

# Beyond technology acceptance to effective technology use: a parsimonious and actionable model

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## ABSTRACT

**Objective** To develop and test a parsimonious and actionable model of effective technology use (ETU).

**Design** Cross-sectional survey of primary care providers ( $n=53$ ) in a large integrated health care organization that recently implemented new medication reconciliation technology.

**Methods** Surveys assessed 5 technology-related perceptions (compatibility with work values, implementation climate, compatibility with work processes, perceived usefulness, and ease of use) and 1 outcome variable, ETU. ETU was measured as both consistency and quality of technology use.

**Results** Compatibility with work values and implementation climate were found to have differential effects on consistency and quality of use. When implementation climate was strong, consistency of technology use was high. However, quality of technology use was high only when implementation climate was strong and values compatibility was high. This is an important finding and highlights the importance of users' workplace values as a key determinant of quality of use.

**Conclusions** To extend our effectiveness in implementing new health care information technology, we need parsimonious models that include actionable determinants of ETU and account for the differential effects of these determinants on the multiple dimensions of ETU.

**Key words:** Effective Technology Use, Technology Acceptance, Technology Implementation Effectiveness, Medication Reconciliation, Patient Safety

## INTRODUCTION

A well-documented source of prescribing error, medication discrepancies fundamentally contribute to preventable adverse drug events (PADEs), increased mortalities, and rising health care costs.<sup>1–7</sup> Although some researchers suggest medication reconciliation (MR) can substantially reduce such discrepancies, their approach to implementation is varied.<sup>8–11</sup> Systematic reviews of MR practices often include clinical pharmacists at key handoffs in care.<sup>4–6,10,12,13</sup> However, some organizations may not be equipped to adopt this somewhat cost-prohibitive approach.<sup>4,5,14,15</sup> Therefore, those aiming to improve MR practices with existing resources need to determine which interventions and redesign efforts will have the greatest sustainable impact on adoption and performance.<sup>5</sup>

A federally funded health care organization with a primary care division that completes an estimated 84,800 outpatient visits per year championed a program to improve the accuracy and sustainability of ambulatory medication reconciliation.

The organization's medical informatics division developed self-service check-in kiosks to collect medication history from patients in advance of their clinic interview and route responses to the provider using the legacy electronic health record (EHR). The kiosk was conceived as a standardized way to address many of the known obstacles to MR, including clinician time constraints, fragmented information sources, and variable patient health literacy.

## BACKGROUND AND SIGNIFICANCE

Health care literature is replete with examples of health care information technologies (HITs) in use that have encountered resistance, underuse, workarounds, and overrides.<sup>16–23</sup> Many researchers have attempted to address this challenge by developing models which help explain and predict user reactions to new HIT. The Technology Acceptance Model (TAM) and its derivatives (TAM2, Unified Theory of Acceptance and Use of Technology, TAM3<sup>24–26</sup>) are often cited in the literature and

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identify many of the variables influencing user perceptions of HIT and tool adoption.<sup>16,27–35</sup> However, several important limitations restrict the utility of these models.

First, many of the included variables are technology specific (eg, results demonstrability) or are based on individual difference factors (eg, personal innovativeness).<sup>20,36–38</sup> These predictors have little utility for change agents as they are beyond the agents' control and are not actionable. Second, these models most often measure individuals' *intentions to use* a new HIT or the *frequency* of use.<sup>24–35,39–44</sup> Thus, extant models do not capture the notion that outcomes from HIT stem from *how effectively* the technology is used. Third, past research overlooks the fact that predictors may relate differentially to different dimensions of use—frequency of use vs quality of use. Responding to Holden and Karsh's<sup>16</sup> call for an “evolved theory” that leads to deeper understanding of technology adoption and use, we have formulated a model of effective technology use (ETU) that includes a parsimonious set of generic, robust (theory-based), and actionable predictors and offers pragmatic guidance to technologists and change agents alike.

