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Acceptance of clinical decision support surveillance technology in the clinical pharmacy

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ABSTRACT

Introduction: There are clinical and economic benefits to incorporating clinical decision support systems (CDSSs) in patient care interventions in the clinical pharmacy setting. However, user dissatisfaction and resistance to HIT can prevent optimal use of such systems, particularly when users employ system workarounds and overrides. *Objectives*: The present study applied a modified version of the unified theory of acceptance and use of technology (UTAUT) to evaluate the disposition and satisfaction with CDSS among clinical pharmacists who perform surveillance to identify potential medication therapy interventions on patients in the hospital setting. *Methods*: A survey of clinical pharmacists (N = 48) was conducted. Partial least squares (PLS) regression was used to analyze the influence of the UTAUT-related variables on behavioral intention and satisfaction with CDSS among clinical pharmacists. *Results*: While behavioral intention did not predict actual use of HIT, facilitating conditions had a direct effect on pharmacists' use of CDSS. Likewise, satisfaction with CDSS was found to have a direct effect on use, with more satisfied users being less inclined to employ workarounds or overrides of the system. *Conclusion*: Based on the findings, organizational structures that facilitate CDSS use and user satisfaction affect the extent to which pharmacy and health care management maximize use in the clinical pharmacy setting.

KEYWORDS

Clinical decision support systems; clinical pharmacists; health care information technology; technology acceptance

Introduction

Understanding the attitudes and dispositions of technology users is of great significance to the field of health informatics. The successful implementation and adoption of health care information systems is contingent on the satisfaction and acceptance of the technology by users (1–4). Further, heath information technology (HIT) systems will ultimately fail to deliver improvements in patient outcomes and health care practice if they are not used and accepted by clinicians (3). Research methodologies on technology acceptance frequently incorporate elements of Davis' original technology acceptance model (TAM), including the key variables of perceived utility (PU), perceived ease of use (PEOU), and attitudes toward information technology (IT), which have been found to be significant predictors of usage intentions (3,5). More recently, the unified theory of acceptance and use of technology (UTAUT), which was formulated to capture and integrate the elements of the other TAMs, serves to deepen understanding of factors influencing technology usage intentions and attempts to explain variations in behavioral intention to use (BI) technology (6). Applying technology acceptance research to HIT can be valuable as it offers key stakeholders, such as health care managers, information on how to select and apply information systems in the health care context. Likewise, understanding user acceptance and satisfaction with technology can help maximize the

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potential benefits of clinical decision support systems (CDSSs) that are being developed and implemented for use in clinical pharmacy settings.

There is an increased impetus for clinicians to use CDSSs in order to provide quality patient care, to increase efficiencies, and to realize cost savings. Furthermore, the advancement of CDSSs is viewed as an important goal in achieving quality and efficient health care delivery. The Office of the National Coordinator (ONC), along with the Agency for Healthcare Research and Quality (AHRQ), recognizes that the usage of CDSSs must be advanced because they are a key component in the effort to improve patient care and health processes by providing patient specific health information at appropriate times in the care process (7). Accordingly, the use of clinical decision support has been included as a core measure for Stage 2 of the Meaningful Use legislation (8). Pharmacists in the hospital setting can use CDSSs to implement interventions that provide clinical and economic benefits.

Background

Clinical pharmacy and the CDSS

As valuable members of the multidisciplinary patient care team, clinical pharmacists in the hospital setting enhance quality patient care by stepping outside of the dispensing role. Clinical pharmacy is the participation of pharmacists who team with physicians and nurses in the effort to enhance the safety, efficiency, and effectiveness of drug therapy to patients (9). Medication management interventions can help reduce the burden placed on primary providers (10). Patient care rounds and chart reviews by clinical pharmacists can result in cost reduction, improved outcomes associated with pharmaceutical therapy, and an increase in medication use interventions (11). Medication use interventions can lead to the prevention of adverse drug events (ADEs) and prescribing errors, appropriate management of antibiotic therapy, and other general safety-related pharmacy interventions (9). Likewise, IV to PO medication interventions, discontinuance of duplicate and unnecessary therapies, renal dose adjustments, and formulary interchange have been shown to contribute to cost savings (12).

Moreover, advancing pharmacy HIT systems to CDSS applications provides even greater potential for cost savings. For example, a case study by Pickette and others (11) outlines the successful implementation of a pharmacy practice model which focused on transitioning the scope of the pharmacy from order entry and distribution to medication management using a web-based surveillance tool. Use of the tool led to approximately 1500 documented pharmacy interventions over the course of a year which resulted in an estimated $1 million in monthly cost avoidance (11). Similarly, clinical pharmacists at a Veteran Affairs primary care clinic reported an estimated cost avoidance of over $3 million one year after implementing an electronic tool to capture the volume of clinical pharmacy interventions (10).

Realizing the potential economic benefits, as well as improving the quality of patient care, depends on the ability of the clinical pharmacist to identify intervention opportunities from data that can be located in disparate systems. CDSSs are software tools that can integrate and present patient-specific pharmaceutical information to clinical pharmacists in a consistent manner. These software systems are designed to enhance patient care by providing situation-specific patient data and knowledge to clinicians to aid them in complex decision-making (13). Additionally, CDSSs may include tools such as alerts and clinical rules, reminders, clinical guidelines, synthesized patient data reports, and summaries to improve the quality of patient care, decrease errors and adverse events, and improve efficiencies (14).

