CONTINUING EDUCATION

Development and Evaluation of Theory-Based Diabetes Support Services

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Technology-enabled support services for diabetes can fulfill patient demand to care for diabetes independently. Patients benefit from such services after greater adoption of the services in healthcare systems. Unfortunately, conventional service development fails to thoroughly understand patient care support, making it difficult to achieve the desired design, and posing substantial challenges in adopting these services. Thus, previously developed services in many cases are not as patients expected, as evidenced by their low acceptance among patients. To solve this problem, adequate strategies must be developed by incorporating theoretical knowledge as a solid foundation in order to improve service design. This study develops technology-enabled diabetes support services based on the self-care theory. A set of self-care service scenarios is also established and combined with theoretical concepts. The developed services consist of a nurse-led consultation service and a mobile application service. Additionally, user acceptance is confirmed by assessing patient perceptions of the diabetes support services in a group of patients with diabetes (N = 27). Results of analysis reveal that patients respond favorably toward the services. Patient preference and perceived ease of use attest to their intention to use the services. Greater adoption of the services can be anticipated, owing to a higher levels of preference and higher perceived ease of use. This study demonstrated that the self-care theory can be linked to nursing informatics research and chronic care clinical practices.

KEY WORDS

Diabetes • Patient acceptance • Self-care theory • Support services

Patients with diabetes demand self-care support to maintain healthy lifestyles. Inadequate support for self-care increases the likelihood of unnecessary hospitalization and diabetes-related complications.[1–5] Growing demand for diabetes care support has motivated healthcare systems to offer technology-enabled support services, which combine timely responses from healthcare professionals and user-friendly technology devices.[6–10] According to related studies, technology-enabled support services show promise in improving disease outcomes after greater adoption of the support service among patients.[7–12] However, the support services have not received widespread adoption partially because of inadequately designed services, leading to low acceptance among patients.[12,13] The support services warrant more comprehensive research to improve the service design and evaluate end-user acceptance of new services.[13]

Lee et al[14] and Hebert et al[15] indicated that current design methods for technology-enabled support services fail to thoroughly understand patient care support. Service

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design generally follows the conventional approach of gathering user needs information (eg, requirement analysis through interviewing users). Nevertheless, the complexity of support for patient care is multidimensional in nature, explaining why developers have difficulty in using a simple process to forecast patient demand and comply with patient expectations.[13,16,17] For instance, the context in which patients adjust their lifestyles toward a stable metabolic status is incomprehensible.[13] Moreover, the emphases of patient care support differ from those of hospital care (ie, timely response vs curative treatment, enhancing patient self-care capability vs monitoring their metabolic indices).[6] Recent studies suggested that adequate strategies to eradicate the previously mentioned difficulty should involve multidisciplinary collaboration[4,9,12] and knowledge guidance of health-related theory.[13,18]

A related study has described the possibility of using a theory-driven approach to minimize the gap between design and reality, while implementing technology-enabled support services.[12] A methodology review of technology-enabled services suggested that the rationale underlying health-related theory contributes to improved design of such support services.[13] Importantly, theory-based interventions produce better effects than those without theoretical foundations.[16,19] As a conceptual system of patient care, the self-care theory has received considerable attention in chronic care research.[20–23] Self-care theory represents a direction of care planning. It can be utilized to facilitate the service design of self-care support for chronic disease. Thus, this theoretical knowledge can potentially guide service developers in shaping the reality of care support, communicating with others, and articulating the importance of such support.[23] Familiarity with self-care theory instills service developers with the insight to fulfill patient needs. A comprehensive theory-driven approach must be developed to lower the complexity of service design to ensure better acceptance by patients.

Additionally, patient acceptance largely determines whether technology-enabled support services are implemented successfully.[7,24] User acceptance is frequently explained through individual perceptions (ie, personal preference[7,24] and perceived ease of use [PEOU][17,25–27]). Investigating patient acceptance early in the design and implementation stages of support services can improve the likelihood of acceptance. Such an effort can also provide healthcare administrators and service developers with valuable information regarding continuous usage of support services.[16,18,28]

The development of technology-enabled support services based on the self-care theory has seldom been studied, especially with respect to patient acceptance. This study examines diabetes support services based on the self-care theory, as well as discusses patient acceptance by evaluating their perceptions and intention to use those services.

