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IMPROVING THE DESIGN OF MEDICATION SAFETY APPS: THE INFLUENCE OF VALUE-IN-EXPERIENCE ON PERCEIVED IMPACT

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ABSTRACT

The prevention of adverse drug events calls for the use of medication safety apps by providers as well as healthcare consumers. To inform the design of medication safety apps, the influence of value-in-experience—information quality, subjective quality, functionality, engagement, and aesthetics—on perceived impact of medication safety apps was investigated. Participants were asked to perform a task using one of three medication safety apps, and following the task, they were administered a questionnaire measuring their value-in-experience and perceived impact. For analysis, the hierarchical latent variable PLS-SEM was employed, using the repeated indicator approach. Across three medication safety apps, we found that value-in-experience influences perceived impact. Information quality and subjective quality influence perceived impact. Functionality, engagement, and aesthetics did not influence perceived impact. Developers and investigators are advised to give equal or more attention to information quality and subjective quality compared to other aspects of medication safety app user experience.

Keywords: Medication Apps, User Experience, Value-in-Experience

INTRODUCTION

With new pharmaceuticals hitting the market on a frequent basis, it has never been more important for both the clinician and the patient to be aware of potential issues related to medications. The availability of apps on mobile devices is making an abundance of medical knowledge available on demand and from anywhere. While many medication adherence apps have existed on the market for some time now, medication safety apps are not as prevalent. Medication safety is a healthcare issue that is being addressed with the use of these mobile apps. The availability of these apps, which report on contraindications, interactions and side effects, is transforming the medication safety knowledge base of both the clinician and the patient.

Half of all Americans take at least one prescription drug daily (Gershman & Fass, 2014), and this puts them at risk for adverse drug events. Many adverse drug events are preventable (Aspden, Wolcott, Bootman, & Croenwett, 2007; U.S. Food and Drug Administration, 2014). With the advent of smart technology, the use of medication safety apps is imperative not only for the physicians but also for healthcare consumers. Chronic disease is on the rise (Centers for Disease Control and Prevention, 2016). Consequently, as medication regimens become complex or even when over-the-counter medication is added to simpler regimens, lack of attention to medication safety can result in dire consequences.

For these medication safety apps to become commonplace in use which means completely integrated in practice or everyday life, the design of the apps, however, must meet the user's expectations in terms of image or impression. Hence, an understanding of user experience is critical for the success of these apps. We examine the user experience of three popular medication safety apps with students who are preparing to work in healthcare. Our study is grounded in a research model. We developed the research model based on prior theoretical constructs of value-in-experience and information system success. We believe that value-in-experience leads to the perceived impact of the app which is a precursor to long-term use. In examining value-in-experience, we isolate several constructs specific to medication apps—information quality, subjective quality, functionality, engagement, and aesthetics. We then study the influence of these constructs on perceived impact of medication safety apps to identify those constructs

that require further attention in the design and development of medication safety apps. The paper is organized as follows: literature review, user experience of medication apps, research model, hypotheses, methods, results, discussion and conclusions.

LITERATURE REVIEW

After researching the functionalities medication apps offered, van Kerkhof et al. determined that drug interaction monitoring was one of the least offered functionalities, only appearing as the functionality in 13 of the 116 applications that were studied (van Kerkhof, van der Laar, de Jong, Weda, & Hegger, 2016). Another important factor to consider is the intended users of these medication safety applications. This factor was observed for the same 116 applications in van Kerkhof et al.'s study from 2016. They found that medication apps are geared towards the patients with 69 out of 116 applications having this distinction.

This information is important to note because of the rapid increase in usage of mobile apps in the healthcare setting. However, apps geared toward the healthcare provider for medication interaction checking, which is an important factor in medication safety, have limited availability. Checking for medication safety is especially significant because the constantly changing environment of pharmacotherapies and medical devices and the pressure to reduce costs while maintaining patient volumes have led to the nearly impossible task of providing consistent patient care with minimal or no errors.

It has even been found that adverse events related to medications are the leading cause of harm when a patient is admitted into a hospital and are considered the cause of a large proportion of hospital admissions in the first place (Keers, Williams, Cooke, & Ashcroft, 2013). Keers et al. (2013) found that medication administration errors account for 19.1% of all the possible chances for error in the hospital setting. This is resulting in worse patient care, higher costs of care, and longer hospital stays.

Lack of an appropriate knowledge base has been found to be one of many causes of an adverse event which occurs due to medication errors. Keers et al. (2013) evaluated 54 studies which presented causes of medication administration errors in hospitals. In 16 of the 54 studies, inappropriate knowledge or rule-based mistakes in the healthcare setting was the cause. In these studies, staff explained they did not know enough about the medications they were giving, the infusion pump which was being used, or even the patient to whom it was being administered (Keers et al., 2013). Having this medication knowledge available at all times at the bedside could potentially begin to reduce these medication errors found in hospitals.