Pharmaceutical therapy efficiencies are enhanced through the real-time surveillance capabilities of the CDSS (15–18). For instance, one Dutch hospital developed a medication surveillance tool that could prevent ADEs by retrieving information from multiple systems and alerting pharmacists to at-risk patients (15). In a similar study, Vanderbilt University Medical Center (VUMC) found that a

computerized pharmacy surveillance system successfully synthesized patient data, applied predefined rules, and provided patient-safety alerts in an effort to deliver optimal pharmaceutical therapy (18). According to Waitman and others (18), awareness of the health risks of ADEs has led to the development of computer surveillance systems to identify intervention strategies to decrease the incidence of these costly events.

Despite the opportunities for improving the quality of patient care, potential cost savings, and the goals of national quality and government agencies to use technology to enhance health care delivery, widespread use of the CDSS among clinicians is still low (2,19,20). Therefore, it is imperative to understand the reasons for this lack of implementation and low adoption rate. By understanding the factors that shape users' intentions to use the CDSS, organizations can work to remove obstacles that prohibit system usage (5). While studies have assessed the acceptance of the CDSS in altering prescribing behaviors, these have been from the physician perspective and not the clinical pharmacist perspective. Since more research is needed to understand technology acceptance and use behaviors related to the CDSS among clinical pharmacists, the contribution of this study will be the application of the UTAUT theoretical framework to a surveillance CDSS in the clinical pharmacy setting.

Understanding technology acceptance in health care

Various technology acceptance theoretical frameworks have been utilized to examine the acceptance of technology and CDSSs in health care settings. Many of these studies have made modifications to Davis' original TAM to create a framework to evaluate clinicians' acceptance of the CDSS and HIT (1,3,4,19,20). The fundamental TAM constructs have been considered appropriate for the assessment of health care professionals' acceptance of technology in numerous studies (1–3,19). Moreover, some researchers advocate theory-based additions to the TAM model to extend the use of TAM in the health care setting to capture its unique contextual elements (5). For instance, Buenestado and others (19) expanded the original TAM to capture influential factors including perceived usefulness, PEOU, habits, compatibility, attitude, and organizational contexts to evaluate the initial attitudes of pediatric physicians and intention to use computerized guidelines and protocols delivered via a CDSS and whether prolonged use of the system altered their opinion. Using this approach, it was found that the overall initial disposition of physicians was good and that prolonged use of the CDSS led to increased acceptance (19).

In a similar study involving a modified TAM approach (TAM2), Sedlmayr and others (2) identified a positive relationship between perceived usefulness, compatibility, and the intention to use the computer-based interventions, or the CDSS, for medication safety in ED. Barriers to usage and intention to use were attributed to factors such as a failure of adequate workflow fit and a low ease of use. The TAM2 model was determined to be a useful tool to identify implementation barriers of medication safety interventions (2). Likewise, Ketikidis and others (3) utilized TAM2 in a study of usage intentions among doctors and nurses and found that several of the TAM2 constructs predicted the intention to use, or accept, HIT, including PEOU, job relevance, and subjective norms.

While studies of HIT acceptance support the use of TAM frameworks among physicians and nurses, there is a lack of research utilizing the TAM theoretical framework to study acceptance of HIT by pharmacy workers (4). Moreover, evidence suggests that factors other than the core TAM variables may be more significant among pharmacy clinicians. For instance, Holden and colleagues (4) assessed pharmacy workers' acceptance of bar-coded medication-dispensing and administration (BCMA) technology using the general TAM framework along with perceived social influence (SI) and satisfaction. The findings suggest that PEOU was not associated with pharmacy workers' intention to use BCMA technology, but it was linked to their satisfaction with BCMA. Perceived

usefulness was not associated with intention to use, but it was a predictor of acceptance due to patient care. In addition, SI was positively associated with the intention to use BCMA (4).

TAM has proven to be the most prominent theoretical approach to describe users' intentions to accept IT, and it offers a foundation upon which researchers can develop new, relevant variables in explaining the use of technology and health informatics (3,5). In the years since Davis' original study, researchers have utilized the underlying TAM framework to develop evolving theoretical models to further explain CDSS user acceptance by professionals in the health care setting. UTAUT is a more recent model that, while being an extension of TAM, unifies IT acceptance literature (5). According to Holden and Karsh (5), tests of UTAUT found that it explained 70% of the variance in behavioral intention and approximately 50% of actual use, supporting its use as a framework for future studies. Comparably, Shibl and others (20) adapted the UTAUT framework to examine how general practitioners utilize the CDSS and to build upon theory to address gaps in the literature such as the lack of studies testing the UTAUT model and CDSS acceptance (20). Using the UTAUT model to explain CDSS acceptance by general practitioners, Shibl and others (20) identified several factors as being influential to the acceptance and use of CDSSs by general practitioners, including performance expectancy (usefulness), facilitating conditions (workflow, training, integration), effort expectancy (ease of use), and trust in the knowledge base.

Research design and theoretical framework

As a well-tested theoretical model, UTAUT has proven to be appropriate for use in the context of the health care setting and with a variety of technologies. In addition, extensions of the UTUAT constructs have been widely applied to studies on technology acceptance, which provides an adaptive framework for incorporating additional variables of interest (21). While UTAUT conceptualizes the psychological variables thought to influence behavioral intentions to use technology (3), the model does not include satisfaction, which evidence from Holden and colleagues' research (4) suggests significantly impacts acceptance in settings where technology use is mandatory. Accordingly, the present study will incorporate satisfaction as an additional dependent variable.