LITERATURE REVIEW

Self-care Theory

Orem et al[20] pioneered a theory that emphasizes an individual's ability to engage in self-care, including a set of related concepts (ie, self-care agent and nursing system). Knowledge acquired from the self-care theory represents an individual care system and interaction between involved actors. This knowledge highlights the emphasis among healthcare providers to strengthen the inherent capabilities of patients to control their chronic diseases via a nursing agent who increases their autonomy and independence.[22] A discussion of improved care is based on the unique care ability of patients and the facilitating power of nursing systems. Meanwhile, enhancing patients' capabilities is a priority when launching care support programs under limited resources in healthcare systems.[29]

Self-care theory has received considerable attention clinically and academically, serving as a practical guide for ongoing care support.[30,31] By using the self-care theory, most studies have designed a framework for continence care, as a theoretical foundation of nurse-led shared care,[21] to explore factors affecting diabetes outcomes.[32] The Orem theory[20] adds structural views to explain the context in which patients undertake daily care activities.[23] A case study involving a theory-based nursing approach collected and systematically analyzed the data of diabetes care.[31] Given the advantages of theory-based approach to develop support services, transforming theoretical concepts into service design tasks is an essential element.

Patient Acceptance Factors

Patient acceptance significantly contributes to whether new technology services are adopted successfully. Many studies have identified several factors contributing to patients' perceptions to estimate the acceptance of new services.[16,17,24,25,27,33] A recently modified model of patient acceptance identifies antecedent factors relating to individual perceptions, including intrinsic motivator factor (ie, preference) and technology factors (ie, PEOU and perceived usefulness [PU]). These factors help to predict patients' behavioral intention to use provider-delivered, technology-enabled services.[18]

Preference of use refers to an individual's interest level, or how likely a user is to use a specific service.[7,18,34] Individual intention to use is initially motivated by user preference, which represents the point at which they begin to use a new service.[7,18,34] Another factor, PEOU, refers to individuals who believe that using a particular service requires no additional effort.[18,24] The PEOU factor can influence user PU and intention to use. Finally, PU refers to an individual's perception of the usefulness of a

technology while using it.[18,24] Although helpful in developing a new technology-enabled service for patients, the survey of these factors addresses only a limited portion of a new approach based on the self-care theory.

METHODS

Diabetes support services were designed to facilitate patients' self-care practices in a multidisciplinary project conducted in Taiwan. In the project, a nurse-led consultation service and mobile application service were offered to assist patients in several care activities (ie, taking exercise) at home or in the workplace. The project consisted of two phases, the first of which was the development process that included designing and constructing the functionalities of the support services, based on self-care theory. The second phase evaluated patient perceptions of using the diabetes support services.

Development of Diabetes Support Services

During the service design phase, the multidisciplinary research group formed a theoretical basis for shaping service scenarios, which represent desirable self-care regimens. The documented service scenarios were used to implement the functionalities of diabetes support services.

Theory-Guided Service Design

The self-care theory[20] served as the theoretical basis for creating the ideal set of services. Ideal services focused on (1) the capability and actions of a self-care agent and (2) the nursing agent with in a nursing system. The next step of creating ideal services involved the design of service scenarios. The theoretical concepts were translated as the attributes of scenarios in this study. The transformation of theoretical concepts is described in detail as follows:

- Self-care refers to the actions performed by a patient, including blood glucose monitoring, healthy eating, physical activity, medication intake, and risk reduction of complications.
- Self-care agency refers to the abilities of a patient to acquire disease self-care–related knowledge and skills. The abilities involve self-testing, self-training, and self-learning.
- Nursing agent with in a nursing system refers to a system managed by a nurse functioning as a care manager who coordinates resources, assists patient care, monitors illnesses, assesses care demand, and develops a care plan.
- Conditioning factors refer to care recourses from local hospitals and other healthcare systems that can provide additional care.
- Self-care demand refers to the need to offer a diabetes knowledge database and care consultations for patients to adjust their lifestyles.

