Published in final edited form as:

Res Social Adm Pharm. 2012 ; 8(6): 509–522. doi:10.1016/j.sapharm.2012.01.004.

Pharmacy workers' perceptions and acceptance of bar coded medication technology in a pediatric hospital

Richard J. Holden, Ph.D.^{1,*}, Roger L. Brown, Ph.D.², Matthew C. Scanlon, M.D.³, and Ben-Tzion Karsh, Ph.D.⁴

¹Assistant Professor, Departments of Medicine and Biomedical Informatics, Vanderbilt University, Nashville, TN, US

²Professor, Clinical Health Science, School of Nursing, University of Wisconsin-Madison, Madison, WI, US

³Associate Professor, Department of Pediatrics, Division of Critical Care, Medical College of Wisconsin, Wauwatosa, WI, US

⁴Associate Professor, Departments of Industrial & Systems Engineering, Family Medicine, Population Health Sciences, and Biomedical Engineering, University of Wisconsin-Madison, Madison, WI, US

Abstract

Background—The safety benefits of bar-coded medication dispensing and administration technology (BCMA) depend on its intended users favorably perceiving, accepting, and ultimately using the technology.

Objectives—(1) To describe pharmacy workers' perceptions and acceptance of a recently implemented BCMA system and (2) to model the relationship between perceptions and acceptance of BCMA.

Methods—Pharmacists and pharmacy technicians at a Midwest US pediatric hospital were surveyed following the hospital's implementation of a BCMA system. Twenty-nine pharmacists and ten technicians' self-reported perceptions and acceptance of the BCMA system were analyzed, supplemented by qualitative observational and free-response survey data. Perception-acceptance associations were analyzed using structural models.

Results—The BCMA system's perceived ease of use was rated low by pharmacists and moderate by pharmacy technicians. Both pharmacists and technicians perceived that the BCMA system was not useful for improving either personal job performance or patient care. Pharmacy workers perceived that individuals important to them encouraged BCMA use. Pharmacy workers generally intended to use BCMA but reported low satisfaction with the system. Perceptions explained 72% of the variance in intention to use BCMA and 79% of variance in satisfaction with BCMA.

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*Corresponding Author: Richard J. Holden, Center for Research and Innovation in Systems Safety, Vanderbilt University School of Medicine, 1211 21st Ave. S, Ste. 732 MAB, Nashville, TN 37212, US, (tel) 1-615-936-4343, (fax) 1-615-936-7373, Richard.Holden@vanderbilt.edu.

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Conclusions—To promote their acceptance and use, BCMA and other technologies must be better designed and integrated into the clinical work system. Key steps to achieving better design and integration include measuring clinicians' acceptance and elucidating perceptions and other factors that shape acceptance.

Keywords

bar coded medication dispensing and administration systems; BCMA; technology acceptance; pediatric hospital

Medication errors may be as prevalent as one per day for the average hospitalized patient.¹ Administration errors are especially common and, compared to errors occurring at other medication management stages, have a low probability of being intercepted.² Bar-coded medication dispensing and administration (BCMA) technology is recommended as one way to prevent inpatient medication administration errors and to detect errors before they cause harm.^{3,4} Recent studies by Poon and colleagues offer evidence that BCMA improves medication dispensing and administration safety.^{5,6} However, there was also evidence that pharmacy workers perceived the BCMA system to worsen work performance, leading to staff resistance.⁷ Research on nurses shows that nurses employ numerous workarounds and often override BCMA systems.^{8,9} Workarounds, overrides, and similar behaviors partially result from clinicians' low acceptance of the health information technology (HIT) in question and low acceptance, in turn, may be caused by unfavorable perceptions concerning the HIT.¹⁰ It is therefore important to assess clinicians' perceptions and acceptance of new HIT and to identify those perceptions associated with HIT acceptance.¹¹ However, nurses' perceptions and acceptance of BCMA are seldom studied,^{12,13} and studies of pharmacy workers' perceptions and acceptance are entirely absent. Thus, this study's two objectives were: (1) to describe hospital pharmacists' and pharmacy technicians' perceptions and acceptance of a recently implemented BCMA system and (2) to model the relationship between perceptions and acceptance of BCMA. Although it is important to measure a variety of BCMA-related perceptions following BCMA implementation (Objective 1), it is equally as important to find out which of these perceptions is driving workers' acceptance of BCMA (Objective 2). The latter allows a more focused approach to generating solutions to improve BCMA acceptance and use.

