computer at home for professional use, and that the proportion of SL prescribers who did the same was higher in Phase 2, suggests that prescribers found it

Table 4 Regression model coefficients, by prescribers and staff

Dependent variable	Independent variable	Regression coefficient,* *P*-value; (95% CI)	Regression coefficient,* *P*-value; (95% CI)
		Prescribers	Staff
Computer use at home for professional use and domain scores			
Finesse	Computer use at home for professional use	0.62, 0.04; (0.03, 1.22)	0.25, 0.34; (–0.27, 0.77)
Intent to use	Computer use at home for professional use	0.49, 0.01; (0.13, 0.86)	0.08, 0.53; (–0.18, 0.35)
Perceived usefulness	Computer use at home for professional use	0.68, 0.001; (0.28, 1.08)	0.11, 0.47; (–0.19, 0.41)
Perceived ease of use	Computer use at home for professional use	0.50, 0.02; (0.08, 0.93)	–0.01, 0.96; (–0.34, 0.33)
Self-assessed computer knowledge and domain scores			
Finesse	Self-assessed computer knowledge	0.95, <0.001; (0.59, 1.30)	0.35, 0.11; (–0.08, 0.79)
Intent to use	Self-assessed computer knowledge	0.14, 0.33; (–0.14, 0.43)	–0.04, 0.70; (–0.27, 0.18)
Perceived usefulness	Self-assessed computer knowledge	0.40, 0.01; (0.10, 0.71)	0.12, 0.35; (–0.13, 0.38)
Perceived ease of use	Self-assessed computer knowledge	0.56, <0.001; (0.28, 0.84)	0.41, 0.003; (0.15, 0.67)

* Linear mixed models (prescribers) or ordinary least square models (staff); controlling for phase and site
CI=confidence intervals

beneficial to e-prescribe from home. It was the SL staff who improved in their self-assessed computer knowledge; perhaps they were able to overcome their apprehension, and actual use increased their confidence.

Answers to the two questions of whether computer use at home or self-assessed computer knowledge predict domain scores may be useful in developing strategies to guide implementation. Prescribers who indicated they used a computer at home for professional use, and those who classified themselves as possessing at least an intermediate level of computer knowledge, achieved higher scores on most domains. Why these associations were not noted for staff can perhaps be attributed to differences in professional role functions. Prescribers are responsible for e-prescribing; staff for queuing refill requests for approval. Staff are also less likely to use a computer for professional use while at home. Our results suggest the answers to the computer use and computer knowledge questions can be used to stratify prescribers into groups so that they may receive education and training customised to their unique roles and levels of expertise.

In our companion study of 'lessons learned', we noted strategies that facilitated adoption.[34] Several of these are aligned with our survey results. E-prescribing implementation was led from the highest level of the organisation, hence intent to use IT was high. Iterative rollout enabled users to overcome the initial anxiety associated with adoption. Intensive training and technical support facilitated adoption by users at all skill levels. Those who were more skilled (early adopters) trained those who required assistance. Demonstrations of use were helpful; Beiter *et al* found the same.[38] Prescribers were enthusiastic about the ability to prescribe from home, which may correlate with the proportion of prescribers who indicated that they use a computer at home for professional use, especially the increase seen for SL prescribers, when comparing Phase 2 with Phase 1. This in turn was associated with scores on the four domains.

Implications of the findings

The results of our study, coupled with our triangulation exercise, suggest that use of the survey instrument *Information Technology in Primary Care* facilitated identification of users that may benefit from support to successfully adopt the e-prescribing innovation.

Comparison with the literature

Researchers other than Dixon and colleagues have found TAM-based instruments useful for predicting adoption of computers in medicine.[15,39] Using an extended version of TAM, Chismar and Wiley-Patton found that perceived usefulness was the only construct that predicted intent to use, which ultimately predicts acceptance.[39] Dansky *et al* isolated the perceived usefulness construct as being the most important predictor of behavioural intention.[15] They also incorporated the construct of computer anxiety, which may be the negative expression of finesse. Kaushal *et al* administered a survey to populations of physicians to compare characteristics of those who use EHRs, those who do not, and those who plan to adopt EHRs within 12 months ('imminent adopters').[22] They found imminent adopters were more experienced in the use of technology, a construct similar to finesse. Other investigators have used an a priori framework to assess physicians' expectations, demands, acceptability, experience and knowledge of computer-based consultation systems.[18] Using these same domains, Cork *et al* developed an 89-question instrument, added the 'computer optimism' construct and validated the psychometric properties of the instrument with physicians across a collection of academic medical centres.[14] They demonstrated that questions about self-assessed computer knowledge are valid predictors of performance on questions that tested *actual* computer knowledge, which was strongly correlated with computer usage. In an academic ambulatory setting, Schectman *et al* evaluated the relationship between physician experiences and attitudes and e-prescribing adoption.[20] They found a strong association between self-reported and actual system use. Although using a version of Cork and colleagues' instrument, Schectman *et al* found that prior computer experience did not affect actual use, although it diminished anxiety.