The ideal services were classified further into three self-care scenarios, described briefly here: (1) patients acquire specific knowledge and skills to modify their cognition or behavior from a mobile application with a built-in knowledge repository; (2) a care manager responds to patients' concerns via hotline consultations and assesses patient health status via the service center with a built-in repository system; and (3) a care manager coordinates with other healthcare providers to provide additional care. An overview of the diabetes support services shows how these scenarios interact with each other (Figure 1).

Service Functionalities

NURSE-LED CONSULTATION SERVICE

A diabetes educator and a senior staff nurse served as care managers responsible for the consultation service in the service center. The care managers provide face-to-face and telephone contacts to respond to patient concerns about diabetes care. The service center provided each patient with a mobile application, blood pressure meter, and glucometer.

MOBILE APPLICATION SERVICE

On the patient side, the functionalities of the mobile application service were developed according to the service scenarios. The diabetes information was drawn from related literature[35] and the Taiwan Association of Diabetes Educators (www.tade.org.tw). The eight functions were physical information management, calorie calculation practice, exercise management, diet management, medicine taking, complication management, foot management, and emergency supports. All of the functions were documented in flowcharts and interface blueprints for technical developers programming the mobile application software. Finally, the application software was embedded in a mobile device. Repetitive tests of the prototype were completed by a diabetes educator, senior staff nurse, and three outpatients with diabetes. Following several modifications according to the testers' comments, the final version was confirmed and implemented as a mobile application service.

Evaluation of the Diabetes Support Services

SAMPLE

Thirty patients with type 2 diabetes were recruited from the outpatient departments of endocrinology and metabolism