Venkatesh and others (6) identified four major constructs that directly determine user acceptance and usage behavior: performance expectancy, effort expectancy, SI, and facilitating conditions. Performance expectancy can be described as the degree to which an individual believes that using the system will enhance job performance. Effort expectancy can be described as the degree of ease of using the system. SI is the degree to which an individual perceives that important others believe the system should be used. Performance expectancy, effort expectancy, and SI affect the BI to use the system. Behavioral intention can be described as the degree to which a user is willing to use the system. The last construct, facilitating conditions, can be described as the degree to which an individual believes that the organization has a structure to support the use of the system. Facilitating conditions do not influence the intention to use a system, but they do have a direct effect on the actual usage of the system (see Figure 1).

Several key moderators identified in UTAUT that moderate the influence of the major construct include gender, age, experience, and voluntariness. These moderators are hypothesized to influence the effect of the major constructs (performance expectancy, effort expectancy, SI, and facilitating conditions) on the BI to use a system, as well as actual use. Venkatesh and others (6) explain that the BI to use a system will consequently have a positive influence on the usage of technology. Holden and others (4) conceptualized BI and satisfaction as predictors to actual usage behavior. Satisfaction can be defined as the general attitude or disposition to use of a system. When incorporated as a dependent variable, satisfaction is useful in discriminating the spectrum of voluntary to mandatory usage behavior (4). For instance, BI may be self-reported as high among clinicians in an environment where use of the technology is mandatory because users feel that this is the expected response. However, studies suggest that even in mandatory environments, clinician users often find workarounds or overrides when there is a general resistance to using health care technology, which could be attributed to unfavorable

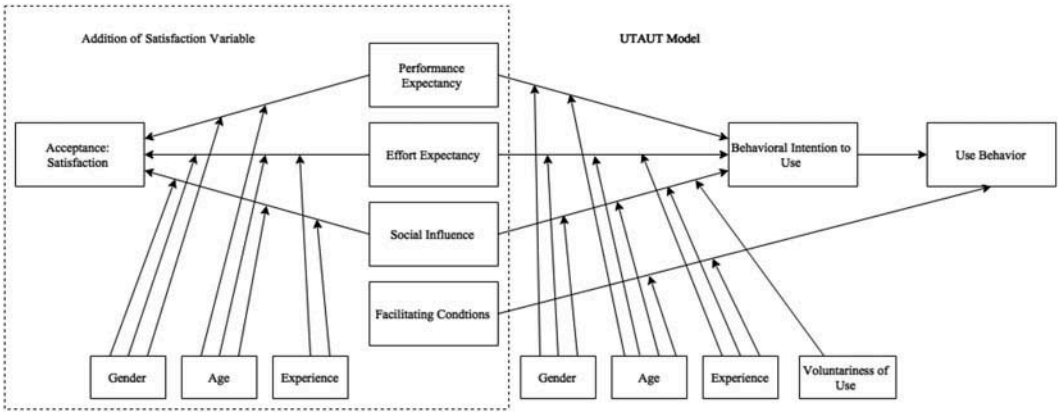

Figure 1. Modified unified theory of acceptance and use of technology (Venkatesh and others (6)).

perceptions or dissatisfaction with the technology. Thus, satisfaction may more accurately predict use behaviors than BI in settings where technology use is mandatory for clinicians (4). Each of the independent variables from UTAUT (performance expectancy, effort expectancy, and SIs) is hypothesized to influence satisfaction. It is hypothesized that the relationships between these independent variables and satisfaction will be moderated by gender, age, and experience.

Similar to effort expectancy, Holden and others (4) conceptualize the perception of effort associated with the use of a technology as PEOU. Additionally, performance expectancy is further delineated by the perceived usefulness to self (PU-SELF) and the perceived usefulness to the patient (PU-PT), reflecting the contextual influences of the health care setting. For clinical pharmacists, PU could be thought of in terms of usefulness to one's own productivity on the job or with respect to usefulness in improving patient care and outcomes (4). Therefore, Holden and others (4) theorize a causal relationship between PEOU, PU-SELF, PU-PT, and SI and technology acceptance (BI and satisfaction) and between acceptance and actual use.

Research questions

The data collection instrument was developed from the Venkatesh and others' (6) article, and the research questions closely follow this model.

Satisfaction (Acceptance):

- What is the influence of performance expectancy on the clinical pharmacist's satisfaction with Sentri7/Quantifi, and how will it be moderated by gender and age?
- What is the influence of effort expectancy on the clinical pharmacist's satisfaction with Sentri7/Quantifi, and how will it be moderated by gender, age, and experience?
- What is the influence of SI on the clinical pharmacist's satisfaction with Sentri7/Quantifi, and how will it be moderated by gender, age, and experience?
- What is the influence of satisfaction on the clinical pharmacist's use behavior of Sentri7/Quantifi?

Behavioral Intention to Use/Use Behavior:

- What is the influence of performance expectancy on the clinical pharmacist's BI to use Sentri7/Quantifi, and how will it be moderated by gender and age?
- What is the influence of effort expectancy on the clinical pharmacist's BI to use Sentri7/Quantifi, and how will it be moderated by gender, age, and experience?

- What is the influence of SI on the clinical pharmacist's BI to use Sentri7/Quantifi, and how will it be moderated by gender, age, voluntariness of use, and experience?
- What is the influence of facilitating conditions on the clinical pharmacist's use behavior of Sentri7/Quantifi, and how will it be moderated by age and experience?
- What is the influence of behavioral intention on the clinical pharmacist's use behavior of Sentri7/Quantifi?

Methods

The clinical pharmacists at Baptist Health (BH) System utilize a CDSS (Sentri7 from Pharmacy OneSource) that runs rules against medication, laboratory, and demographic patient data to provide real-time surveillance of pharmaceutical therapies in a dashboard view. Data from these systems are interfaced to Sentri7 via HL7 messages over the Cloverleaf interface engine.