Dixon and Stewart's pilot study most closely resembles our current study.[13] Using a cross-sectional study design, they administered their survey to a group of family practice physicians who had self-stratified into categories of low, intermediate, and high users of IT. They found a significant difference among groups for each of the four domains ($P<0.001$). Our present study extends these earlier findings to respondents who were actually e-prescribing when surveyed. In this setting, too, we found finesse, perceived usefulness and perceived ease of use to be important constructs, as they are predicted by self-assessed computer knowledge. We found the relationship with intent to use less striking. Perhaps this construct is less valuable when eventual use is a foregone conclusion.

Strengths and limitations

Strengths of our study include the underlying theoretical construct of the instrument, the high reliabilities and the fact that we included staff as well as prescribers. There are also limitations. The ITAM model was designed to describe individual adoption behaviour. Individuals are also affected by the surrounding system and culture. These are not captured by Dixon's instrument. Triangulating with our lessons learned enriches the context. Generalisability may be limited to the primary care setting, and the fact that the EHR and e-prescribing system were internally developed. Users' responses may reflect the fact that electronic transmission of prescriptions was limited to computer faxing; the system lacked full functionality to transmit to a receiving computer. Because our research design followed The Everett Clinic's implementation schedule, the SL site provided the only truly pre- and post-implementation comparison. Participation was voluntary, and the participation rate for staff was lower than desired. We do not know whether our results are representative of the entire population of users. Because of the anonymity of the staff responses, we were unable to account for correlation among these.

Future development and conclusions

In today's environment, demands on prescriber and staff time require the use of succinct survey instruments. We believe that questions mapping to the domains of Dixon's instrument can predict adoption acceptance in a parsimonious fashion. The results of our work provide quantitative evidence in support of this idea. By allowing users to self-classify using a structured survey approach, those most likely to benefit from education and training can be more easily identified, perhaps enabling a more efficient use of limited resources. A brief survey tool that achieves these ends may be useful to those leading implementation efforts and investing allocated resources in the coming years.

AUTHOR CONTRIBUTIONS

EB Devine was responsible for conception and design of the study, assisted in data acquisition, conducted the analysis, interpreted the results, drafted the manuscript and is responsible for intellectual content. R Patel assisted in data analysis, interpreted the results, assisted in drafting and critically reviewed the manuscript for intellectual content. D Dixon created the instrument, provided guidance for data analysis, and critically reviewed the manuscript for intellectual content. SD Sullivan conceived the study design, interpreted the analysis, and critically reviewed the manuscript for intellectual content.

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REFERENCES

1 Dick RS. *The Computer-based Patient Record: an essential technology for health care*. Washington, DC: National Academies Press, 1991.
2 Dick RS. *The Computer-based Patient Record: an essential technology for health care, Revised edition*. Washington, DC: National Academies Press, 1997.
3 *Crossing the Quality Chasm: the IOM Healthcare Quality Initiative*. Washington, DC: National Academies Press. 2008. www.iom.edu/Global/News%20Announcements/Crossing-the-Quality-Chasm-The-IOM-Health-Care-Quality-Initiative.aspx (accessed 27 August 2010).
4 DesRoches CM, Campbell EG, Rao SR *et al*. Electronic health records in ambulatory care: a national survey of physicians. *New England Journal of Medicine* 2008;359: 50–60.
5 Ash JS and Bates DW. Factors and forces affecting EHR system adoption: report of a 2004 ACMI discussion. *Journal of the American Medical Informatics Association* 2005;12:8–12.
6 Middleton B, Hammond WE, Brennan PF and Cooper GF. Accelerating US EHR adoption: how to get there from here. Recommendations based on the 2004 ACMI retreat. *Journal of the American Medical Informatics Association* 2005;12:13–19.
7 Gans D, Kralewski J, Hammons T and Dowd B. Medical groups' adoption of electronic health records and information systems. *Health Affairs (Millwood)* 2005;24: 1323–33.
8 Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW and Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in US hospitals. *Health Affairs (Millwood)* 2004; 23:184–90.
9 HR1. *American Recovery and Reinvestment Act of 2009*. 2009. frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_billsanddocid=f:h1enr.pdf (accessed 27 August 2010).
10 Crosson JC, Isaacson N, Lancaster D *et al*. Variation in electronic prescribing implementation among twelve ambulatory practices. *Journal of General Internal Medicine* 2008;23:364–71.
11 Dixon DR and Dixon BJ. Adoption of information technology enabled innovations by primary care physicians: model and questionnaire development. *Proceedings of the Annual Symposium on Computer Application in Medical Care* 1994:631–5.
12 Dixon DR. The behavioral side of information technology. *International Journal of Medical Informatics* 1999;56:117–23.
13 Dixon DR and Stewart M. Exploring information technology adoption by family physicians: survey instrument valuation. *Proceedings of the AMIA Symposium* 2000:185–9.
14 Cork RD, Detmer WM and Friedman CP. Development and initial validation of an instrument to measure physicians' use of, knowledge about, and attitudes toward computers. *Journal of the American Medical Informatics Association* 1998;5:164–76.
15 Dansky KH, Gamm LD, Vasey JJ and Barsukiewicz CK. Electronic medical records: are physicians ready? *Journal of Healthcare Management* 1999;44:440–54; discussion 54–5.
16 Gadd CS and Penrod LE. Assessing physician attitudes regarding use of an outpatient EMR: a longitudinal, multi-practice study. *Proceedings of the AMIA Symposium* 2001:194–8.
17 Penrod LE and Gadd CS. Attitudes of academic-based and community-based physicians regarding EMR use during outpatient encounters. *Proceedings of the AMIA Symposium* 2001:528–32.
18 Teach R and Shortliffe EH. An analysis of physician attitudes regarding computer-based clinical consultation systems. *Computers and Biomedical Research* 1981;14:542–58.
19 Wakefield DS, Halbesleben JR, Ward MM, Qiu Q, Brokel J and Crandall D. Development of a measure of clinical information systems expectations and experiences. *Medical Care* 2007;45:884–90.
20 Schectman JM, Schorling JB, Nadkarni MM and Voss JD. Determinants of physician use of an ambulatory prescription expert system. *International Journal of Medical Informatics* 2005;74:711–17.
21 Simon SR, Kaushal R, Cleary PD *et al*. Correlates of electronic health record adoption in office practices: a statewide survey. *Journal of the American Medical Informatics Association* 2007;14:110–17.
22 Kaushal R, Bates DW, Jenter CA *et al*. Imminent adopters of electronic health records in ambulatory care. *Informatics in Primary Care* 2009;17:7–15.