Adverse drug events are believed to be the most costly and significant problems in nursing homes as well today. They are believed to account for an estimated 93,000 deaths a year and nearly four billion dollars in additional healthcare expenses. The data related to these adverse drug events in nursing homes indicates that nearly half are preventable, and somewhere in the range of 59-68% are related to medication prescribing errors. This high incidence of medication prescribing errors is more than likely related to limited knowledge regarding appropriate medication prescribing practices and appropriate knowledge related to drug-to-drug interactions (Handler et al., 2013).

Despite the limited availability of these types of apps, the benefits are beginning to be realized. Historically, the potential of using such technology to prevent adverse drug events has not been known. However, in a recent survey of 558 physicians, 42% reported using a mobile device to assist them with prescribing medications in the nursing home setting (Handler et al., 2013). These physicians most commonly used the drug reference app Epocrates Rx. Of the physicians who used a mobile device to assist with prescribing medications in a nursing home setting, 98% reported looking up at least one drug per day with the application and typically performed, on average, one to two lookups per day searching for potential drug-to-drug interactions (Handler et al., 2013). Of even more interest, the results of the study also indicated that physicians who use these applications regularly perceive the applications assist them in reducing adverse drug events. The most relevant statistic found within the study is that 88% of physicians believed the medication safety application they were using helped to prevent an adverse drug event in the four weeks prior to the survey being administered (Handler et al., 2013). This is astounding considering the low availability and usage of medication safety applications in the healthcare environment.

Medication safety is not just an issue found within the healthcare setting. The elderly population is routinely prescribed medication regimens that can be tough to manage, especially with the availability of numerous over-the-counter medications and dietary supplements which may interact with the patient's prescribed medications. One study held in-home interviews and maintained medication logs with 2,976 individuals between the ages of 57 and 85 (Qato et al., 2008). This study found that 29% of these individuals actively take at least 5 prescription medications. Of these, 46% took an over-the-counter medication and 52% took a dietary supplement. The findings show that 4% of these individuals were at risk for major drug interactions in their medication regimen. This study demonstrates the need for not only the clinician to have basic drug-to-drug medication knowledge, but also the patient. A patient is not always going to be able to reach their care team, nor will they feel it is always necessary. However, a complex medication regimen combined with the availability of over-the-counter medications and dietary supplements can have serious consequences for patients.

The Institute of Medicine (IOM) reports that at least 1.5 million preventable adverse drug events occur in the United States annually. Many studies demonstrate the importance of medication safety, and inappropriate medication has been found to be one of the largest culprits when it comes to medication errors. In 2006, the IOM issued a report that explained ways to prevent such medication errors. In 2007, the Institute for Safe Medication Practices released a white paper addressing medication errors. This white paper was essentially a call to action for pharmacists to increase patient safety by reducing the amount of inappropriate medication usage (Gershman & Fass, 2014). The IOM's recommendations included empowering patients to take control over their own healthcare and encouraging pharmacists to utilize the medication safety resources which are available on the market (Gershman & Fass, 2014). The preceding implies how important using medication safety apps can be in reducing adverse drug events and medication errors and in educating the patients about their medication regimen (Gershman & Fass, 2014).

USER EXPERIENCE OF MEDICATION APPS

To realize successful use of medication safety apps by both providers and healthcare consumers, consideration of the user experience of such apps is critical. The user experience of an app is predicated on the design of an app. Hence, an assessment of the user experience can further improve medication safety apps. While usability focuses on task-based achievement of goals, user experience assesses the user's feelings about "presentation, functionality, system performance, interactive behavior, and assistive capabilities of the interactive system" (Stewart, 2008). In this study, we do not conduct usability testing which requires an analysis of each screen within a medication safety app. Instead, our interest is in user experience. Surveys are deemed appropriate for understanding this overall experience of the user with the app.

In analyzing medication apps, researchers have deployed different approaches to understanding the user experience. Approaches range from pre- and post-intervention studies to randomized controlled trials (Anglada-Martínez et al., 2016; Ben-Zeev et al., 2013; Hayakawa et al., 2013; Kang & Park, 2016; Mira et al., 2014; Parmanto et al., 2013; Patel et al., 2013; Stinson et al., 2013).The focus of medication apps included in these studies has been on adherence rather than on safety. Often, the objective of the studies is to capture improvement in adherence realized as a result of using the app. Hence, to our knowledge, no studies exist on the user experience of medication apps geared toward drug information and safety.