To examine clinical pharmacists' acceptance of the CDSS in the BH System, Institutional Review Board (IRB) approval was obtained from Northern Kentucky University. In the process, permission to conduct research in three hospitals at Louisville, Paducah, and Corbin was also obtained from the hospitals. The study surveyed all of the 48 clinical pharmacists at BH Louisville, Corbin, and Paducah via an online questionnaire to measure their ongoing disposition toward a pharmacy surveillance CDSS. The response rate was 52%; that is, 25 clinical pharmacists responded to the questionnaire. Informed consent from all study participants was secured for the online questionnaire. All responses collected from the study participants were anonymous.

The disposition of the study participants was measured by an online questionnaire administered through Qualtrics (see Appendix B). Initial in-person meetings were arranged with potential study participants at BH Louisville and Paducah prior to the study. These meetings were necessary to provide the study participants with information regarding the study and instructions on how to access the online survey questionnaire. An e-mail introduction, along with the online questionnaire link, was sent to clinical pharmacists at BH Corbin. Data collection lasted approximately 2 weeks per site. The online questionnaire was open to the BH Louisville clinical pharmacists for a 2-week period in June 2014. The clinical pharmacists at BH Paducah and BH Corbin had access to the questionnaire for a 2-week period in late October and early November 2014.

The online survey questionnaire consisted of a number of questions that measured the ongoing disposition of the clinical pharmacists toward the CDSS surveillance software in accordance with the constructs of UTAUT developed by Venkatesh and others (6). Written permission was obtained to adapt the original UTAUT instrument and constructs from the publisher of the Venkatesh and others' (6) article for use in this study. The major constructs of UTAUT (performance expectancy, effort expectancy, social influence, and facilitating conditions) were operationalized as independent variables in the online survey. Each of these variables was measured by a series of items (questions) adapted from previous studies to ensure construct validity. The self-reported responses from the study participants were measured on a 5-point Likert scale. Data on the moderating variables (gender, age, and experience) were also gathered via the online questionnaire.

The dependent variables included behavioral intention and usage behavior. As recommended by Holden and others (4), an additional dependent variable, satisfaction, was included to capture acceptance in environments where technology use is mandatory, which was the case with this study population. The dependent variables were measured on a 5-point Likert scale. The reader is referred to Appendix B for the questions contained in the survey questionnaire. The variables are indicated next to each item in the questionnaire.

Results

Women make up 60% of the clinical pharmacists at the three BH locations we studied (see Table 1). Among the surveyed clinical pharmacists, 64% (16 clinical pharmacists) are under 40 years of age

Table 1. Clinical pharmacist distribution by gender in three Baptist Health locations.

Gender	Frequency	Percent (%)
Female	15	60.0
Male	10	40.0
Total	25	100.0

Table 2. Clinical pharmacist distribution by age in three Baptist Health locations.

Age	Frequency	Percent (%)
20–30 years	7	28.0
31–40 years	9	36.0
41–50 years	4	16.0
Over 61 years	1	4.0
Total	25	100.0

Table 3. Years of experience of clinical pharmacists at three Baptist Health locations.

Experience	Frequency	Percent (%)
Less than 5 years	6	24.0
5–10 years	6	24.0
11–15 years	7	28.0
16–20 years	1	4.0
Over 20 years	5	20.0
Total	25	100.0

(see Table 2). Table 2 provides a breakdown by age of the clinical pharmacists in the three BH locations. Also, 76% of the clinical pharmacists, 19 clinical pharmacists, had fewer than 15 years of experience, while 48% of the clinical pharmacists (12 clinical pharmacists) had fewer than 10 years of experience (see Table 3).

Questionnaire items were tested for reliability. The mean scores and standard deviations for the questionnaire items are presented in Table 4. Question 14 (measuring facilitating conditions) and Question 10 (measuring SI) with low factor loadings (<0.4) were removed from analysis. Further, based on low Cronbach's alpha values (0.000–0.355), Question 19 (measuring behavioral intention) and Questions 25 and 26 (measuring use) were removed from analysis. We retained items with Cronbach's alpha 0.569.

To assess discriminant validity, we calculated correlation coefficients. None of the correlations between use and satisfaction were greater than 0.5, illustrating discriminant validity between the two variables—use and satisfaction. Also, the correlation coefficients between performance expectancy and effort expectancy are low (<0.3), indicating discriminant validity.

We utilized Smart PLS to conduct partial least squares (PLS) regression to analyze the influence of performance expectancy, effort expectancy, and SI on behavioral intention toward as well as on satisfaction with Sentri7/Quantifi. PLS is considered an adequate method for analyzing the influence in a model that posits moderating effects (6). The same statistical procedure was applied to understand (a) the impact of behavioral intention and facilitating conditions on use and (b) the influence of satisfaction on use.

Behavioral intention of clinical pharmacists Re Sentri7/Quantifi

In the first set of research questions, we aimed to analyze the influence of performance expectancy, effort expectancy, and SI on the behavioral intention of clinical pharmacists at the BH locations toward Sentri7/Quantifi. In the mandatory environment of these clinical pharmacists which requires them to use Sentri7/Quantifi, none of the variables—performance expectancy, effort expectancy, or SI—affect behavioral intention. Also, behavioral intention of clinical pharmacists toward Sentri7/Quantifi does not influence use of Sentri7/Quantifi. However, when we observed the influence of

Table 4. Mean, standard deviation, and variance of questionnaire item.