Conceptual framework

The study's conceptual framework (Figure 1) is adapted from the Technology Acceptance Model (TAM), a family of theories—TAM,¹⁴ TAM2,¹⁵ and TAM3¹⁶—that posit a causal relationship (a) between user perceptions of technology and user acceptance and (b) between acceptance and actual use.* TAM is the most widely used theoretical framework in the health IT acceptance and use literature, though no previous work has used TAM to study BCMA or pharmacy workers.¹¹ Following TAM, this study assessed three categories of BCMA perceptions:

- Perceived ease of use (PEOU), or “the degree to which a person believes that using a particular system would be free of effort.”¹⁴, p.320
- Perceived usefulness (PU), or “the degree to which a person believes that using a particular system would enhance his or her job performance.”¹⁴, p.320 Holden and

*The Technology Acceptance Model (TAM) was originally developed in the mid-1980s to explain variation in technology use behavior. It was adapted from the Theory of Reasoned Action, a social-psychological theory applicable to a wide range of behaviors. As TRA was updated and evolved into the Theory of Planned Behavior (TPB), similar updates were made to subsequent versions of TAM. Some, though not all, of those updates are reflected in the models tested in this study.

Karsh note that PU is often defined in terms of usefulness for the user's productivity on the job (PU-SELF) but that in healthcare settings, PU can also be thought of in terms of usefulness for improving patient care (PU-PT).¹¹ PU-SELF and PU-PT were both measured in this study.

- Perceived social influence (SI), or “the degree to which an individual perceives that important others believe he or she should use the new system.”¹⁷, p.451

This study also assessed two categories of pharmacy workers' acceptance of BCMA:

- Behavioral intention (BI) to use BCMA.
- Satisfaction (SATISF) with BCMA.

BI and SATISF are the two classic conceptualizations of technology acceptance, and both are believed to predict actual use.^{18,19} BI is conceptually similar to an individual's motivation to use BCMA and is the measure of acceptance specified in TAM.¹⁴ SATISF is an overall evaluation or attitude toward BCMA and is the measure of acceptance recommended when technology use is mandatory.²⁰ Although perceived ease of use, perceived usefulness, and social influence are typically hypothesized to predict acceptance, behavioral theory and evidence from TAM research in healthcare suggests that in different contexts, different predictors will be salient.^{11,21} Thus, for example, it can be hypothesized that perceived usefulness for patient care will be a salient predictor of acceptance of a safety-promoting technology in a clinical setting and may be a stronger predictor of acceptance than a more generic measure of usefulness for one's job performance.

METHODS

Design and setting

The study was a cross-sectional, paper survey administered to pharmacists and pharmacy technicians at a 236-bed free-standing pediatric academic community hospital in the Midwest US. The survey was administered August-November 2007, about 8 months after a phased roll-out of a BCMA system (GE Healthcare's *Centricity Pharmacy*). The hospital additionally used computerized provider order entry (CPOE) and automated medication-dispensing cabinets. The study was approved by Institutional Review Boards at the University of Wisconsin-Madison and the study hospital. Details on survey administration procedures are available elsewhere.²²

Survey instrument

Standard multi-item scales validated in prior TAM studies were used for PEOU,²³ PU-SELF,²³ and SI.²⁴ BI was measured with two items from Venkatesh and Morris²⁵ and two items created for the study. PU-PT and SATISF scales were newly created for the study. All survey items were based on strong theory and underwent extensive pre-testing by the research team, survey experts, and clinicians. Frequent prompts in the survey asked respondents to think of “the past 30 days.” Responses were on a numbered seven-point scale ranging from 0 to 6, with the response category labels “not at all,” “a little,” “some,” “a moderate amount,” “pretty much,” “quite a lot,” and “a great deal,” as well as an option to mark “don't know.” Table 2 shows individual scale items and reports each scale's internal consistency.

Analysis

Descriptive statistics for perceptions and acceptance scales and individual items were calculated in SPSS. Scores on each scale were calculated for respondents by taking the mean of all valid individual item responses from that scale (using a floating denominator).

Scale means and standard deviations were then calculated for all pharmacy workers, pharmacists only, and pharmacy technicians only. Pharmacists' and technicians' mean scores were compared with independent samples t-tests with unequal variances assumed. Response frequencies were calculated for individual scale items. Because there was some missing data, response frequencies were calculated using the total number of valid responses (i.e., not counting item non-responses) as the denominator.

To test the perception-acceptance relationship, two Composite Indicator Structural Equation (CISE)-alpha models²⁶ were analyzed in MPlus, using maximum likelihood estimation with pair-wise deletion. In this approach, composite indicators (scales) are modeled and adjusted for measurement error. Measurement error for the composite indicators can either be fixed based on a priori knowledge of the reliability of the composites, or from sampled measures of Cronbach's alpha or split-half reliability. In this study's models, the measurement error was fixed and based on an estimate of reliability of composite variables, $(1 - \text{Cronbach's alpha}) * \sigma^2$.²⁷

In one model, the outcome was BI (behavioral intention to use BCMA); in the other, SATISF (satisfaction with BCMA). In both models, PEOU, PU-SELF, PU-PT, and SI served as the predictors. The participant's role (ROLE: pharmacist vs. pharmacy technician) was entered as a covariate to adjust all estimated relationships for differences in role and to test whether BCMA acceptance differed by role. An a priori alpha criterion of .05 was used. 95% confidence intervals and model R^2 were calculated.