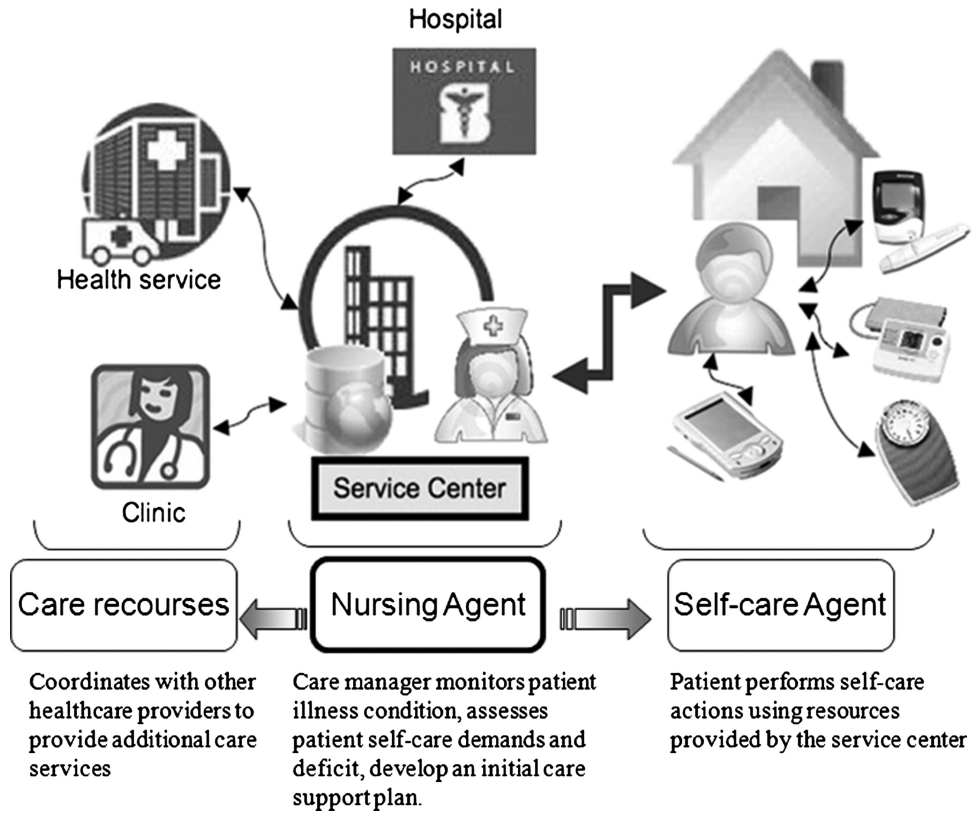

FIGURE 1. An overview of the diabetes support services.

at three tertiary hospitals in Taiwan for participation as test subjects in using the diabetes support services. Each outpatient department was requested to recruit 10 patients. Potential subjects were referred to researchers by endocrinologists to be screened for eligibility. Eligible subjects were then selected according to their willingness to participate in the project. The inclusion criteria were as follows: (1) minimum age of 20 years, (2) ability to read and write, and (3) ability to use a mobile device, as well as conduct a blood glucose test as their routine for 6 weeks. Subjects were excluded if they had a severe vision or dexterity problem, or if they had an alcohol or drug abuse problem. Interested patients received a call from a researcher to schedule a research orientation visit, which included an explanation of the study objectives, process, and the operations of diabetes support services. Written consent was obtained from the subjects before enrollment in the study. Of 30 patients recruited as subjects, 27 completed the study (90%), and three dropped out because of personal reasons and incomplete questionnaires.

INSTRUMENTS

Demographic and personal health information with respect to age, gender, educational level, duration of diabetes, complication numbers, and body mass index was gathered from the subjects' self-report. The survey of subject's acceptance used a set of questionnaires adapted from the patient acceptance model.[18] The questionnaires include the variables of preference, PEOU, PU, and intention to use. The preference contained eight items on a four-point Likert scale, where 1 denotes "strongly dislike," and 4 denotes "strongly like." Perceived usefulness contained eight items on a four-point Likert scale, where 1 denotes "extremely useful," and 4 denotes "extremely useless." For example, the preference and PU items reported participants' perceptions of how interesting and useful the disease complication management function of the mobile application was. Perceived ease of use contained five items with scales ranging from 1 to 5 and anchored by strongly disagree and strongly agree. A sample sentence in the PEOU tested the clarity of service orientation and training program. Subjects answered the question: "Will you continue to use the service?" which represented the variable of intention to use.

PROCEDURE

The subjects were provided with a face-to-face orientation training program on how to use the diabetes support services, a set of instruction manuals of mobile application, and other devices (eg, blood pressure meters and glucometers). Subject skills in using the mobile and devices to assess physiological data were verified by a demonstration upon completion of the training program. One week

after the training program, care managers followed up with each subject by phone to confirm their service usage.

The subjects were instructed to input their personal health information into the mobile application as a daily routine, which included blood pressure, blood glucose, urine sugar, urine protein, and prescription drugs. The subjects were advised to self-test and acquire self-learning from the application in order to obtain diabetes care-related knowledge skills. If questions or concerns arose, the subjects were encouraged to call or meet the care manager of a service center in person. The subjects were also informed of their right to withdraw from the study at any time.

All subjects were free to use the diabetes support services and equipment, yet had to return the equipment upon project completion. During the fifth week, the user acceptance survey was collected from the subjects' description of their perceptions, using an anonymous method of numbered stickers. At the sixth week, the subjects returned the equipment and received complementary diabetes information booklets. Password protection was designed in the mobile application to conceal the privacy of subjects and maintain data confidentiality. The uploading of personal information in the service center and questionnaire survey was anonymous to maintain confidentiality for further analysis.

Data Analysis

Exactly how the subjects' demographics affected preference, PEOU, and PU was determined based on nonparametric analysis. Standard descriptive statistics, including the frequency score for each scale, was used. Next, correlation analysis and path analysis were performed to determine whether patients' perceptions (preference, PEOU, PU) influenced their intention to use the diabetes support services. Finally, questionnaire data were analyzed using SPSS version 17.0 (SPSS Inc, Armonk, NY).