In the present study, users performed a task with a medication safety app. The participants were given the task to gain experience with the app. The three medication safety apps—Epocrates, Medscape, and Drugs.com—we administered and assessed are similar in constitution and are designed to look up drug information, check interactions and identify pills. After the users performed the task with these medication safety apps, we proceeded to assess their user experience by soliciting responses on information quality, subjective quality, aesthetics, engagement, functionality, and perceived impact. Our contribution to user experience research is that we study aspects of medication safety app user experience that are grounded in theoretical constructs. In accomplishing the preceding, we deploy a reliable and valid instrument to assess the mobile app user experience.

RESEARCH MODEL

To understand the user experience of medication safety apps, we draw from the literature on value-in-experience and information system success in developing our research model. In doing so, we focus on how value-in-experience influences perceived impact of the app, which is an antecedent to long-term use.

Value may vary across different stages of customer experience; hence, what constitutes value-in-experience in anticipated consumption can be different from value experienced in direct use of a product (Turnbull, 2009). Our interest is in value-in-experience in anticipated consumption as the users of the app have not yet undertaken direct use.

Holbrook asserts that "Value is an interactive relativistic preference experience" (as cited in Turnbull, 2009, p. 4). In Holbrook's typology of value-in-experience, self-oriented value can be derived from excellence, play, and aesthetics which are the dimensions relevant for assessing the user experience of a mobile app (Holbrook, 1999). Holbrook's excellence encompasses quality and performance. In our research model, excellence is captured through the information quality of the app, subjective quality of the app, and functionality of the app. Holbrook's play can be described as the system's engagement with the user. According to Jacques et al., engagement happens when a system "holds [users'] attention and [users] are attracted to it for intrinsic rewards" (as cited in Webster and Ahuja, 2006, p. 664). In 1982, Holbrook and Hirschman "extended the traditional information processing model of consumer behavior to incorporate a hedonic component including exploratory behavior, daydreams, fun and learning by association" (Turnbull, 2009, p. 3). Later, Venkatesh et al. (2012) also updated their model of consumer acceptance and use of technology to include hedonic motivation. The extension of these research models to include the hedonic component reflects an increasing interest in the potential for engagement or play in apps. In our research model, we refer to Holbrook's play as engagement. Lastly, the aesthetics of the app can be value derived from its attractiveness. These five dimensions—information quality, subjective quality, functionality, engagement, and aesthetics—constitute value-in-experience in our research model.

Jayanti and Ghosh (1996) view perceived value as a direct consequence of perceived quality. Hence, we reviewed information system quality literature to establish a relationship between value-in-experience and the outcome of such experience. We draw upon DeLone and McLean (2003) and Petter and McLean (2009) who purport in their research model of information system success that information quality and system quality affect net benefits accrued. Their constructs of information quality and system quality align with the dimensions we derived from Holbrook's typology which Turnbull (2009) describes as value-in-experience. The outcome of such experience, net benefits accrued, includes impact on individuals as well as organizations. We identify this outcome of value-in-experience as perceived impact in our model because the user has not yet accepted and/or directly used the app. Hence, these are impacts that are perceived in anticipated consumption prior to direct use of consumer technology rather than actual impacts observed subsequent to direct use of consumer technology. It is also important to note that our focus is on the perceived impacts of the app rather than on the user's behavioral intention to use and/or the actual use of the app. As such, although related to the research on consumer acceptance and IT use by Venkatesh et al. (2012) and others, our model differs in its focus on a particular stage of consumer behavior which is the stage when users perceive impacts in anticipated consumption. In healthcare, perceived impacts of IT on healthcare operations and patient outcomes are critical. Accordingly, perceived impacts are a significant precursor to behavioral intention to use and the use of consumer technology.

Our model depicts the relationship between user value-in-experience and perceived impact of medication safety apps. The research model represents a novel and significant contribution in its application of theoretical constructs in studying the user experience of medication safety apps. We are interested in the user's perceptions of value-in-experience subsequent to briefly using the app and his/her perceptions of the impact of the medication safety app at the anticipated consumption stage. The research model is illustrated in Figure 1.