## DERIVATION OF THE RESEARCH MODEL

TAM proposes that the following 2 end-user perceptions predict technology acceptance: (1) *usefulness* (the degree to which a person believes that using a particular technology would enhance job performance; and (2) *ease of use* (the degree to which technology use is believed to be free from effort. In an effort to improve the predictability of TAM, numerous additions have been offered. Predictors included in these “added variable models” can be classified into the following 4 types of determinants: (1) individual difference factors (personality or demographic factors); (2) system characteristics (attributes of the information technology (IT)); (3) social influence factors (the social pressures and processes that affect individuals' perception of a new IT); and (4) facilitating conditions (the organizational practices and policies put in place to support the use of a new IT).<sup>16,26</sup> While these expanded models have contributed to our understanding of HIT acceptance and use, a consolidation of the findings into a parsimonious, robust (theory-based), and actionable model with applicability across health care technologies is useful. Our review of the literature and the development of our hypotheses were conducted with these goals in mind. We note constructs that have repeatedly been included in models of health care technology acceptance and have strong empirical support.

A tension that underlies the proliferation of TAM-based models in health care is the controversy over the need for highly contextualized vs generic determinants.<sup>16,26,28,45</sup> While we agree that contextualization helps uncover specific and actionable causes of generic variables, we propose that there is support for a “middle ground approach.” For example, we agree the meaning of usefulness changes as we move across differing HITs; however, we propose that the variable “compatibility with workplace values” is a generic construct that at the same time contextualizes perceived usefulness (predicts how useful a *specific* HIT will be perceived to be). In sum, our

proposed model offers an integration of past research and reconciles many of the issues that currently plague the research base, making for a model that is not only parsimonious and robust but also actionable, with high utility for those tasked with developing and implementing HIT.

## RESEARCH MODEL AND HYPOTHESES DEVELOPMENT

Our research model, the Effective Technology Use Model (ETUM) is shown in figure 1. In this section, we define each of the constructs in the research model and explicate the causal mechanisms that underlie our hypotheses.

### Determinants Of Usefulness, Ease Of Use, And Effective Technology Use

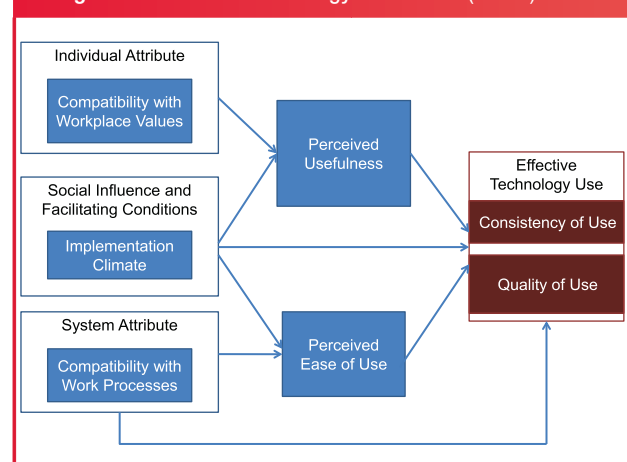
#### Compatibility

The role of compatibility beliefs is a recurrent theme in technology acceptance literature.<sup>29,31,32,36, 40,41,46–53</sup> Compatibility assesses the extent of congruence or “fit” between an information technology and aspects of the individual or the situation in which the technology will be used. Karahanna et al<sup>46</sup> notes that compatibility is a widely researched but poorly operationalized construct, with the majority of studies examining only limited aspects of the compatibility construct or combining differing aspects of the construct such that meaningful relationships are obscured. Following Karahanna et al,<sup>46</sup> we differentiate 2 distinct and actionable types of compatibility—compatibility with workplace values and compatibility with existing work processes.

#### Compatibility with Workplace Values

A review of the literature suggests that users' workplace values may be a potent predictor of perceived usefulness and technology acceptance.<sup>46,54,55</sup> It is well documented that clinicians interpret differently what is useful about HIT. We propose that clinicians' workplace values drive these differing perceptions of usefulness. For example, one physician may value patient involvement in decision making, whereas another may value physician autonomy in decision making. These differing

Figure 1: Effective Technology Use Model (ETUM).



workplace values will influence perceptions of the usefulness of a patient-centered HIT.

Consistent with the research by Karahanna et al.<sup>46</sup> and Liang et al.<sup>36</sup> we hypothesize that compatibility with users' workplace values is a determinant of perceived usefulness. Thus, in contrast to prior research, which has predominantly regarded beliefs about compatibility as an independent predictor of technology acceptance,<sup>25,29,31,32,34</sup> we propose that perceived usefulness will fully mediate the effect of compatibility with workplace values on effective technology use.<sup>46,47,51,56</sup>

Hypothesis 1: Perceived usefulness will fully mediate the effect of compatibility with workplace values on effective technology use.