RESULTS

Demographic characteristics of the subjects (N = 27) revealed that 59.3% (n = 16) were male, with ages ranging from 23 to 76 years old (mean, 45.26 [SD, 12.3]). Notably, 59.2% (n = 16) of the subjects had at least a bachelor's degree. Also, 22.2% (n = 6) had diabetes for more than 10 years (mean, 6.87 years [SD, 7.65]), and 25.9 (n = 7) also had multiple complications. Subject body mass index ranged from 19 to 41 kg/m^2 (mean, 26.93 [SD, 5.13] kg/m^2), and 76.7% of subjects were over 24 kg/m^2. Nonparametric evaluation revealed insignificant results of how the subjects' demographics impact preference, PEOU, and PU (Table 1).

Table 1

Nonparametric Evaluation of Subjects' Demographic Impacts on Preference, PU, and PEOU Variables

		Preference		PU		PEOU	
	n (%) or Mean (SD)	Mean	*P*	Mean	*P*	Mean	*P*
Gender		0.485		0.155		0.399	
Male	16 (59.3)	24.75		25.88		18.31	
Female	11 (40.7)	23.55		24.18		19.82	
Age, y	45.26 (12.3)		.612		.632		.722
<40	10 (37.0)	23.4		24.2		18.6	
≧40	17 (63.0)	24.76		25.76		19.12	
Education level			.726		.481		.933
Elementary school	6 (22.2)	23.5		26.5		19.5	
Senior high school	5 (18.5)	26.00		27.4		17.00	
College or university	9 (33.3)	24.44		24.22		18.67	
Master or PhD	7 (25.9)	23.43		23.71		20.14	
Duration of diabetes mellitus, y	6.87 (7.65)		.243		.201		.192
≤1	7 (25.9)	25.86		27.14		19.29	
1∼10	14 (51.9)	24.29		25.36		19.86	
>10	6 (22.2)	22.33		22.50		16.33	
Complications	0.70 (1.07)		.828		.860		.071
0	17 (63.0)	24.71		25.06		20.59	
1	3 (11.1)	23.33		24.67		18.33	
2	6 (22.2)	23.50		26.00		15.17	
4	1 (3.7)	24.00		24.00		15.00	
BMI (kg/m^2)	26.93 (5.13)		.194		.126		.815
Normal (18.5–24 kg/m^2)	9 (33.3)	22.44		22.78		18.67	
Overweight (24–27 kg/m^2)	8 (29.6)	26.38		26.88		19.00	
Obesity (≥27 kg/m^2)	10 (37.0)	24.20		26.00		19.10	

Significant at the 0.05 level (two-tailed).

Table 2

Mean Scores[a] of User Preference for the Services

Items of Function	Preference Mean	SD	Rank
Complication management	3.19	0.557	1
Medicine taking	3.15	0.602	2
Foot management	3.15	0.602	2
Emergency supports	3.07	0.730	4
Diet management	3.04	0.759	5
Physiological information management	2.96	0.854	6
Exercise management	2.88	0.711	7
Calorie calculation practice	2.81	0.694	8

[a]1 = Strongly dislike, 2 = dislike, 3 = like, 4 = strongly like.

Table 3

Mean Scores[a] of PEOU for the Functions of Services

Procedure of Using the Services	PEOU Mean	SD	Rank
Find it easy to use	4.07	0.730	1
Clarity of service orientation and training program	3.96	1.055	2
Clear and understandable	3.81	1.001	3
Perceived enjoyment	3.56	1.188	4
Convenient to use	3.52	1.369	5

[a]1 = Strongly disagree, 2 = disagree, 3 = indifference, 4 = agree, 5 = strongly agree.