CISE-alpha modeling is a variant of regression and therefore should meet sample size requirements for conducting regression. The current analyzed sample size met the common rule of thumb criterion that there should be at least a five-to-one ratio between the number of subjects ($N = 39$) and the number of estimated parameters (five in the present models: four predictors and one covariate).²⁸ CISE-alpha was selected because, for small sample sizes, it is a superior approach compared to structural equation modeling, which involves a large number of parameters, or path analysis, which does not adjust for measurement error and results in less reliable estimates.^{29, 30}

Qualitative data for interpreting survey findings

Qualitative observation and open-ended survey data were collected and analyzed to help interpret pharmacy workers' BCMA perceptions. Observations of 16 pharmacy workers (7 pharmacists, 9 pharmacy technicians) were conducted February – March 2008, a little over one year after BCMA implementation. Open-ended responses about BCMA were analyzed from a follow-up survey administered to pharmacy workers February – May 2008. Qualitative data were analyzed for themes and specific examples that might explain pharmacy workers' quantitative survey responses.

RESULTS

Forty-one of 73 (56.2%) pharmacy workers completed the survey. Two respondents were removed from analyses because they had no direct clinical duties or did not report their work role. This resulted in an analyzed sample of 39 respondents: 29 pharmacists and 10 pharmacy technicians. Sample demographics are reported in Table 2.

Perceptions of BCMA system

Table 3a reports pharmacy workers' mean scores on the four perception scales (response frequencies for individual items are reported in the Appendix). Pharmacists rated the BCMA system as not easy to use. Twenty-four percent of pharmacists perceived that BCMA was "not at all" easy to use and 41% that using BCMA required "quite a lot" of mental effort or

more. In contrast, technicians had moderate or higher ratings of BCMA ease of use, with 50% of technicians responding that BCMA was “quite a lot” or “a great deal” clear and understandable.

Pharmacy workers did not perceive that BCMA was useful for improving either personal job performance or patient care. Thirty-seven percent of all respondents (37% of pharmacists, 37% of technicians) believed that BCMA did “not at all” improve job performance and 52% (56% of pharmacists, 25% of technicians) perceived that BCMA did “not at all” make patient care easier. However, 47% of respondents (48% of pharmacists, 43% of technicians) believed that BCMA reduced the likelihood of medication error “a moderate amount” or more.

Pharmacy workers reported high social influence to use BCMA. In response to the question, “To what extent do people who influence your behavior think that you should use the bar-coding system,” 69% (77% of pharmacists, 44% of technicians) responded “quite a lot” or more. Statistically significant correlations were found between PEOU and PU-SELF ($r = .57$), PEOU and PU-PT ($r = .59$), and PU-SELF and PU-PT ($r = .65$).

Acceptance of BCMA system

Table 3b reports mean scores on the two acceptance scales. Intention to use BCMA was moderate and although pharmacy workers predicted that they would use the system, 28% (32% of pharmacists, 12% of technicians) reported that if it were up to them, they would not use it at all. Twenty-nine percent of pharmacy workers (30% of pharmacists, 25% of technicians) responded “not at all” to the question “How much do you want to use the bar-coding system?” Satisfaction with BCMA was low. Forty-six percent of all respondents (46% of pharmacists, 43% of technicians) reported that they would not recommend the BCMA system to a friend at another hospital and 63% (68% of pharmacists, 43% of technicians) reported “a moderate amount” or more dissatisfaction with BCMA. (Ninety-one percent of pharmacy workers, and 100% of pharmacy technicians, reported a non-zero level of dissatisfaction with BCMA.) A statistically significant correlation was found between BI and SATISF ($r = .61$).

Perceptions associated with BCMA acceptance

In CISE-alpha models, the combination of perceptions explained 72% ($\pm 32\%$) of variance in behavioral intention (BI) to use BCMA and 79% ($\pm 9\%$) in satisfaction (SATISF) with BCMA. Significant predictors of BI were, in order of magnitude, perceived usefulness of BCMA for patient care (PU-PT) and perceived social influence to use BCMA (SI). Significant predictors of SATISF with BCMA were, in order of magnitude, perceived ease of use of BCMA (PEOU), perceived usefulness of BCMA for patient care (PU-PT), and perceived usefulness of BCMA for one’s job (PU-SELF). In neither of the models was the covariate ROLE statistically significant. Table 4 reports unstandardized and standardized parameter estimates for the two CISE-alpha models.