### Climate for Implementation

Climate for implementation, the extent to which technology use is perceived as expected, supported, and rewarded, captures the effects of social influence and facilitating conditions. Social influence is the degree to which an individual perceives that others (eg, supervisors, peers, patients, regulatory bodies) believe she or he should or should not adopt the new technology.<sup>16,25,57</sup> Facilitating conditions are the managerial practices and policies put in place to support and reward technology use.<sup>25</sup>

Studies indicate that differing types of social influence and differing sets of practices and policies can lead to the same level of technology acceptance.<sup>54,58</sup> Thus, effects of social influence processes and facilitating conditions on technology acceptance may best be understood as a process that is *equifinal*.<sup>54,58–60</sup> Equifinality pushes researchers away from the search for a *precise* set of social influence factors and organizational practices and policies that lead to technology acceptance, and focuses attention on users' perceptions of the extent to which HIT use is encouraged, supported, and rewarded in the organization.

Based on prior research, we propose that climate for implementation impacts users' perceptions of the technology (usefulness and ease of use) as well as technology use itself.<sup>24,57,61–63</sup>

Hypothesis 2: Perceived usefulness will partially mediate the effect of climate for implementation on effective technology use.

Hypothesis 3: Perceived ease of use will partially mediate the effect of climate for implementation on effective technology use.

### Compatibility with Work Processes

Compatibility with work processes is the extent to which a new technology is perceived as consistent with existing work processes and may be thought of as a proxy for the degree or extent of change required in work methods.<sup>46</sup> Behavioral decision

theory suggests individuals make *initial* ease of use assessments based on past experiences with similar systems.<sup>64</sup> The human associative view of learning specifies that people's ability to learn new things is affected by prior experience.<sup>65</sup> Technologies perceived as compatible with existing work processes facilitate the learning process.

Thus, based on decision and learning theories, we propose that compatibility with existing work practices will be a significant predictor of perceived ease of use.<sup>46,66</sup> Partial mediation is proposed because a new technology can be highly compatible with existing work practices but still be very complicated to use (ie, high cognitive effort is required for skillful technology use).

Hypothesis 4: Perceived ease of use will partially mediate the effect of compatibility with work processes on effective technology use.

### Differential Effects of Values Compatibility and Climate on Quality of Use and Consistency of Use

Research on conformity and commitment implies that employees who perceive technology use to be congruent with their important workplace values are more likely to be committed and enthusiastic in their technology use; whereas individuals who perceive technology use as a means to avoid punishments or obtain rewards are likely to be compliant but not wholly invested in their technology use.<sup>67,68</sup>

Because a strong implementation climate provides social pressures and incentives for technology use, it may foster compliant technology use.<sup>54</sup> However, a strong climate does not ensure that the technology is congruent with users' workplace values. We propose that skillful, internalized, and committed technology use takes both a strong climate for implementation and a technology that is perceived as compatible with users' important workplace values.

Hypothesis 5: When the implementation climate is strong but values compatibility is low, consistency of technology use will be high, but quality of technology use will be low.

Hypothesis 6: When the implementation climate is strong and values compatibility is high, consistency and quality of technology use will be high.

## METHODS

### Research Sample and Data Collection Methods

To test our model, we gathered survey data about the MR kiosk implementation from medical providers working in 6 geographically dispersed primary care clinics. Details of the technology design are published elsewhere.<sup>69</sup> At the time of our data collection, medical providers had access to the HIT for approximately 21 months. Two senior members of the research team administered the survey at monthly clinic staff meetings to all 111 primary care providers and internal medicine residents. All data were collected anonymously. Completed surveys were

received from 91 primary care staff providers and residents for an overall response rate of 82%. Of the 91 staff providers and residents responding to the survey, 38 indicated that either they did not know of the HIT or they knew about the HIT but had not seen the output in the patient's electronic health record. Although all surveyed providers worked in clinic locations where the HIT was deployed, there were several reasons why these 38 providers may not have known of the HIT or had not seen the output in the patient's electronic health record. First, providers and residents new to a clinic may have been unfamiliar with the technology. Second, for a provider to see the MR output in the EHR, the patient must have agreed to check-in using the self-service kiosk, and a mid-level staff member must have inserted the collected data into a standard intake note. Respondents that did not know about the HIT or had not seen the output were directed to skip to the last page of the survey and provide demographic data only.