From data analysis of questionnaires, Table 2 and Figure 2 list the scores of preference. According to this table, the highest mean score for preference items is disease complication management (3.19). The scores for medicine taking and foot management ranked second in the preference items, while the lowest one was calorie calculation (2.81). Figure 2 summarizes the frequency of preference items, indicating that most response percentages have a score of 3 (3 = like). Notably, more than half of the subjects reported their preference for these functions of the self-care application.

Table 3 and Figure 3 summarize the scores of PEOU for the procedure of using the diabetes support services. According to this table, the highest mean score is find it easy to use (mean, 4.07 [SD, 0.73]) and is rated agree or strongly agree by 48.1% (n = 13) and 29.6% (n = 8) of subjects' response, respectively (Figure 3). The lowest score was convenient to use (mean, 3.52 [SD, 1.369]), and the percentage of disagreement response was 22.2.

Table 4 and Figure 4 list the scores of PU. According to this table, complication management and physiological information management share the highest mean score (3.31), while calorie calculation (2.88) had the lowest mean score. This figure revealed that most subjects rated these functions of the services as useful or extremely useful.

Table 5 summarizes the path analysis results; preference has a significant path coefficient with PEOU (β = .698, $P < .001$) and PU (β = .739, $P < .001$). The path coefficient from PEOU to PU is significant as 0.427 (P = .026). Perceived ease of use has a significant correlation coefficient with intention to use (β = .497, P = .011). Although PU has a significant correlation coefficient (r = 0.39) with intention to use, its path coefficient failed to achieve a significant level (β = .178, P = .337).

DISCUSSION

This study used a theory-based approach to design and implement the diabetes support services procedure. Theoretical concepts are the predominant elements of service scenarios on which diabetes support services were based. Building knowledgeable scenarios allows developers to obtain the design view, goals, and range of services, thus

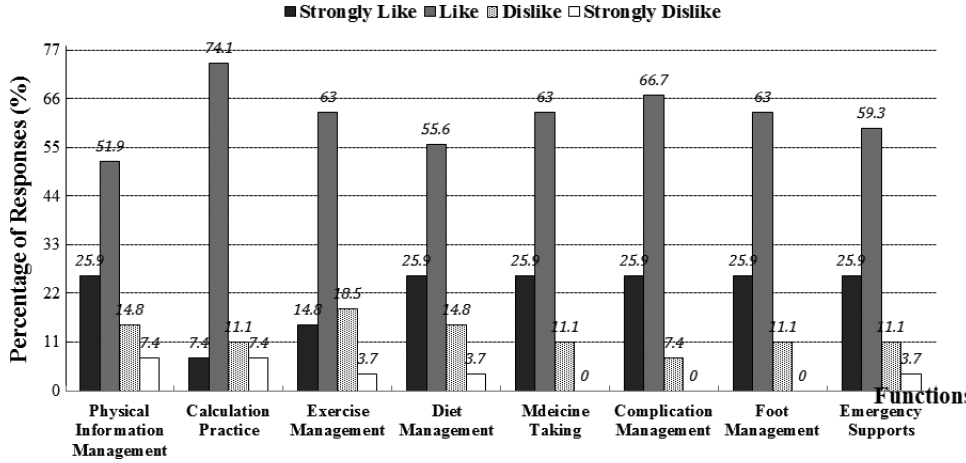

FIGURE 2. Preference of the diabetes support services (N = 27).