DISCUSSION

Pediatric hospital pharmacists did not find their recently implemented BCMA easy to use, and neither pharmacists nor technicians found BCMA useful to themselves. Pharmacy workers were not satisfied with BCMA, despite social pressure from others to use BCMA and a moderate level of intention to do so. While surveys did not quantitatively assess the specific reasons behind these perceptions, qualitative data from observations and open-ended responses to a follow-up survey provide some insight. Findings of low perceived ease of use and usefulness should alert those who design, procure, and implement BCMA that,

from the pharmacy employee's perspective, a BCMA system may not be usable or beneficial and may need to be modified.^{7,31} The next two sections use the results of qualitative data to illustrate some of the specific ways in which the studied BCMA often did not meet usability and usefulness requirements, possibly explaining the survey findings. Recommendations are available for addressing these and other usability and usefulness concerns.^{32–34}

Ease of use

Observations revealed that BCMA imposed new steps and added time in the medication management process, particularly for pharmacists. As one pharmacist wrote on the follow-up survey, "I would not recommend the bar-code system to any other hospital. It is a very inconsistent system and takes much more time to use than not."

Bar-codes had to be printed on unit-dosed medication labels and because bar-codes were dose-specific, labels could not be reused when dosing changes were made, requiring new labels to be printed. Sometimes this feature of BCMA created extra work for pharmacists, who had to "play games" with BCMA, as one pharmacist said,³⁵ to allow nurses to administer a full dose: for example, to administer up to 100mg of fentanyl PRN (as needed), as ordered, using 2 × 50mg doses of fentanyl as dispensed from the automatic dispensing cabinet (accompanied by 50mg bar-code labels).

Pharmacists also found themselves paying more careful attention to the timing of medications. In one observation, at 8:40am, a pharmacist in the pediatric intensive care unit's satellite pharmacy received an order to change the timing on a medication from once every 48h to once every 36h. Thirty-six hours from the most recently documented administration of the dose would be at 8:00 that morning (40 minutes ago). Furthermore, the hourly delivery run from central pharmacy had just left (at 8:30) and the next one would not be until 9:30. The pharmacist selected 10:00 as the scheduled administration time. The pharmacist explained that prior to BCMA, there would not have been as much concern in selecting a "realistic" timing and the expectation would be that the medication would be administered as soon as possible, with the nurse documenting the actual time and the reason for any lateness. With BCMA, any late medication would automatically be marked as a "missed dose," an outcome that the observed pharmacist preferred to avoid. When pharmacists did schedule medications that could not be realistically administered on time, nurses would request that the pharmacists change the timing in the BCMA system, something that would happen several times in a typical day.

There were other examples of "extra" work. An institutional policy was in place allowing clinicians to use a blank paper medication administration record (MAR) for quickly documenting the administration of lifesaving medications during (non-code) emergency situations. However, BCMA was being used to retroactively charge these administered medications, which would require the pharmacist to enter a new order for those medications into BCMA, charge them, and then discontinue them immediately. As another example "one-time" doses that nurses could previously administer (and document) a second time if necessary "disappeared" from the electronic MAR after the first administration. This resulted in pharmacists having to add an additional PRN order. Referring to an observed case of this type, a pharmacist remarked, "See all the monkey business we do? That's where things used to be a lot faster." Importantly, new steps and work processes introduced following BCMA implementation may in fact have helped to improve quality and safety; indeed, the new processes and roles around a new technology may be as important to quality and safety as the technology itself.³⁶ However, when new processes and expectations are experienced by pharmacy workers as "extra work," this may be because accommodations

such as freeing up work time were not made; this may lead to rushing or skipping steps, which may in turn negatively affect safety and quality.³⁷

Pharmacy technicians seemed to perceive less additional BCMA-related work than pharmacists, consistent with their ratings of ease of use being higher than pharmacists' ratings. Technicians who repackaged pills from bulk bottles to individual blister packs had to print and affix bar-code labels to each new package. One pharmacy technician commented during observations that the new packaging process was less problematic as it became easier over time.

Usefulness

In a follow-up survey response, a pharmacy technician commented, "The pharmacy has incurred a great deal more work, and I would consider it worth the time and effort if it improved patient safety. This is not the case." Indeed, neither pharmacists nor technicians believed that BCMA was useful for their job in general or for patient care. One frequently cited barrier to BCMA improving patient care was that "nurses have been overriding the system a lot. Some have even admitted to pharmacy [that] they wait until the end of their shift to scan the bar-codes of the meds they have already administered. This defeats the purpose of having bar-coding systems" (from a follow-up survey, pharmacy technician). Such behavior would be consistent with findings from other hospitals around the country.^{3,8,37,38} Two pharmacists described one reason why nurses might override BCMA: bugs in the BCMA system sometimes resulted in correct medications either not scanning or, upon being scanned, generating an error message identical to the message generated to alert nurses of an incorrect medication.