## Measures

Items for all scales used in tests of the research hypotheses are published online as Appendix A. Validated scales used in prior studies were adapted for this study and were used to measure climate for implementation,<sup>70,71</sup> compatibility with work processes,<sup>72–74</sup> perceived usefulness,<sup>72–74</sup> perceived ease of use,<sup>72–74</sup> and consistency of use.<sup>71</sup> We developed new scales to measure compatibility with workplace values and quality of HIT use.

The compatibility with work values scale was based on research literature.<sup>10,75–77</sup> Compatibility with work values was measured as the extent to which providers valued the task of doing medication reconciliation with their patients. All survey items were piloted with 2 sequential groups of primary care providers to ensure that wording and formatting were clear and potential for bias was minimized.

Effective technology use was operationalized as both the *quality* with which providers employed the HIT to perform medication reconciliation and the *consistency* with which they employed it. The legacy EHR database and HIT logs did not support a valid means to measure quality of use. Therefore, we developed a new scale using the same methodology as described and validated by Holahan et al.<sup>71</sup> We asked respondents to indicate how they were currently using the HIT. Each of the 10 use statements was assigned a weight representing quality of use. The weights were derived via consensus among subject matter experts, each with over a decade of medical experience and all well versed in the complexity of the medication reconciliation task. The weights varied from 3 to 9, and the aggregate score across all tasks was used as an index for quality of technology use. For example, using the HIT to identify medication discrepancies between a clinic's records and a patient's self-report is a rather rote use of the technology and was given a weight of 4. By calculating each provider's score as the sum of the positive ratings across the 10 weighted tasks, we were able to assess the extent to which the provider was using the technology in a quality or skillful way. We calculated an aggregate score across all tasks ranging from 0 to 65 and used it as

a measure of quality of use. A score of 0 indicated providers did not use the HIT to address MR. Effective technology use was computed by standardizing respondents' scores for consistency and quality of use and then summing the standardized means.

Responses for compatibility with work values, climate, compatibility with work processes, perceived usefulness, and perceived ease of use scales were measured using a 5-point Likert scale anchored by "1 = strongly disagree" and "5 = strongly agree." Consistency of use was measured on a 5-point Likert scale with "never," "rarely," "sometimes," "usually," and "always or almost always."

Descriptive statistics and psychometric properties of the scales are reported in tables 1 and 2. We tested the convergent and discriminant validity of our variables using Fornell and Larcker's<sup>78</sup> and Chin's<sup>79</sup> criteria. The measured variables evidenced acceptable convergent and discriminant validity.

## RESULTS

### Preliminary Analyses

We conducted *t* tests to determine if the 38 respondents who did not know of the HIT or had not seen the output in the patient's electronic health record differed from the 53 respondents included in the analysis. No significant differences were found with respect to age, sex, or years in practice. Prior to conducting tests of our hypotheses, we also tested the normality of our variables. All variables evidenced a normal or nearly normal distribution.

### Hypotheses Tests

We tested hypotheses 1 through 4 using multiple regression analysis and Baron and Kenny's<sup>80</sup> approach for testing mediation hypotheses. Baron and Kenny's method for testing mediation is a very conservative test—it is likely an effect will go undetected unless it is large, and the probability of committing a type I error is low.<sup>81</sup>

Hypothesis 1 states that perceived usefulness will fully mediate the effect of values compatibility on ETU. As seen in Table 3, values compatibility is positively related to both usefulness in Model A ( $\beta = .35; P = .01$ ) and ETU in Model B ( $\beta = .32; P = .02$ ). Values compatibility is not significantly related to ETU in Model C when the mediator, perceived usefulness, is controlled for ( $\beta = .10; P = .43$ ). Thus, hypothesis 1 is supported.

Hypothesis 2 states that usefulness will partially mediate the effect of climate for implementation on ETU. As seen in table 3, climate for implementation is positively related to both usefulness in Model A ( $\beta = .40; P = .005$ ) and ETU in Model B ( $\beta = .44; P = .002$ ). Climate is also related to ETU when the mediator usefulness is controlled for in Model C ( $\beta = .27; P = .04$ ). However, the strength of the relationship is diminished, supporting partial mediation. To confirm this partial mediation effect, we applied Sobel's<sup>82</sup> significance test ( $P = .02$ ). Thus, hypothesis 2 is supported.