	N	*M*	SD	*V*
Q1. I find that using Sentri7 enables me to identify clinical interventions more quickly.	25	4.64	0.490	0.240
Q2. I find that using Sentri7 and Quantifi increases my productivity.	25	4.36	0.810	0.657
Q3. I find that using Sentri7 and Quantifi will increase my chances of receiving an exceptional performance evaluation.	25	3.28	0.891	0.793
Q4. I find that using Sentri7 and Quantifi is clear and understandable.	25	4.44	0.507	0.257
Q5. I find that using Sentri7 and Quantifi is easy.	25	4.40	0.500	0.250
Q6. I find that learning to operate Sentri7 and Quantifi is easy.	25	4.20	0.913	0.833
Q7. People who influence my work behavior think that I should use Sentri7 and Quantifi.	25	4.16	0.943	0.890
Q8. People who are important to me at work think that I should use Sentri7 and Quantifi.	25	4.08	0.954	0.910
Q9. I feel that Baptist Health Pharmacy management has been helpful in my use of Sentri7 and Quantifi.	25	4.12	0.781	0.610
Q10. I feel that Baptist Health administration supports my use of Sentri7 and Quantifi.	25	4.28	0.458	0.210
Q11. I have the resources necessary to use Sentri7 and Quantifi.	25	4.32	0.476	0.227
Q12. I have the knowledge necessary to use Sentri7 and Quantifi.	25	4.48	0.510	0.260
Q13. I find that Sentri7 and Quantifi are compatible with other pharmacy or patient information systems that I use.	25	3.76	0.879	0.773
Q14. I feel that Baptist Health super users are available for assistance with Sentri7 and Quantifi technical issues.	25	4.16	0.943	0.890
Q15. I feel that the use of Sentri7 to identify ALL clinical intervention opportunities is mandatory.	25	3.12	1.269	1.610
Q16. I feel that the use of Quantifi to document ALL clinical interventions is mandatory.	24	3.79	1.215	1.476
Q17. I want to use the Sentri7 dashboard to identify ALL clinical interventions.	25	3.96	0.611	0.373
Q18. I want to use Quantifi to document on ALL clinical interventions.	24	4.17	0.963	0.928
Q19. I want to use the Sentri7 rule builder to construct personal clinical intervention rules to enhance my job performance.	24	2.75	1.422	2.022
Q20. Which of the following describes your satisfaction with using Sentri7 in your clinical daily workflow?	25	4.20	0.577	0.333
Q21. Which of the following describes your satisfaction with using Quantifi in your daily workflow?	23	3.91	0.668	0.447
Q22. The use of Sentri7 and Quantifi as a new method of identifying and documenting on clinical interventions is better than the old method.	25	4.16	0.850	0.723
Q23. I would recommend Sentri7 and Quantifi to a peer at another hospital.	25	4.20	0.577	0.333
Q24. I use all of the Sentri7 dashboard functionalities to identify clinical interventions.	25	4.20	0.500	0.250
Q25. I use other methods outside of Sentri7 to identify clinical interventions.	25	2.88	0.881	0.777
Q26. I use the Sentri7 rules builder to build new clinical rules to enhance my job performance.	25	2.12	1.301	1.693
Q27. I use the Sentri7 functionalities to their fullest.	25	3.84	0.746	0.557
Q28. I use the Quantifi functionalities to their fullest.	23	3.61	1.118	1.249

M = mean, SD = standard deviation, *V*= variance.

behavioral intention and facilitating conditions on the use of Sentri7/Quantifi, as postulated by Venkatesh and others (6), of the two constructs, facilitating conditions influence clinical pharmacists' use of Sentri7/Quantifi ($p < 0.05$).

The four moderators—age, gender, clinical pharmacists' years of experience, and their voluntariness of use—had no effect on the influence of the independent variables—performance expectancy, effort expectancy, and SI—on behavioral intention of clinical pharmacists toward Sentri7/Quantifi. The effect of the same moderators was also nonsignificant on the influence of behavioral intention of clinical pharmacists on their use of Sentri7/Quantifi.

Satisfaction of clinical pharmacists Re Sentri7/Quantifi

Due to the mandatory setting of Sentri7/Quantifi in clinical pharmacy work, we aimed to also analyze the influence of performance expectancy, effort expectancy, and SI on satisfaction, as postulated by Holden and others (4) in their study of pharmacy workers. Holden and others' (4) influential constructs, although labeled differently, are considered to be similar to performance expectancy, effort expectancy, and SI.

Hence, we tested the influence of performance expectancy, effort expectancy, and SI on satisfaction of clinical pharmacists with Sentri7/Quantifi. Two of the three independent variables significantly influence satisfaction. Both clinical pharmacists' performance expectancy and effort

Table 5. Influence of performance expectancy, effort expectancy, and social influence on satisfaction of clinical pharmacists.

Determinant	*t*-statistic
Performance expectancy	2.684*
Effort expectancy	2.839*
Social influence	0.844

$R^2 = 0.492$.
*Significant $p < 0.05$.

Table 6. Influence of satisfaction on use of Sentri7 by clinical pharmacists.

Determinant	*t*-statistic
Satisfaction	4.045*

$R^2 = 0.379$.
*Significant $p < 0.05$.

expectancy influence satisfaction of clinical pharmacists ($p < 0.05$) with Sentri7/Quantifi (see Table 5). The influence of SI on satisfaction of clinical pharmacists with Sentri7/Quantifi was nonsignificant (Table 5). However, similar to the influence of behavioral intention of clinical pharmacists toward Sentri7/Quatifi on the use of Sentri7/Quantifi, their satisfaction with Sentri7/Quantifi also influences the use ($p < 0.05$) of Sentri7/Quantifi (see Table 6).