Pharmacy workers also may have reported low perceived usefulness of BCMA because of the limits of the BCMA in supporting the entirety of medication management. At the time of the survey on perceptions and acceptance, BCMA was not being used to manage pharmacy inventory (though there were plans to, e.g., add automated prompts to restock PRN medications based on the number of doses documented in BCMA as administered) or to keep track of drip rates in "real time." Additionally, BCMA could not verify important information such as whether a technician had accurately prepared a medication, whether a prepared medication was expired, or the true contents of a temporary medication container (e.g., the BCMA might scan and verify the bar-code affixed to a prepared syringe but could not determine the syringe's true contents or compare the accuracy of the label relative to those contents). Indeed, pharmacy workers and nurses continued to make major contributions to medication safety, with BCMA providing perhaps only marginal added usefulness in that regard. One pharmacist wrote on the follow-up survey, "As much as technology has helped improve the dispensing process, the human element remains the most important.... We need to be masters of the technology not slaves to it."

However, some pharmacy workers recognized that BCMA could be useful. One pharmacist wrote, "We are still better off with it then without it..." and several pharmacists and technicians commented during observations how much they valued BCMA's "Timeline" feature, which gave pharmacy workers quick and easy access to an electronic history of when each medication was documented as administered. The Timeline feature was deemed useful for scheduling administration times and for pharmacokinetics processes. This finding in particular summarizes the current state of health IT in general – that aspects of health IT that support clinician cognitive work are valued, but aspects that increase workload or complicate work, are deemed failures.³⁹

It should be noted that the self-reported low ratings of ease of use and usefulness of BCMA, and the comments and observations that may explain those ratings, do not provide evidence

about BCMA's actual impact on quality and safety. These ratings do, however, provide evidence that pharmacists and pharmacy technicians do not believe BCMA is easy to use or useful. Although it is possible and perhaps even likely that the BCMA design features or policies for BCMA use that contributed to users' low ratings of ease of use and usefulness did also reduce safety and quality, it is not known what the overall net effect of BCMA was.

Predictors of BCMA acceptance

Pharmacy workers' perceptions of BCMA explained 72% of variation in their intentions to use it and 79% of their satisfaction, indicating the importance of perceptions. BCMA's perceived ease of use was strongly associated with pharmacy workers' satisfaction with BCMA, but not with their intentions to use BCMA. This suggests that pharmacy workers may put up with a difficult-to-use system if they must, but that they may not be satisfied with it. Consequently, the usability of a BCMA or other health IT used by pharmacy workers should be a central concern.³⁹

The perceived usefulness of BCMA for personal job performance was associated with satisfaction but not intention to use BCMA, whereas the perceived usefulness of BCMA for patient care was a strong and significant predictors of both acceptance outcomes. Clearly, pharmacy workers make decisions about and evaluate technological systems based on their potential benefit for patient care, and less so on generic job performance. The perceived impact on patient care of BCMA and other health IT should therefore be measured and should be included in models along with (or instead of) measures of generic perceived usefulness.^{11, 40}

Social influence—or the perception that others wanted pharmacy workers to use BCMA—was positively associated with intention to use BCMA, but not with satisfaction, highlighting the role of social forces in shaping BCMA use behavior, and the need to better understand those forces.⁴¹ Although pharmacy workers did not offer comments about the social influence on them to use BCMA, observations and analysis of organizational policies showed that BCMA use was mandatory in most parts of the hospital and that hospital administration expected that BCMA would be used. Indeed, pharmacy workers gave a mean response of 5.6 on the 0–6 scale in answer to the question, “To what extent is the decision to use the bar-coding system beyond your control?” Clinical and management processes (e.g., compliance monitoring) had been newly designed or redesigned around the new BCMA system, lending BCMA a ubiquitous presence; joked one pharmacy technician, “Even our food is bar-coded.”

Limitations

This study was conducted in only one site, whose characteristics and pre-BCMA work patterns likely influenced how pharmacy workers responded to BCMA. As an example, the number of older pharmacists at the research site may have contributed to lower ratings of BCMA's perceived ease of use. However, in unreported analyses, there was no correlation between age category and any of the perceptions or acceptance scales. In any case, it is important to replicate these findings in other settings and with different BCMA systems.