Hypothesis 3 states that ease of use will partially mediate the effect of implementation climate on ETU. In table 4, climate



Table 1: Descriptive statistics and scale properties for the measured variables ( $n = 53$ )

Construct	Min	Max	Mean	SD	Cronbach $\alpha$	AVE	Composite Reliability	Inter-Construct Correlations						Quality of Use	ETU
								Values Compat	Climate	Compat w WP	Usefulness	Ease of Use	Consis of Use		
Values Compat	1.00	4.86	3.63	.78	.85	.56	.90	(.75) <sup>a</sup>							
Climate	2.14	4.43	3.13	.44	.75	.43	.84	.12	(.66) <sup>a</sup>						
Compat w WP	1.00	4.75	2.97	.58	.84	.66	.89	.67**	.15	(.81) <sup>a</sup>					
Usefulness	1.00	4.25	3.12	.75	.92	.63	.93	.52**	.44**	.52**	(.79) <sup>a</sup>				
Ease of Use	1.67	4.33	3.04	.72	.74	.65	.85	.40**	.34*	.52**	.63**	(.81) <sup>a</sup>			
Consis of Use	1.00	5.00	3.67	1.12	–	–	–	.16	.42**	.30*	.47**	.38**	–		
Quality of Use	0.00	65.00	42.12	18.55	–	–	–	.41**	.43**	.36*	.63**	.53**	.58	–	
ETU	–3.75	2.42	.08	1.74	–	–	–	.37*	.47**	.38**	.62**	.52**	.88	.89	–

SD, Standard deviation; AVE, Average variance extracted; Values Compat, Values compatibility; Climate, Climate for implementation; Compat w WP, Compatibility with work process; Usefulness, Perceived usefulness; Ease of Use, Perceived ease of use; Consis of Use, Consistency of use; ETU, Effective technology use.

<sup>a</sup>Diagonal elements represent square root of AVE for that construct.

\* $P \leq .05$

\*\* $P \leq .01$

for implementation is positively related to the mediator ease of use in Model A ( $\beta = .30$ ;  $P = .03$ ) and to the dependent variable, ETU, in Model B ( $\beta = .41$ ;  $P = .004$ ). Climate is also related to ETU in Model C when the mediator is controlled for ( $\beta = .28$ ;  $P = .04$ ), but the strength of the relationship is diminished, supporting partial mediation. Sobel's<sup>82</sup> significance test resulted in  $P = .01$ . Thus, hypothesis 3 is supported.

Hypothesis 4 states that ease of use will partially mediate the effect of the technology's compatibility with work processes on ETU. In Table 4, compatibility with work processes is positively related to the mediator ease of use in Model A ( $\beta = .50$ ;  $P = .004$ ) and to the dependent variable, ETU, in Model B ( $\beta = .33$ ;  $P = .02$ ). However, compatibility with work processes is not related to ETU in Model C when the mediator is controlled for ( $\beta = .10$ ;  $P = .47$ ). Ease of use thus mediated the relationship between compatibility with work processes and ETU. However, contrary to our prediction, this mediation was full and not partial. Thus, hypothesis 4 is partially supported.

Hypotheses 5 and 6 state that when implementation climate is strong, consistency of technology use will be high; however, only when climate is strong and values compatibility is high will quality of technology use be high. To test these hypotheses, we first inspected the correlations among these variables. From table 1, it may be seen that while climate is significantly correlated with both consistency of use and quality of use ( $r = .42$  and  $.43$ , respectively), values compatibility has a non-significant correlation with consistency of use ( $r = .16$ ) and a significant correlation with quality of use ( $r = .41$ ). We then conducted  $t$  tests using 2 subgroups of providers. Specifically, we employed a median split to code the climate and values compatibility variables. Nine providers perceived a strong climate and highly valued doing MR with their patients. Fourteen providers perceived a strong climate and only moderately valued doing MR with their patients. These 2 groups showed no significant difference in consistency of technology use ( $t = -1.06$ ;  $P = .24$ ). However, the group with high scores on values compatibility had higher quality of use ( $t = -3.54$ ;  $P = .002$ ). These findings support hypotheses 5 and 6. Given the small sample sizes used in the tests of hypotheses 5 and 6, we reran these analyses using the Mann-Whitney  $U$  test. Our findings remained unchanged.