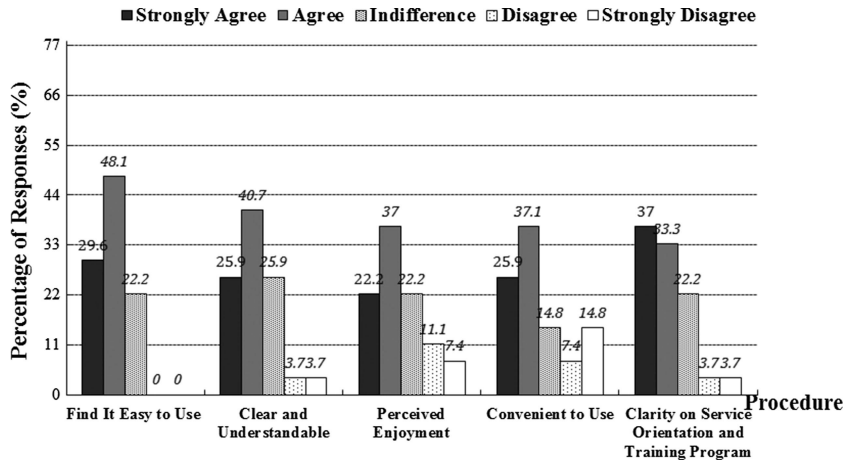

FIGURE 3. Perceived ease of use related to the diabetes support service.

defining the whole picture of diabetes support services. The theory of Orem et al[20] offers an important perspective in which the multidisciplinary team believes that patients can be viewed as actively engaged resources and can also be instructed what to do for their diabetes care. The team created the diabetes support services by sharing the opinions of active patients' self care based on this theory.

Diabetes support programs require careful consideration to define patient demand, as well as concerted efforts to design improved care support services. Support programs in many cases generally seek an intervention approach by using external sources rather than individual empowerment for self-care by developing individual strengths.[6,13,36] Hence, the proposed diabetes care support ought to consider a flexible mean of integrating adoptable technology and facilitating the capability of patients to take individual responsibility for their chronic illness. The proposed method represents an effective means of overcoming the challenges of chronic disease care. Meanwhile, patient demands must be handled without time and location constraints, thus alleviating societal burdens of chronic illness.[4,5,9]

Table 4

Mean Scores[a] of PU for the Functions of Services

	PU		
Items of Function	**Mean**	**SD**	**Rank**
Complication management	3.31	0.618	1
Medicine taking	3.27	0.724	3
Foot management	3.23	0.652	4
Emergency supports	3.12	0.816	5
Diet management	3.12	0.766	5
Physiological information management	3.31	0.788	1
Exercise management	3.00	0.707	7
Calorie calculation practice	2.88	0.833	8

[a]1 = Extremely useless, 2 = useless, 3 = useful, 4 = extremely useful.

The care managers were responsible for the nursing system in the diabetes support services. While similar to an out-of-hospital service in other studies,[37,38] the service mode is an extended care model, which differs from traditional inpatient care. While engaged in self-care for chronic diseases, patients should not be obstructed by the boundary of hospitals or clinics if they require care support.[5] The diabetes support services are characterized by the service implemented in an out-of-hospital setting without the added burden of modern healthcare settings in which clinical practitioners are hesitant to approach (eg, additional workload and conflicting responsibilities of healthcare providers).[17] Detecting problems early and responding to patient demand in timely fashion are a dimension of preventive services worthy of wide adoption.

The evaluation of patient acceptance of using theory-based diabetes support services was completed after 5 weeks. Acceptance analysis results indicated that patients expressed favorable perceptions of the diabetes support services, including a high level of preference, PEOU, and PU. Those variables have a positive correlation with patients' intention to use the services. In the path analysis, patients' preference directly affected PU and PEOU, as well as indirectly affected the intention to use. Patients' preferences for the services refers to a positive affective reaction toward using new services. The finding is consistent with those of previous studies,[18,39] in that users who are highly interested in the services tend to use them more.

Other findings show that PEOU directly influenced PU of the services and intention to use, which is similar to the findings of most studies.[18,40,41] Difficulty in participating in the self-care program also explains why patients reject or hesitate to accept a new service, especially those that involved technology.[18] Ease of use is an essential criterion for design if the aim is to increase patients' willingness to use the services.