Although pharmacy workers' perceptions and acceptance were measured and modeled, this study did not include measures of pharmacy workers' actual BCMA use. Nevertheless, prior empirical and theoretical work contends that acceptance does in fact predict the volume and nature of actual IT use as well as performance with IT.^{17–19,42} In fact, there is more evidence for the relationship between acceptance and IT use than there is for the relationship between IT system quality and use.⁴³ The health IT literature abounds with case studies of unfavorable perceptions of health IT linked to non-use (overrides, workarounds, feature non-

use), resistance, and even abandonment.^{44–51} There is also emerging quantitative evidence linking perceptions to health IT use.¹¹ Even when clinicians report intending to use a system, dissatisfaction with the system may lead them to use it minimally or perhaps to work around it when possible. For example, Holden and colleagues suggested that nurses' negative perceptions of the process for documenting medication administration post-BCMA may have resulted in nurses working around the BCMA system studied here.¹² It bears investigating whether similar workaround behaviors would be found in the pharmacy context. It could be hypothesized that even in mandatory use environments, certain use behaviors including workarounds and the selective use of BCMA features would result from unfavorable perceptions of BCMA and low satisfaction, even if self-reported intention to use BCMA is high. Further, it might be opined that even if BCMA is used as mandated in the course of pharmacy work, pharmacy workers dissatisfied with BCMA would be less likely to volunteer additional effort to, for example, help nurses to use BCMA more effectively and efficiently.

A small sample size ($N = 39$) was analyzed, although the response rate was reasonable and over half of the study hospital's pharmacy workers were surveyed. With pharmacists and technicians combined, the sample size met the rule of thumb criteria for conducting regression-based modeling analyses. This required the combination of two dissimilar work roles. However, all model parameters were adjusted by including ROLE as a covariate and, additionally, there were no differences in acceptance between pharmacists and technicians. Separate pharmacist-only models, not reported here, produced essentially the same pattern of results. This is consistent with the fact that the conceptual models tested here have been validated across a very large variety of worker types within as well as outside of healthcare.^{11,52–57} Nevertheless, it is worth pursuing further research into whether there are profession- or role-related differences in the acceptance of BCMA or other health IT.⁵⁸

Some of the survey scales and individual items were either newly created or modified for this study. While their validity requires further testing, the new items were developed based on strong theory; all items were subjected to rigorous pre-testing; all scales had very high internal consistencies (all Cronbach's alphas $\geq .80$); and factor structure was validated using confirmatory factor analysis (not reported). The predictive validity of the survey measures was confirmed by study results.

CONCLUSION

User perceptions and acceptance of health IT are important, especially when the (safety) benefits of the IT depend on the nature of its use. Present findings raise concerns about how well commercially available BCMA systems are designed and implemented for pharmacists and pharmacy technicians. It is suggested that more attention be paid to the IT-related perceptions, acceptance, and use behavior of healthcare professionals. Users' perceptions of a health IT system are "expert opinions" because, after all, they are the ones using it daily. That does not mean only asking users their preferences for design but also systematically learning about their experiences and involving users as participants in IT usability testing. Additionally, users' interactions with a health IT ultimately decide its value: even a well-designed IT fails to achieve its outcomes if it is not used, worked around, or used in a limited way or inappropriately. Improved IT design must be accompanied by workable policies for its use and better integration of IT into the structures and processes of work.

Acknowledgments

The authors wish to thank the study participants and colleagues involved in the Bar-coding study. This work was supported by a grant from the Agency for Healthcare Research and Quality (AHRQ) (1 R01 HS013610) and National Library of Medicine (1 R01 LM008923) to author BK. The funding agencies had no role in the study or

publication except for providing funding for the study. The authors thank two anonymous reviewers for their helpful feedback.

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Appendix

Appendix A

Pharmacists' response frequencies for individual scale items.

	Response frequencies (%) on 0–6 scale						
	0 not at all	1 a little	2 some	3 moderate amount	4 pretty much	5 quite a lot	6 a great deal
Perceived ease of use (PEOU)							
... clear and understandable	0%	11%	21%	29%	25%	14%	0%
... easy to use	24%	31%	14%	14%	10%	7%	0%
... requires a lot of mental effort	0%	0%	14%	28%	17%	7%	34%