23 Menachemi N. Barriers to ambulatory EHR: who are 'imminent adopters' and how do they differ from other physicians? *Informatics in Primary Care* 2006;14:101–8.
24 Stream GR. Trends in adoption of electronic health records by family physicians in Washington State. *Informatics in Primary Care* 2009;17:145–52.
25 El-Kareh R, Gandhi TK, Poon EG *et al*. Trends in primary care clinician perceptions of a new electronic health record. *Journal of General Internal Medicine* 2009;24:464–8.
26 Rogers EM. *Diffusion of Innovations*. New York: The Free Press, 1995.
27 Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 1989:318–40.
28 Davis FD, Bagozzi RP and Warshaw PR. User acceptance of computer technology: a comparison of two theoretical models. *Management Science* 1989;35:982–1001.
29 Topi H. *Modeling Individual Decisions on the use of Information Technologies: integration of two theoretical perspectives*. Diffusion Interest Group in IT (DIGIT), presentation, 1994.
30 Mathieson K. Predicting user intentions: comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research* 1991;2:173–91.
31 Ajzen I. From intentions to actions: a theory of planned behavior. In: Kuhl J and Beckmann J (eds) *Action Control: from cognition to behavior*. Berlin: Springer-Verlag, 1985.
32 Marcolin B, Huff SL and Munro MC. End user sophistication: measurement and research model. *Administrative Sciences Association of Canada* 1992:108–20.
33 Marcolin BL, Huff SL, Compeau DR and Munro MC. End user sophistication: a multitrate–multimethod analysis. *Administrative Sciences Association of Canada* 1993: 110–21.
34 Devine EB, Wilson-Norton JL, Hansen R, Hollingworth W, Fisk AW and Sullivan SD (eds) *Implementing an Ambulatory E-Prescribing System: strategies employed and lessons learned to minimize unintended consequences*. Rockville, MD: Agency for Healthcare Research and Quality, 2008. Publication No. 08-0034-4.
35 Devine EB, Hollingworth W, Hansen RN *et al*. Electronic prescribing at the point of care: a time–motion study in the primary care setting. *Health Services Research* 2010;45:152–71. Epub. 19 November 2009.
36 Agency for Healthcare Research and Quality. *Health IT Survey Compendium. No. 74*. healthit.ahrq.gov/portal/server.pt?open=514andobjID=12714andparentname=CommunityPageandparentid=6andmode=2andin_hi_userid=3882andcached=true (accessed 27 August 2010).
37 DeVellis RF. Classical test theory. *Medical Care* 2006; 44:S50–9.
38 Beiter PA, Sorscher J, Henderson CJ and Talen M. Do electronic medical record (EMR) demonstrations change attitudes, knowledge, skills or needs? *Informatics in Primary Care* 2008;16:221.
39 Chismar WG and Wiley-Patton S. Test of the technology acceptance model for the internet in pediatrics. *Proceedings of the AMIA Symposium* 2002:155–9.

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ETHICS

The University of Washington Human Subjects Committee approved all activities in this study.

CONFLICTS OF INTEREST

None.

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