## DISCUSSION

### Principal Findings and Implications

TAM has proven an important theoretical tool for health IT research.<sup>16,27,29,31,36</sup> However, despite the recent proliferation of “added variables models” in the health IT context, the utility of TAM and its derivatives to change agents and health care decision-makers remains limited. Our research sought to increase the utility of TAM to change agents and health care decision-makers and to extend traditional technology acceptance models in several important ways. First, although HITs must be used effectively to realize maximum benefit, very little research on technology acceptance has examined ETU. We conceptualize ETU as falling along a continuum, ranging from avoidance (nonuse) to skilled and consistent use. Indeed, we

Table 2: Factor loadings and cross loadings

Item	Climate	Ease of Use	Usefulness	Values Compat	Compat w WP
Climate1	.67***	.11	.26	.15	.25
Climate2	.65***	.34	.25	.21	.18
Climate3	.69***	.31	.21	-.02	.13
Climate4	.81***	.40	.44	.14	.20
Climate5	.56**	-.10	.05	.08	.11
Climate6	.56**	.07	.28	.10	.06
Climate7	.64***	.12	.23	.20	.14
Ease of Use1	.08	.74***	.46	.29	.45
Ease of Use2	.23	.85***	.64	.49	.44
Ease of Use3	.47	.83***	.46	.36	.51
Usefulness1	.37	.53	.85***	.35	.36
Usefulness2	.36	.57	.88***	.43	.37
Usefulness3	.24	.45	.78***	.50	.56
Usefulness4	.43	.47	.76***	.42	.40
Usefulness5	.46	.48	.82***	.38	.51
Usefulness6	.29	.55	.62***	.42	.44
Usefulness7	.14	.56	.72***	.48	.41
Usefulness8	.35	.49	.88***	.51	.45
Values Compat1	.09	.28	.40	.78***	.56
Values Compat2	.11	.30	.49	.83***	.47
Values Compat3	.06	.43	.44	.83***	.62
Values Compat4	.08	.40	.26	.69***	.43
Values Compat5	.04	.21	.17	.57***	.28
Values Compat6	.23	.36	.41	.74***	.59
Values Compat7	.30	.46	.52	.76***	.51
Compat w WP1	.30	.55	.61	.50	.77***
Compat w WP2	.17	.39	.42	.50	.83***
Compat w WP3	-.01	.36	.30	.61	.82***
Compat w WP4	.20	.51	.33	.61	.84***

Values Compat, Values compatibility; Climate, Climate for implementation; Compat w WP, Compatibility with work process; Usefulness, Perceived usefulness; Ease of Use, Perceived ease of use.

\* $P \leq .05$

\*\* $P \leq .01$

\*\*\* $P \leq .001$

identified considerable heterogeneity in the quality and depth of use. Some providers used the medication history to update prescription data, negotiate care plans, and recruit additional management resources. Others only identified and documented adherence gaps. If we are to extend our understanding of

technology acceptance and use, we need to conceptualize technology acceptance as ETU and develop more granular models that can account for ETU.

Second, we predict and support that determinants have differential effects on dimensions of ETU. We demonstrate that

Table 3: Tests of hypotheses 1 and 2

	Model A:	Model B:	Model C:
	Mediator (Usefulness) Regressed on Predictors,	DV (ETU) Regressed on Predictors,	DV (ETU) Regressed on Predictors with Mediator (Usefulness) Controlled,
	$\beta$	$\beta$	$\beta$
Values Compat	.35**	.32*	.10
Climate	.40**	.44**	.27*
Usefulness			.51**
F Value	8.87***	8.92***	12.03***
R <sup>2</sup>	.32	.33	.51
R <sup>2</sup> Change		.01	.18***

DV; Dependent Variable; Values Compat, Values compatibility; Climate, Climate for implementation; Usefulness, Perceived usefulness; ETU, Effective technology use.

\* $P \leq .05$

\*\* $P \leq .01$

\*\*\* $P \leq .001$

Table 4: Tests of hypotheses 3 and 4

	Model A:	Model B:	Model C:
	Mediator (Ease of Use) Regressed on Predictors,	DV (ETU) Regressed on Predictors,	DV (ETU) Regressed on Predictors with Mediator (Ease of Use) Controlled,
	$\beta$	$\beta$	$\beta$
Climate	.30*	.41**	.28*
Compat w WP	.50**	.33*	.10
Ease of Use			.44**
F Value	11.91***	9.12***	9.72***
R <sup>2</sup>	.38	.32	.44
R <sup>2</sup> Change			.12**

DV; Dependent Variable; Climate, Climate for implementation; Compat w WP, Compatibility with work process; Ease of Use, Perceived ease of use; ETU, Effective technology use.