	Response frequencies (%) on 0–6 scale						
	0 not at all	1 a little	2 some	3 moderate amount	4 pretty much	5 quite a lot	6 a great deal
... easy to get it to do what I want	21%	29%	29%	4%	14%	4%	0%
Perceived usefulness for self (PU-SELF)							
... improves job performance	37%	19%	19%	19%	7%	0%	0%
... increases productivity	64%	14%	14%	7%	0%	0%	0%
... enhances effectiveness in job	39%	18%	29%	11%	4%	0%	0%
... useful in job	18%	32%	7%	21%	11%	11%	0%
Perceived usefulness for patient (PU-PT)							
... improves patient care	22%	26%	17%	9%	13%	13%	0%
... reduces likelihood of medication error	24%	12%	16%	16%	8%	16%	8%
... facilitates better patient care decision making	50%	18%	5%	14%	5%	5%	5%
... makes caring for patients easier	56%	20%	12%	8%	0%	0%	4%
Perceived social influence (SI)							
... people who influence my behavior want me to use system	7%	0%	4%	4%	7%	52%	26%
... people who are important to me want me to use system	8%	8%	8%	12%	12%	24%	28%
Behavioral intention to use system (BI)							
... intend to use system, if I have access <i>i</i>	7%	15%	19%	15%	7%	15%	22%
... predict I will use system, if I have access	0%	8%	19%	4%	4%	23%	42%
... would want to use system, if it were up to me	32%	0%	11%	21%	7%	21%	7%
... want to use the system	30%	11%	15%	26%	4%	11%	4%
Satisfaction with system (SATISF)							
... satisfied with system	21%	21%	21%	11%	11%	14%	0%
... prefer system to prior process	33%	21%	17%	8%	4%	13%	4%
... dissatisfied with system	11%	14%	7%	14%	11%	25%	18%
... would recommend to a friend at another hospital	46%	14%	11%	11%	7%	11%	0%

Appendix B

Pharmacy technicians' response frequencies for individual scale items.

	Response frequencies (%) on 0–6 scale						
	0 not at all	1 a little	2 some	3 moderate amount	4 pretty much	5 quite a lot	6 a great deal
Perceived ease of use (PEOU)							
... clear and understandable	0%	0%	20%	0%	30%	20%	30%
... easy to use	0%	22%	0%	11%	44%	0%	22%
... requires a lot of mental effort	11%	0%	44%	22%	11%	0%	11%

	Response frequencies (%) on 0–6 scale						
	0 not at all	1 a little	2 some	3 moderate amount	4 pretty much	5 quite a lot	6 a great deal
... easy to get it to do what I want	25%	0%	13%	13%	25%	13%	13%
Perceived usefulness for self (PU-SELF)							
... improves job performance	38%	0%	25%	13%	0%	25%	0%
... increases productivity	50%	13%	13%	13%	0%	0%	13%
... enhances effectiveness in job	25%	13%	25%	0%	25%	0%	13%
... useful in job	22%	11%	11%	22%	22%	0%	11%
Perceived usefulness for patient (PU-PT)							
... improves patient care	20%	0%	0%	0%	60%	20%	0%
... reduces likelihood of medication error	14%	0%	43%	14%	0%	14%	14%
... facilitates better patient care decision making	67%	0%	0%	0%	0%	33%	0%
... makes caring for patients easier	25%	25%	0%	25%	25%	0%	0%
Perceived social influence (SI)							
... people who influence my behavior want me to use system	0%	11%	11%	33%	0%	0%	44%
... people who are important to me want me to use system	0%	11%	11%	22%	11%	0%	44%
Behavioral intention to use system (BI)							
... intend to use system, if I have access	0%	13%	50%	0%	0%	25%	13%
... predict I will use system, if I have access	0%	0%	33%	17%	0%	17%	33%
... would want to use system, if it were up to me	13%	13%	0%	13%	13%	25%	25%
... want to use the system	25%	13%	25%	0%	0%	13%	25%
Satisfaction with system (SATISF)							
... satisfied with system	0%	13%	13%	13%	25%	38%	0%
... prefer system to prior process	33%	0%	17%	0%	17%	33%	0%
... dissatisfied with system	0%	14%	43%	14%	0%	14%	14%
... would recommend to a friend at another hospital	43%	0%	14%	0%	0%	43%	0%

Figure 1.

The study's conceptual model, depicting a relationship between several perceptions of technology and technology acceptance, conceptualize as behavioral intention to use and/or satisfaction with technology. A relationship between acceptance and use behavior is posited but not within the scope of the present study.

Table 1

Measurement scales, item wording, and Cronbach's alphas for scales.