Although performance expectancy and effort expectancy were found to influence satisfaction of clinical pharmacists with Sentri7/Quantifi, the impact of moderators—age, gender, and clinical pharmacists' years of experience—on the influence of performance expectancy and effort expectancy on satisfaction of clinical pharmacists with Sentri7/Quantifi was nonsignificant. The influence of the same moderators on the influence of satisfaction of clinical pharmacists with Sentri7/Quantifi on their use of Sentri 7/Quantifi was also nonsignificant. We did not include clinical pharmacists' voluntariness of use as a moderator in the preceding analysis. Voluntariness was not considered a moderator in this analysis due to its limited application in a mandatory setting.

Discussion

The UTAUT model postulates three direct determinants of BI—performance expectancy, effort expectancy, and SI—and two direct determinants of usage behavior—intention and facilitating conditions (6). We found only one of these relationships to be significant. Facilitating conditions did influence use of Sentri7/Quantifi, consistent with Venkatesh and others (6). That is, we found facilitating conditions to be significant in influencing usage behavior among BH clinical pharmacists. This is not surprising to us. BH locations had a robust infrastructure in place for the Sentri7/Quantifi to succeed. Super users and IT staff were readily available to the clinical pharmacists to start and continue their use of the CDSS which is integrated with essential systems.

Performance expectancy, effort expectancy, and SI, however, did not influence behavioral intention in the mandatory environment of BH locations. Several extensions of the original TAM framework, including the UTAUT model, have been applied to study clinicians' acceptance of CDSS and HIT (1,3,4,19,20). As indicated previously, in adapting the UTAUT model to understand CDSS acceptance among general practitioners, Shibl and others (20) identified performance expectancy (workflow, training, integration), facilitating conditions, effort expectancy, and trust in the system as influential. We have two explanations for our findings. First, the mandatory environment of Sentri7/Quantifi could have minimized the impact performance expectancy and effort expectancy would otherwise have had on behavioral intention. In other words, behavioral intention itself may not be as relevant in a mandatory setting. If the clinical pharmacists are required to use the CDSS, their intention to use the systems becomes less important. Hence, their perceptions of the degree to

which using the system will enhance job performance (performance expectancy) and the degree of ease of using the system (effort expectancy) although influential generally were not so on behavioral intention. In the mandatory setting of BH hospitals where clinical pharmacists' managers require them to use the CDSS, pharmacists' perceptions of benefits that the CDSS may offer to job performance and ease of use of the CDSS became less relevant to their intention to use the CDSS.

Second, SI, the other factor, is somewhat different. SI is the degree to which an individual perceives that important others believe the system should be used. SI generally erodes over time, eventually becoming nonsignificant with sustained use. As would be expected, Venkatesh and others (6) explain that SI is only found to be significant in mandatory settings during the early stages of individual experience with IT use. We collected data midway through implementation of Sentri7/Quantifi. It had been 6 months since it was installed and operational. At this stage, the majority would have already been using the CDSS to some extent. As such, the influence of perceptions of important people becomes less impactful. Additionally, as noted, we believe that behavioral intention is not as meaningful in an environment where use of the CDSS is required.

We had anticipated some of these scenarios and included satisfaction as a construct to examine the effect of performance expectancy, effort expectancy, and SI on the use of the CDSS in the clinical pharmacy (4). Holden and others (4) analyzed satisfaction in health care organizations in their model. Many of their constructs are similar to those in the UTAUT model. Their PEOU is similar to effort expectancy. Perceived usefulness for one's own performance (PU-SELF) and perceived usefulness for patient care (PU-PT) together are similar to performance expectancy which subsumes both patient care/safety and personal job performance in a health care environment. SI is similar to Venkatesh and others' (6) SI construct. It differs in Holden and others' (4) posit that PEOU, PU-SELF, PU-PT, and SI can influence either behavioral intention or satisfaction gained from use. In turn, behavioral intention or satisfaction gained from use can affect actual use of the CDSS. The model's additional element of satisfaction in understanding the same determinants had made it more likely choice for our analysis.

Holden and others' (4) application to BCMA found that perceived usefulness and ease of use were associated with satisfaction but not with intention to use. We also found that although performance expectancy and effort expectancy did not influence behavioral intention, both of these constructs did indeed influence clinical pharmacists' satisfaction gained from use of the CDSS at BH. Holden and colleagues (4) found that SI was not associated with satisfaction. We found this relationship as well. Also, in our study, satisfaction gained from use of Sentri7/Quantifi affected clinical pharmacists' actual use of the CDSS.

From a management perspective, the results show that clinical pharmacists are more likely to use Sentri7/Quantifi when they are satisfied. This happens when pharmacists perceived Sentri7/Quantify as useful to their personal performance and patient care and perceived that it functions to deliver desired performance. The surveillance capabilities of CDSS in preventing ADEs based on synthesized patient data from multiple systems is well established in the literature (15–18). Clinical pharmacists were also more likely to use Sentri7/Quantifi when the use of the CDSS was facilitated. When a CDSS decreases the amount of time and effort of using multiple IT systems and manual chart searches, it eliminates potential errors and decreases the effort in time spent on identifying pharmaceutical interventions. It makes it easier for them to use the CDSS. As a result, the pharmacists are more satisfied and trust the system. They utilize the CDSS to aid them in identifying interventions and produce inter-pharmacist communication and notification via Quantifi. Quantifi is a powerful tool for clinical pharmacists to communicate on pharmaceutical interventions. This affords the clinical pharmacists the ability to collaborate and transition care to the other clinical pharmacists on specific patient interventions.