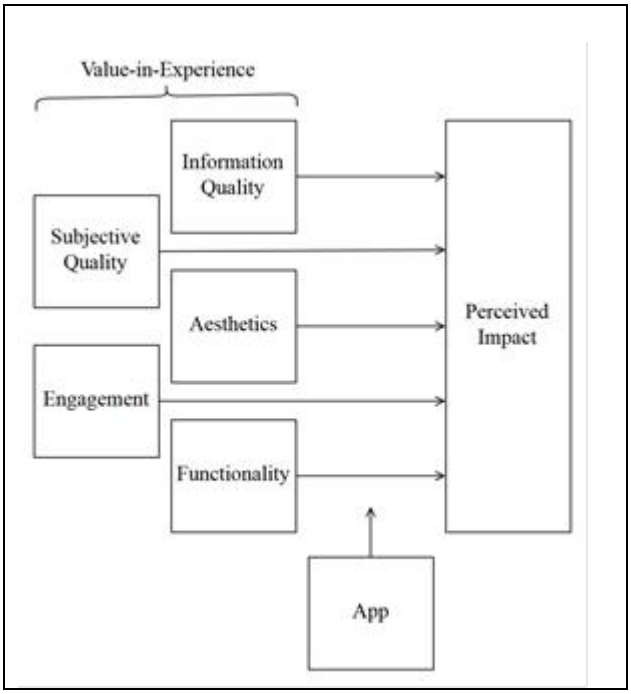


Figure 1. Research Model

All pertinent constructs displayed in the research model are defined in Appendix 1. In summary, value-in-experience is captured through information quality, subjective quality, aesthetics, engagement, and functionality. We examine the influence of information quality, subjective quality, aesthetics, engagement, and functionality on perceived impact of the medication safety app. The exogenous variable, app, in the research model accounts for variation across multiple medication safety apps.

Based on our research model, the research hypotheses to test the influence of value-in-experience on perceived impact of the medication safety app are as follows:

H1: Value-in-experience influences perceived impact of the app
H2: Information quality of the app influences perceived impact of the app
H3: Subjective quality of the app influences perceived impact of the app
H4: Aesthetics of the app influences perceived impact of the app
H5: Engagement presented by the app influences perceived impact of the app
H6: Functionality of the app influences perceived impact of the app
H7a: App influences information quality
H7b: App influences subjective quality
H7c: App influences aesthetics
H7d: App influences engagement
H7e: App influences functionality
H7f: App influences value-in-experience

METHODS

Data Collection

Upon receiving IRB approval in October 2016, we used Qualtrics to deliver our survey instrument, embedded with a task, to our participants. We sent the link that contained the task and the survey to 97 participants who had one week to complete both. One participant did not respond. This resulted in a response rate of 99%.

Our target population is nursing and allied health professionals entering practice in healthcare. We employ convenience and non-probabilistic sampling to collect data from nursing and allied health students who already are or will soon be in the healthcare workforce.

Participants were primarily undergraduate students in nursing, radiologic science, respiratory care, or health science. Very few students were from other majors, such as computer science or communication. Hence, the majority of students were already working or preparing to work in healthcare. All of the participants were enrolled in three sections of a health informatics course. The average age of participants is 23.9. While the majority of participants were under 25, some participants were in age groups above 25 (15.3% in 25-34, 7.7% in 35-49, and 1.4% in 50 and above). Ninety percent of the participants were female and 10% were male. As most of the participants were already or soon would be working in healthcare, their experience with the app and their perceptions of impacts from using the app can reveal important limitations that must be addressed in the design and development of medication safety apps.

Free versions of three medication safety apps—Epocrates, Medscape and Drugs.com—were assigned to each of the three sections of the course. We chose these three medication safety apps because they are currently the most popular medication safety apps that are freely downloadable. Our interest in these apps stems partly from our desire to understand if these apps are similar or different in terms of value-in-experience and perceived impact anticipated. Our larger goal, however, was to examine the influence of value-in-experience on perceived impact among targeted users.

Participants were asked to perform a task. This task involved downloading and installing a medication safety app. After installing the app, they were asked to follow a series of steps to check for drug interactions between Coumadin and Advil. Upon completing the task, data was collected using a survey instrument with multiple items for each construct from our research model. The survey instrument, which fits our theoretical model, was developed by Stoyanov, Hides, Kavanagh, and Wilson (2016). The authors establish the reliability and validity of the published instrument. Upon receiving permission to use this survey instrument, we modified items to be suitable for the context of medication safety app use. In a pilot test prior to data collection, two graduate students in health informatics completed the task and answered questions from the survey instrument.

Analysis

Upon collecting data, we tested to see if there were any differences across the three apps in our survey items. We applied ANOVA to test for differences across the three apps. We found that only one item for engagement (E3, Table 1) has a statistically significant difference between means across the three apps ($p = 0.01$). To determine how the apps differ in terms of E3 in the sample, we conducted pairwise comparisons using Tukey HSD. We found that there is a mean difference between Medscape and Epocrates ($p = 0.03$) and a mean difference between Medscape and Drugs.com ($p = 0.02$). However, there was no mean difference between Epocrates and Drugs.com.