Scales	Items	Chronbach's alpha*
Perceived ease of use (PEOU)	<ul style="list-style-type: none"> In actual practice, to what extent is the bar coding system clear and understandable? In actual practice, to what extent do you find the bar coding system to be easy to use? In actual practice, to what extent does interacting with the bar . coding system require a lot of your mental effort? In actual practice, to what extent do you find it easy to get the bar coding system to do what you want it to do? 	.80
Perceived usefulness for self (PU-SELF)	<ul style="list-style-type: none"> In actual practice, to what extent does using the bar coding system improve your performance in your job? In actual practice, to what extent does using the bar coding system in your job increase your productivity? In actual practice, to what extent does using the bar coding system enhance your effectiveness on the job? In actual practice, to what extent do you find the bar coding system to be useful in your job? 	.93
Perceived usefulness for patient (PU-PT)	<ul style="list-style-type: none"> In actual practice, to what extent has the bar coding system improved patient care? In actual practice, to what extent has the bar coding system reduced the likelihood of medication errors? In actual practice, to what extent has the bar coding system facilitated better patient care decision-making? In actual practice, to what extent has the bar coding system made caring for patients easier? 	.93
Perceived social influence (SI)	<ul style="list-style-type: none"> To what extent do people who influence your behavior think that you should use the bar coding system? To what extent do people who are important to you think that you should use the bar coding system? 	.84
Behavioral intention to use system (BI)	<ul style="list-style-type: none"> Assuming you have access to the bar coding system, to what extent do you intend to use it? If you will have access to the bar coding system, to what extent do you predict that you will use it? If it were up to you, to what extent would you want to use the new bar coding system? How much do you want to use the bar coding system? 	.81
Satisfaction with system (SATISF)	<ul style="list-style-type: none"> To what extent are you satisfied with the bar coding system? How much better do you like the new method of administering medication compared to the old way? To what extent are you dissatisfied with the bar coding system? To what extent would you recommend the bar coding system to a friend at another hospital? 	.88

* Based on the full sample analysis (N=39).

Table 2

Sample demographics.

	All pharmacy workers	Pharmacists	Pharmacy technicians
Analyzed N	N = 39	N = 29	N = 10
% Female	51%	41%	80%
% White, non-Hispanic	97%	96%	100%
Age			
18–29	10%	11%	10%
30–39	10%	7%	20%
40–49	50%	46%	60%
50–59	26%	32%	10%
60+	3%	4%	0%
Education			
% completing college	31%	100%	50%
% completing graduate/professional school	56%	72%	10%
Years in occupation	18.0	21.0	9.8
Years with hospital	13.5	16.2	5.9
Shift worked			
Day	56%	65%	30%
Evening	23%	21%	30%
Night	8%	7%	10%
Floating	10%	7%	20%
Weekend only	3%	0%	10%
Hours worked in average week (SD)	38.8(14.7)	40.7(12.4)	33.4(19.8)

Table 3

Mean scores on perception and acceptance scales for all pharmacy workers, pharmacists, and pharmacy technicians.*

	Mean (SD)		
	All pharmacy workers	Pharmacists	Pharmacy technicians
(a) Perceptions			
Perceived ease of use (PEOU) **	2.56(1.35)	2.17(1.10)	3.68(1.42)
Perceived usefulness for self (PU-SELF)	1.57(1.38)	1.38(1.17)	2.17(1.86)
Perceived usefulness for patient (PU-PT)	2.04(1.68)	1.88(1.71)	2.61 (1.54)
Perceived social influence (SI)	4.20(1.76)	4.29(1.75)	3.95(1.86)
(b) Acceptance			
Behavioral intention to use system (BI)	3.12(1.66)	3.14(1.57)	3.06(2.03)
Satisfaction with system (SATISF)	2.23(1.64)	2.03(1.58)	2.78(1.76)

* Scale range from 0 to 6.

** p .05 for independent samples t-test comparing pharmacists and technicians.

Table 4

Results of Composite Indicator Structural Equation (CISE)-alpha modeling analysis with (A) behavioral intention to use BCMA and (B) satisfaction with BCMA as the outcomes.*

		Unstandardized parameter estimate (95% confidence interval)	Standardized parameter estimate (95% confidence interval)
(A)	Behavioral intention to use system (BI) ($R^2 = .72$; 95% CI [.40, 1.04])		
	Perceived ease of use (PEOU)	.01 (–.47, .49)	.01 (–.44, .46)
	Perceived usefulness for self (PU-SELF)	.36 (–.02, .74)	.37 (–.03, .78)
	Perceived usefulness for patient (PU-PT) ***	.49 (.17, .82)	.62 (.26, .98)
	Perceived social influence (SI) **	.34 (.05, .62)	.41 (.07, .74)
	Covariate: Pharmacist vs. technician (ROLE)	.52 (–.45, 1.50)	.18 (–.16, .52)
(B)	Satisfaction with system (SATISF) ($R^2 = .79$; 95% CI [.70, .88])		
	Perceived ease of use (PEOU) ***	.63 (.28, .98)	.60 (.33, .88)
	Perceived usefulness for self (PU-SELF) ***	.40 (.09, .70)	.41 (.08, .75)
	Perceived usefulness for patient (PU-PT) ***	.38 (.12, .63)	.48 (.15, .81)
	Perceived social influence (SI)	–.03 (–.24, .19)	–.03 (–.29, .23)
	Covariate: Pharmacist vs. technician (ROLE)	.43 (–.33, 1.19)	.15 (–.10, .40)

BCMA = Bar coded medication administration and dispensing system; CI = confidence interval.

* Parameter estimates refer to the predictor-outcome or covariate-outcome association.

**
p .05,

p .01