We applied the Holden and others' (4) model to assess clinical pharmacists' satisfaction with and use of the CDSS. Future studies must more thoroughly explore performance expectancy from the perspective of both personal usefulness to the clinical pharmacist's job and usefulness to patient care. In health care environments, this contextual element must be captured in TAMs.

Our findings are generally applicable to any health care organization in implementing HIT. The findings are also applicable in health care organizations such as BH where the implementation has been successful for the most part; that is, we found that only a small percentage of clinical pharmacists (16%) were always or most of the time motivated to use the Sentri7 rules builder to build new clinical rules to enhance their job performance (Table 4). A large percentage (68%) had never or rarely built new clinical rules. We also found that while a small percentage of clinical pharmacists (12%) had always or most of the time employed workarounds by applying solutions from elsewhere, the majority (60%) had sometimes used workarounds (Table 4). Altogether, 72% employed workarounds.

The goal is to minimize workarounds and/or overrides and maximize use. The BH clinical pharmacists collaborate in building clinical decision rules which enable them to identify potential pharmaceutical interventions in a timely manner in accordance with best practices and regulatory standards. This system also allows clinical pharmacists the ability to individually build clinical decision rules that are specific to their patient population. Any rules that are built by a clinical pharmacist can be shared with others as needed. Sentri7/Quantifi is a flexible tool because it allows pharmacists the ability to build just about any clinical decision rule needed if the proper HL7 interface is in place to transport data from the source system. When clinical pharmacists use the Sentri7 rules builder, the CDSS is in full use.

The second issue we found was that clinical pharmacists employed workarounds (for instance, manual chart reviews). Pharmacists' perceptions of HIT are important to patient safety and outcomes because these benefits depend directly on its use and how it is used. Dissatisfaction with CDSSs can lead to nonuse of system features, workarounds, overrides, or minimal use. Such patterns of nonuse or not using the system as intended can lead to safety concerns or errors (4). Also, the potential cost–benefit savings from improved efficiency in preventing medical errors are not realized (4,6).

In a mandatory setting, clinical pharmacists would be expected to report that they intend to use Sentri7/Quantifi, yet, if not satisfied, they would be more likely to employ workarounds or overrides. If the clinical pharmacists are satisfied with Sentri7/Quantifi, they would use it better, which is consistent with the relationship between satisfaction and use found in this study.

Limitations

We consider our relatively small sample size of 25 clinical pharmacists a limitation in the study. Our response rate of 52% is also not entirely adequate. We studied three hospitals in the BH System; however, two of the three authors worked at the time in the BH System, and one continues to deliver health care in the BH System. The preceding could have hindered higher response rate due to apprehension of responses being shared with managers. We did assure the clinical pharmacists of utmost confidentiality. Only the author who is unaffiliated with the BH System received the participant responses; the other two authors did not have access to individual participant responses and were only privy to responses in the aggregate form. Also, the small sample size likely rendered the impact of moderators—age, gender, and clinical pharmacists' years of experience—nonsignificant. Most of the participants were under the age of 40. As such, the results may not reflect age-related perceptions about technology from older workers' perspectives. Future studies with a larger sample size will likely find an effect. The sample came from within one health care system, so results are likely to be influenced by the organizational culture and, thus, are not generalizable.

We had studied the BH clinical pharmacists during the first year of implementation; however, we did so midway through this year, which may have also affected the relevance of the notion of behavioral intention. BH clinical pharmacists had become familiar and experienced with using Sentri7/Quantifi. The CDSS implementation did leave room for reaching its full potential which is discussed below.

Conclusions and recommendations

Our study provides useful information to administrators and managers in any health care organization, including those such as BH where Sentri7/Quantifi has been implemented successfully because satisfaction with technology is important. The pharmacists are the ones using it on a daily basis and ultimately will decide its value. It does not matter how well-designed the HIT system is if it is not used or if it is used inappropriately (4).

Specifically, to further the implementation and potential of the Sentri7/Quantifi, managers must focus on showing how Sentri7/Quantifi enhances not only clinical pharmacists' everyday workflow (2), but also how it improves patient care and safety, a major impetus driving health care today. Clinical pharmacists will likely use the CDSS if they trust the knowledge base (20). Managers must illustrate to all that the CDSS (a) identifies adverse drug events (15,18); (b) interfaces with other systems to increase the effectiveness of pharmaceutical therapy such as renal dose adjustments, using laboratory data to identify appropriate antibiotic selection or dosing, and switching from IV to PO (9,12); (c) allows compliance with the myriad of quality initiatives or public reporting programs that are tied to patient safety, patient outcomes, hospital accreditations, and reimbursements; and (d) improves efficiency by minimizing pharmaceutical errors that are extremely costly in both damage to the patient and financially to the hospital (10,11). Managers must demonstrate that the CDSS provides a reliable tool to help the pharmacists and management to identify and control potential errors and optimize care.

Consistent with Venkatesh and others (6), we found that facilitating conditions influenced use among the clinical pharmacists in the BH System. The BH System has an infrastructure in place to facilitate use of Sentri7/Quantifi. Integrating multiple systems will decrease effort and time, resulting in ease of use, which will, in turn, result in satisfaction gained from use and can increase and improve actual use of the Sentri7/Quantifi to reach its fullest potential.

At BH, several groups collaborated to enable Sentri7/Quantifi to have the needed data to make it useful. Information services facilitated the integration between the pharmacy, laboratory, and core EHR information systems to build the required HL7 interfaces to provide Sentri7 with the needed data to build clinical decision rules. Clinical pharmacists' ability to pull data from disparate systems in identifying interventions is key. A fully functioning system will enhance the role of the clinical pharmacist as a team member in health care and in delivering safe, effective care.