To test our research model, we employed partial least squares structural equation modeling (PLS-SEM). As noted previously, Medscape differed from the other two apps in terms of E3. To address this minor difference, we estimate the parameters with a hierarchical latent variable model in PLS-SEM. The hierarchical latent variable model accounts for the exogeneity of the app in model estimation. While we had estimated the parameters with a hierarchical latent variable model here, to ensure consistency, we also estimated the same parameters using a general latent variable model. The estimated parameters from the hierarchical latent variable model were consistent with those from the general latent variable model.

For our analysis, we followed the guidelines for reflective-formative hierarchical latent variable models recommended by Becker, Klein, and Wetzels (2012). Becker et al. (2012) present three approaches: (1) the repeated indicator approach, (2) the two-stage approach, and (3) the hybrid approach. Becker et al. (2012) compare the three approaches and recommend the repeated indicator approach with formative measurement (Mode B) for repeated indicators as this achieves more precise parameter estimates and a more reliable higher-order construct score.

Therefore, we used the repeated indicator approach (Mode B) for estimating the parameters. The repeated indicator approach (Mode B) is illustrated in Figure 2.

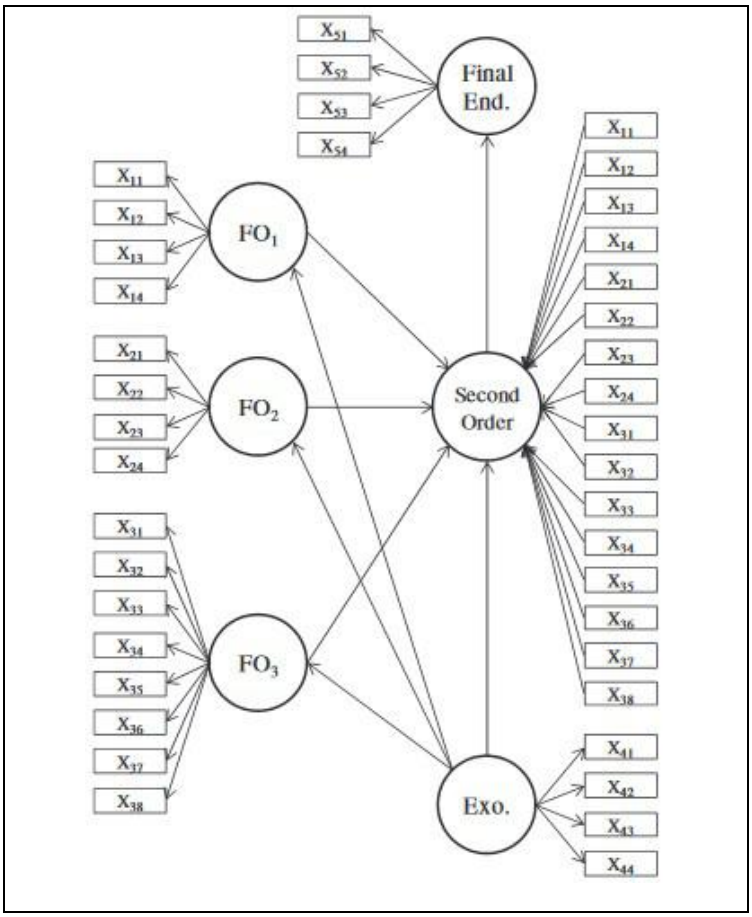


Figure 2. Repeated Indicator Approach (Mode B). Reprinted from "Hierarchical Latent Variable Models in PLS-SEM: Guidelines for Using Reflective-Formative Type Models," by J. -m. Becker, K. Klein, and M. Wetzels, 2012, *Long Range Planning, 45*, 380. Copyright 2012 by Elsevier.

In the repeated indicator approach (Mode B), all the indicators for first-order constructs were also used for the second-order construct, value-in-experience. We estimated our model using SmartPLS 2.0 (Ringle, Wende, & Will, 2005). For path-modeling estimation, we applied 300 for the maximum number of iterations and path weighting scheme. PLS-SEM uses bootstrapping which is a nonparametric technique. For the bootstrapping procedure, we set samples equal to 5,000 and cases equal to 96 to reflect the total number of observations (Hair, Ringle, & Sarstedt, 2011; Wong, 2013). According to Hair et al. (2011), PLS-SEM does not require a normal distribution. As our sample is a reasonable representation of the target population, it meets the assumption for the procedure (Hair et al., 2011).

Reliability and Validity

We present our reliability and validity measures in Table 1 and Table 2. Hair et al. (2011) explain composite reliability to be a more appropriate measure for internal consistency than Cronbach's alpha which tends to take into account the outer loadings of the indicator variables. Our composite reliability is well above the acceptable threshold of 0.7 (Wong, 2013). For a more conservative measure, Cronbach's alpha was computed for each construct.