The PU of the services is an insignificant factor to predict the intention to use. We can thus infer that the patient

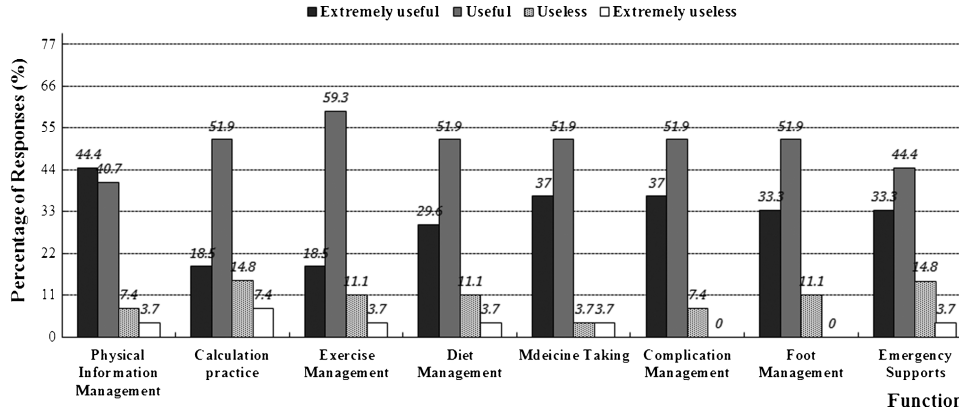

FIGURE 4. Perceived usefulness of the diabetes support services.

PU of the services had less impact on their willingness to use it. Previous studies found contradictory results of PU related to intention to use.[42–44] While one study found that PU had only an indirect influence through user attitude,[42] other studies found that preimplementation and postimplementation have different influences on the intention to use.[43,44] Broader adoption of the diabetes support services by all patients would require that they have positive perceptions toward continuously using the service. Assessments of acceptance from patients' self-report have provided a preliminary explanation of their expectations.[18]

Future efforts should consider how to force the healthcare sector to deploy support services for disease-specific patient. Our results suggest that service issues (ie, mechanism and content) should receive more emphasis than advanced monitoring technology, since technology does not necessarily ensure optimal success. Moreover, an appropriate business model requires that all sectors operate new support services in healthcare systems.[13] A more comprehensive approach toward all dimensions of individual life is necessary to ensure that an increasing usage rate of technology-enabled support services empowers individuals to manage their health independently as much as possible.[18,34]

Finally, a theoretical approach encounters certain difficulties, such as requiring researchers to familiarize themselves with the theory of Orem et al.[20] Additionally, theoretical studies facilitate the development of a technology-enabled service, yet are insufficient to demonstrate different theories for different conditions.[13] Moreover, the result of this study cannot be generalized to patients as a whole because of the sample size and recruiting method. Patients were recruited according to their willingness to participate in this study.

CONCLUSION

This study links, for the first time, theory to practice within the unique domain of nursing informatics. Healthcare service providers should focus on patient capabilities to better fulfill the increasing demand of chronically ill individuals, while care responsibility shifts more toward health consumers. The self-care theory represents a foundational science and art of patient-centered care. The theory-based

Table 5

Summary of Path Analysis for Evaluating the Factors of Intention to Use the Services

Dependent Variable	r	Independent Variable	Unstandardized Coefficient	Standardized Coefficient (β)	*t*	*P*	R^2
PU		Constant	5.963				0.55
	0.74[a]	Preference	0.792	.739	5.489	<.001	
PEOU		Constant	1.545				0.49
	0.70[a]	Preference	0.716	.698	4.877	<.001	
PU		Constant	16.74				0.18
	0.43[a]	PEOU	0.446	.427	2.362	.026	
Intention to Use		Constant	−0.386				0.35
	0.60[b]	PEOU	0.044	.497	2.74	.011	
	0.39[b]	PU	0.015	.178	0.178	.337	

[a]Correlation is significant at the .01 level (two-tailed).
[b]Correlation is significant at the .05 level (two-tailed).

approach requires repeated studies in various settings to determine its effectiveness in practice.

Mobile technology can provide a value-added service as mobile devices become more popular and accepted as part of daily life. Acceptance evaluation is still an ongoing work, accompanied by the development of technology-enabled support services. User acceptance assessment-related research provides further insight into how to improve support services for chronic care. Hence, an accessible and acceptable service can fulfill ongoing patient demands and function as an effective strategy for improving healthcare system practices.

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