In addition to the above, our recommendation would be to identify possible barriers to use and to enhance technical and organizational environments to support CDSS implementation. For instance, the absence of technical support or super users during nights and evenings may cause pharmacists to consult other sources for necessary information, such as paper charts or phone calls to nursing staff. Likewise, having the CDSS in readily available and multiple locations eliminates barriers to access, which facilitates use. Facilitating conditions can be maintained through an organizational commitment to invest in necessary software updates and training to minimize barriers to sustained use that can arise when systems become outdated, run slowly, or are not integrated with other systems.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this study.

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Appendix A

Variables and operational definitions

Variable to be measured	Variable type	Operational definition
Performance expectancy	Independent	Degree to which an individual believes that using Sentri7/Quantifi will enhance job performance.
Effort expectancy	Independent	Degree of ease of using Sentri7/Quantifi.
Social influence	Independent	Degree to which an individual perceives that important others believe Sentri7/Quantifi should be used.
Facilitating conditions	Independent	Degree to which an individual believes that the organization has a structure to support the use of Sentri7/Quantifi.
Voluntariness of use	Moderating	The decision to utilize all of the clinical decision support rules in Sentri7/Quantifi is self-determined.
Gender	Moderating	An individual's gender.
Experience	Moderating	The number of years that a user has utilized health information technology.
Age	Moderating	An individual's age.
Behavioral intention	Dependent	An individual's motivation to use Sentri7/Quantifi.
Satisfaction (Acceptance)	Dependent	A conceptualization of acceptance: An individual's attitude or opinion about using Sentri7/Quantifi as part of the clinical pharmacy workflow.
Usage behavior	Dependent	The extent to which an individual is engaged and uses all of Sentri7/Quantifi functionalities to perform job tasks. In other words, the extent to which an individual does more than the minimum required by the Sentri7/Quantifi and its designers.

Appendix B

Participant questionnaire

(PE—performance expectancy, EE—effort expectancy, SI—social influence, FC—facilitating conditions, VOL—voluntariness of use, AGE—age, GE—gender, EXP—experience (HIT), BI—behavioral intention to use, SATIS—satisfaction, USE—usage behavior)

Q1. [PE] I find that using Sentri7 enables me to identify clinical interventions more quickly.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q2. [PE] I find that using Sentri7 and Quantifi increases my productivity.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q3. [PE] I find that using Sentri7 and Quantifi will increase my chances of receiving an exceptional performance evaluation.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q4. [EE] I find that using Sentri7 and Quantifi is clear and understandable.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q5. [EE] I find that using Sentri7 and Quantifi is easy.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q6. [EE] I find that learning to operate Sentri7 and Quantifi is easy.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q7. [SI] People who influence my work behavior think that I should use Sentri7 and Quantifi.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q8. [SI] People who are important to me at work think that I should use Sentri7 and Quantifi.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q9. [SI] I feel that Baptist Health Pharmacy management has been helpful in my use of Sentri7 and Quantifi.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q10. [SI] I feel that Baptist Health administration supports my use of Sentri7 and Quantifi.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q11. [FC] I have the resources necessary to use Sentri7 and Quantifi.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q12. [FC] I have the knowledge necessary to use Sentri7 and Quantifi.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q13. [FC] I find that Sentri7 and Quantifi are compatible with other pharmacy or patient information systems that I use.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q14. [FC] I feel that Baptist Health super users are available for assistance with Sentri7 and Quantifi technical issues.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q15. [VOL] I feel that the use of Sentri7 to identify ALL clinical intervention opportunities is mandatory.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q16. [VOL] I feel that the use of Quantifi to document ALL clinical interventions is mandatory.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q17. [BI] I want to use the Sentri7 dashboard to identify ALL clinical interventions.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q18. [BI] I want to use Quantifi to document on ALL clinical interventions.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q19. [BI] I want to use the Sentri7 rule builder to construct personal clinical intervention rules to enhance my job performance.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q20. [SATIS] Which of the following describes your satisfaction with using Sentri7 in your clinical daily workflow?

- Very Satisfied
- Satisfied
- Neutral
- Dissatisfied
- Very Dissatisfied

Q21. [SATIS] Which of the following describes your satisfaction with using Quantifi in your daily workflow?

- Very Satisfied
- Satisfied
- Neutral
- Dissatisfied
- Very Dissatisfied

Q22. [SATIS] The use of Sentri7 and Quantifi as a new method of identifying and documenting on clinical interventions is better than the old method.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q23. [SATIS] I would recommend Sentri7 and Quantifi to a peer at another hospital.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Q24. [USE] I use all of the Sentri7 dashboard functionalities to identify clinical interventions.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q25. [USE] I use other methods outside of Sentri7 to identify clinical interventions.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q26. [USE] I use the Sentri7 rules builder to build new clinical rules to enhance my job performance.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q27. [USE] I use the Sentri7 functionalities to their fullest.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q28. [USE] I use the Quantifi functionalities to their fullest.

- Always
- Most of the Time
- Sometimes
- Rarely
- Never

Q29. [AGE] Please indicate your age in years.

- 20–30 years
- 31–40 years
- 41–50 years
- 51–60 years
- Over 61 years

Q30. [GE] Please indicate your gender.

- Male
- Female

Q31. [EXP] I have worked with health information technology as a clinical pharmacist in my career for:

- Less than 5 years
- 5–10 years
- 11–15 years
- 16–20 years
- Over 20 years