Cronbach's alpha for our constructs is approximately or greater than 0.70, which can be considered acceptable according to Nunnally and Bernstein (1994).
To assess construct validity, we examined all item loadings. The factor loadings were above the recommended level of 0.70 (Hair, Anderson, Tatham, & Black, 1998). We also computed the average variance extracted (AVE), and it is above the recommended threshold of 0.50. The preceding supports convergent validity.
To assess discriminant validity, we compared the square root of the AVE of each construct to the interconstruct correlations. We found that the square root of the AVE for each construct was greater than its interconstruct correlations.

Table 1. Internal Consistency of Constructs and Indicator Loadings

Construct	**Composite Reliability**	**Cronbach's Alpha**	**Loadings**
Information Quality	0.89	0.77	-
• IQ1: Is the app content correct, well written, and relevant to the goal/topic of the app?			0.87
• IQ2: Is the information within the app comprehensive but concise?			0.93
Subjective Quality	0.88	0.70	-
• SQ1: Would you recommend this app to people who might benefit from it?			0.89
• SQ2: What is your overall (star) rating of the app?			0.87
Aesthetics	0.85	0.73	-
• A1: Is the arrangement and size of buttons, icons, menus and content on the screen appropriate?			0.85
• A2: How high is the quality/resolution of graphics used for buttons, icons, menus and content?			0.74
• A3: How good does the app look?			0.81
Engagement	0.85	0.73	-
• E1: Is the app fun/entertaining to use? Does it have components that make it more fun than other similar apps?			0.73
• E2: Does it allow you to customize the settings and preferences that you would like to (e.g. sound, content and notifications)?			0.83
• E3: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)?			0.85
Functionality	0.83	0.71	-
• F1: How easy is it to learn how to use the app; how clear are the menu labels, icons, menus and content?			0.83
• F2: Does moving between screens make sense; does the app have all necessary links between screens?			0.79
• F3: Do taps/swipes/pinches/scrolls make sense? Are they consistent across all components/screens?			0.75
Perceived Impact	0.84	0.71	-
• PI1: The app has changed my attitudes toward improving medication safety.			0.76
• PI2: This app would encourage me to seek further help to address medication safety (if I needed it).			0.83
• PI3: Use of this app will increase medication safety.			0.79
Note: The Cronbach's Alpha for subjective quality was rounded up to 0.70.			

Table 2. Interconstruct Correlations

	IQ	SQ	A	E	F	PI
IQ	**0.81**					
SQ	0.34	**0.77**				
A	0.47	0.49	**0.63**			
E	0.30	0.43	0.52	**0.65**		
F	0.47	0.26	0.47	0.39	**0.63**	
PI	0.47	0.50	0.46	0.37	0.32	**0.77**

Note: Diagonal values are the AVE for each construct. IQ = Information Quality; SQ = Subjective Quality; A = Aesthetics; E = Engagement; F = Functionality; PI = Perceived Impact.

RESULTS

Hypothesis Testing

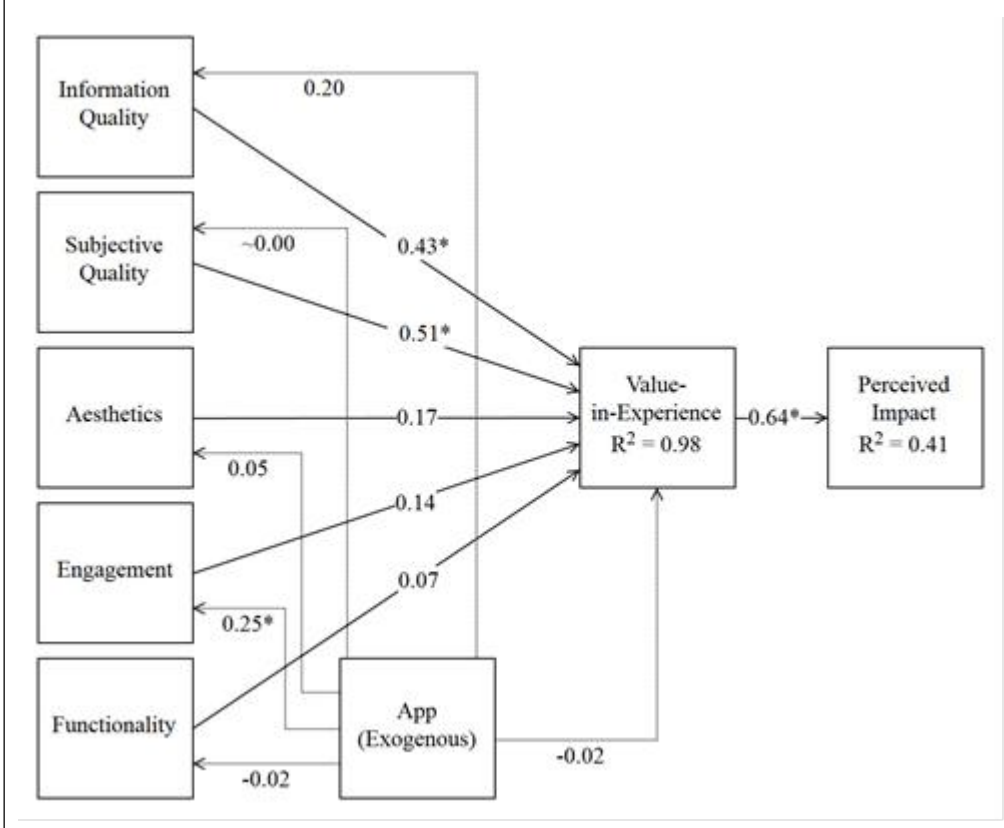
The results are summarized in Figure 3. We find significant direct effects of value-in-experience on perceived impact (Table 3). The information quality and subjective quality facets of value-in-experience have a significant influence on the higher-order construct and hence on perceived impact (Table 3). We find nonsignificant influence of the lower-order, value-in-experience facets—aesthetics, engagement, and functionality—on the higher-order construct and hence on perceived impact (Table 3). Of the significant facets of value-in-experience, subjective quality has the highest weight at 0.51 followed by information quality with a value of 0.43 (Table 3).