\* $P \leq .05$

\*\* $P \leq .01$

\*\*\* $P \leq .001$

climate for implementation predicts consistency of use but not quality of HIT use. Quality of use is only found under conditions where there is a strong climate for implementation *and* the technology is perceived as consistent with users' important workplace values. Demonstrating the differential effects for determinants of ETU is an important extension of traditional technology acceptance models.

Third, our model responds to the call for models that provide actionable guidance to change agents by supporting 3 “belief-based” variables—work values compatibility, climate for implementation, and compatibility with work processes—as important predictors of technology perceptions and use. Beliefs not only predict behavior but also are amenable to managerial manipulation.

Individuals' work-related values exert a strong influence on how useful they perceive a new technology to be. Clinicians typically act in an autonomous manner and possess considerable leverage to resist organizational change.<sup>18,83–87</sup> Thus, values alignment may need to be addressed through strategic messaging and managerial actions, which facilitate the development of collective meaning for the HIT.<sup>10,88</sup>

Climate for implementation has direct effects on technology perceptions (usefulness and ease of use) as well as ETU. Thus, it is imperative that users perceive HIT use as expected, supported, and rewarded. Organizational interventions may include the creation of policies and incentives that support HIT use such as the use of onsite clinical advocates (go-betweens among the system developers, users, and institutional authorities) tasked with removing obstacles to technology use, supporting users in mastering the new HIT, and adapting the HIT to the context.<sup>39,89–91</sup> We regard the climate construct as *equifinal* (ie, differing sets of practices and policies across organizations can lead to the same level of technology acceptance and use).<sup>54,58</sup> Finally, the extent to which users perceived the technology to be compatible with existing work processes directly affected their perceptions of ease of use. Developers must therefore closely map the target work domain throughout the development lifecycle, and implementers must emphasize similarities or consistencies between current work processes and the new technology.

## LIMITATIONS AND FUTURE RESEARCH

Data for this study were collected at a single point in time. Although adequate for examining relationships among variables, these data are not adequate for the purposes of inferring causation. We tested for common method bias<sup>92</sup> using Harman's<sup>93</sup> single-factor test. The single factor explains 36% of the variance. Thus, we concluded that it was not having an appreciable effect on our results. However, we must note that the HIT used in the study is locally developed, requires multi-user coordination, and leverages legacy software. Many device attributes may be unique and may not apply to other HIT implementations. Additionally, our sample size is small, and therefore results should be interpreted with caution.

Several directions for future research emerge from our findings. It is well documented that management's technology-based solutions to improve efficiencies, accountability, and reduce costs, etc, often conflict with users' workplace values.<sup>18,39,54,55,91,94</sup> Thus, one of the most challenging aspects of technology development and implementation may be managing the alignment between management and users' workplace values. Prior research suggests user participation may be instrumental in increasing the perceived compatibility between the HIT and users' workplace values or in modifying users' workplace values.<sup>62,95</sup> However, how user participation may affect users' perceptions of a new technology and its fit with their workplace values has not been extensively researched. Second, organizational change is considered by many to be a communications-driven phenomenon.<sup>96–98</sup> The types of communication that managers use to create, sustain, and focus a

change may have implications with respect to the modification or alignment of values. For example, ethos-appeals produce moral legitimacy that "rests not on judgments about whether an activity benefits the evaluator, but rather on judgments about whether the activity is the 'right thing to do.'"<sup>98(p579)</sup> A more fine-grained understanding of how communication strategies can influence users' workplace values is needed.

Finally, a fuller understanding of the differential effects that various determinants have on both affective outcomes (eg, enthusiasm, commitment, indifference, resistance) as well as performance outcomes (eg, consistency of use, quality of use) would greatly add to our understanding of technology acceptance and the effective implementation of new IT.

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PJH: Conception and design of the study; data analysis and interpretation of data; drafting the article and revising it critically for important intellectual content; final approval of the version submitted. BJL: Conception and design of the study, acquisition of data; drafting the article and revising it critically for important intellectual content; final approval of the version submitted. KA: Design of the study; acquisition of data; data analysis; drafting the article and revising it critically for important intellectual content; final approval of the version submitted. KW: Data analysis and interpretation of data; drafting the article and revising it critically for important intellectual content. VC: Design of the study; drafting the article and reviewing it critically for important intellectual content.

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## DISCLAIMER

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## COMPETING INTERESTS

None.

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