The R^2 of our higher-order construct, value-in-experience, is 0.98. Normally, the R^2 of a formative higher-order construct is close to 1.00 as its facets explain it fully (Becker et al., 2012). R^2 for perceived impact is 0.41.

As we had included three medication safety apps, we considered "app" as an exogenous variable. We found the exogenous variable app significantly influenced the level of engagement. This finding was in line with our ANOVA results that showed differences across one item for engagement (E3). The exogenous variable app, however, did not significantly influence the presence of information quality, subjective quality, aesthetics, functionality, or value-in-experience.

Table 3. Results of Hypothesis Testing

Hypotheses	Weights	Result
H1: Value-in-Experience → Perceived Impact	0.64	Supported
H2: Information Quality → Perceived Impact	0.43	Supported
H3: Subjective Quality → Perceived Impact	0.51	Supported
H4: Aesthetics → Perceived Impact	0.17	Not Supported
H5: Engagement → Perceived Impact	0.14	Not Supported
H6: Functionality → Perceived Impact	0.07	Not Supported
H7a: App → Information Quality	0.20	Not Supported
H7b: App → Subjective Quality	~0.00	Not Supported
H7c: App → Aesthetics	0.05	Not Supported
H7d App → Engagement	0.25	Supported
H7e: App → Functionality	-0.02	Not Supported
H7f: App → Value-in-Experience	-0.02	Not Supported



Note: All relationships denoted with an asterisk (*) are significant at 95% confidence level.

Figure 3. Results - Hierarchical Latent Variable Model using PLS-SEM with Repeated Indicator Approach (Mode B)

DISCUSSION

In our research model, value-in-experience is the value derived from the assessment of information quality, subjective quality, functionality, engagement, and aesthetics. Two of the five constructs—information quality and subjective quality—directly influence perceived impact of the medication safety app. The preceding, however, does not altogether diminish the role that the other three constructs—functionality, engagement, and aesthetics—play in the user's overall value-in-experience because all five constructs constitute value-in-experience which does affect perceived impact. Functionality, in this study, captures elements related to how the app performs rather than what the app does which should be included in future investigations. Engagement refers to any form of interaction offered by the app that is specific to the user, and aesthetics deals mostly with the appearance of the app. Our findings suggest that functionality, engagement, and aesthetics may not be as important to the user as information quality and subjective quality when users think about the impact that a medication safety app can have in healthcare practice; nevertheless, these constructs do play some role in the users' composite value-in-experience.

DiDonato et al., in their interviews with users, found that the medication app features patients desired most are related to appearance, customization, communication, functionality, input and the app platform (DiDonato, Liu, Lindsey, Hartwig, & Stoner, 2015). These features identified by DiDonato et al. are present in three of our constructs that constitute value-in-experience. DiDonato et al.'s customization, communication, and input are related to engagement. DiDonato et al.'s appearance of the app is related to aesthetics. Functionality is a construct that is present in our value-in-experience as well as in DiDonato et al.'s findings. DiDonato et al. did not address

information quality and subjective quality of the app. On the other hand, we do not consider app platform to be integral to successful use of a medication safety app because we presumed the operating system to be separate from software that is the app. We do acknowledge that the app platform can facilitate or hinder use as well as affect ease of use of an app. As such, we recommend further research on how the app platform affects the use of medication apps.

The majority of user experience studies of medication apps which often are adherence apps rather than safety apps focus on functionality and aesthetics of the app (Anglada-Martínez et al., 2016; Hayakawa et al., 2013; Kang & Park, 2016; Mira et al., 2014; Patel et al., 2013). The studies examine whether the app is appealing to the user and/or whether the app is effective in achieving adherence. To some extent, usability testing studies further explore medication apps (Ben-Zeev et al., 2013; Parmanto et al., 2013; Stinson et al., 2013). Stinson et al. (2013) and Parmanto et al. (2013) have found engagement, in addition to functionality and aesthetics, to be important in apps designed for compliance. Stinson et al. emphasize the importance adolescents placed on the game-based nature and the reward system of the Pain Squad app. Parmanto et al. state that the iMHere system's ability to communicate with providers sets it apart from its competitors. Parmanto et al. point to the significance of engagement in spite of findings that necessitated improvements in workflow, navigation and interface as well as in communication. As such, engagement, which is one of the five facets of value-in-experience, may require an in-depth probe to fully understand its impact.

Our finding of high subjectivity quality of the three medication safety apps—Epocrates, Medscape, and Drugs.com—is in agreement with the widely available user ratings given to these apps in the App Store and Google Play. Further analysis in this study shows that such a subjective quality of a medication safety app, which captures the user's perception of usefulness of the app, does influence perceived impact of the medication safety app.

The information quality of medication safety apps, however, is not assessed in the App Store or Google Play. Information quality is an important aspect of all medication apps, but it is especially important in medication safety apps. The accuracy and depth of information presented and the ease with which the user is able to comprehend the information can result in either positive outcomes or dire consequences. The users in our study found information quality to be critical in likely impact. Given our finding, it is noteworthy that this aspect of a medication app has not been the focus either in user experience studies or in usability testing. Information quality measures, however, have been addressed in a number of studies in information systems (IS) (Lee, Strong, Kahn, & Wang, 2002) which can be applied to assess the information quality in medication safety apps. As an understudied factor, the influence that information quality can have on the perceived impact of a medication safety app is the most significant finding in our study.

LIMITATIONS

As the data analyzed in this study is based on a convenience sample, generalizations of the results must be made with caution. We have studied students in nursing and allied health who will soon be entering the healthcare workforce if they have not already. However, there are other populations in healthcare besides nursing and allied health professionals who can benefit from improvements in the design of medication safety apps. Among those are physicians who are the heaviest users of drug information apps. If it is possible to study this population to understand its user experience, the findings would constitute a valuable contribution toward the design of medication safety apps. Also, the elderly patient population tends to manage multiple prescription medications, over-the-counter medications, and dietary supplements. A medication safety app can minimize risks in their medication management. Therefore, analyzing the user experience of the elderly in interacting with medication safety apps can be an important contribution.

CONCLUSIONS

Our study has implications for developers given the significant influence of information quality and subjective quality that we have found on perceived impact which is a precursor to long-term use of the medication safety app. To improve the subjective quality of an app, developers must critically think about and address the usefulness of a

medication safety app to the user's unique healthcare setting or situation. Developers of medication safety apps must also consider the quality of information presented in a medication safety app to be as important as or even more important than functionality and aesthetics which often receive due consideration in the design and study of medication apps but, in our study, were found to be nonsignificant in influencing perceived impact of the medication safety app.

An aspect that may require further development in medication safety apps is engagement. We did not find engagement to be significant in its influence on perceived impact of the medication safety app. However, engagement has been found to be useful among adolescent users of medication apps (Stinson et al., 2013), and evidence suggests that engagement in the form of communication with providers (Parmanto et al., 2013) can increase proper use of medication safety apps among all healthcare consumers. Also, engagement is one of the five constructs that constitute value-in-experience which does influence perceived impact. Hence, it may be worthwhile to probe this particular aspect of medication safety apps in greater depth to understand the discrepancy.

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APPENDIX

SUMMARY OF CONSTRUCTS

Construct	**Definition**	**Source**
Value-in-Experience	It is the value experienced in anticipated consumption.	Turnbull (2009)
Information Quality	It is the value derived from the characteristics (e.g. accuracy, timeliness, and completeness) of the output.	Petter and McLean (2009)
Subjective Quality	It is the value derived from sentiment.	Stoyanov, Hides, Kavanagh, and Wilson (2016)
Aesthetics	It is the value derived from attractiveness.	Holbrook (1999)
Engagement	It is the value derived from holding users' attention and drawing users with intrinsic rewards.	Webster and Ahuja (2006)
Functionality	It is the value derived from performance.	Holbrook (1999)
Perceived Impact	It is the perceived effect or influence on healthcare practice.	Stoyanov, Hides, Kavanagh, and Wilson (2016)