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The Evaluation of Diabetic Patients' Use of a Telehealth Program

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Diabetes is a metabolic disorder that, if not treated promptly and appropriately, can cause complex health complications and mortality. Care models that apply technology, such as telehealth, may be useful in working with diabetes patients. The development and application of wireless communication telehealth have significantly affected healthcare in recent years. Thus, the purpose of this study was to evaluate diabetic patients' use of a telehealth program by using questionnaire survey and laboratory data results. A quantitative study, 1-group pretest-posttest design, was conducted. This study recruited 20 diabetic patients who received telehealth service to measure their glucose, heart rate, and blood pressure, with data uploaded back to the hospital daily. A questionnaire survey was conducted in May 2012 and between August and January 2013 with 20 participants. The test values (blood pressure, heart rate, and blood glucose) of subjects were obtained from the hospital telecare platform and the outpatient monthly reporting system. Study findings showed an overall satisfaction rating of 91% by telehealth participants. Nonparametric statistical analysis demonstrated a significant difference ($P < .01$) in participants' glycosylated hemoglobin and resultant effective control. These findings indicated that participants accepted this care model, and telehealth could improve participants' glucose control.

KEY WORDS

Diabetes • Questionnaire survey • Satisfaction • Telehealth

The average life expectancy for humans is gradually increasing with the progression of medicine and hygiene and improved healthcare standards. In addition, birth rates are continuously decreasing, and the current nurse population is aging, thereby resulting in human resource shortages, which anticipate the need for enhanced models of care.[1,2] Telehealth is an assistive technology that has been applied to mitigate the lack of healthcare personnel and assist in chronic disease treatment. In addition to improving patient safety and independence at home and reducing medical expenditures, telehealth enables real-time health-condition monitoring of patients with chronic diseases by enabling the recording of physiological signs that cannot be observed during clinical visits.[3]

Long- and short-term studies on the effects of real-time blood glucose monitoring of patients with type 2 diabetes have shown that after 1 to 3 months of active intervention, substantial differences occur in patient glycosylated hemoglobin (HbA_{1c}) levels during the follow-up period.[4,5] Telehealth users also require fewer medical resources, such as hospitalizations and hospital treatment.[6,7] However, several studies have shown that patients think that the novel technology is difficult to use and lacks face-to-face contact,[8] which prompted the patients to believe that the effects of telehealth are associated with the Hawthorne effect.[9] Therefore, this study evaluated telehealth user satisfaction, changes in patient physiological parameters, and patient experiences in participating in the telehealth program.

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In addition, besides the applications of telehealth to improve diabetic control, researchers have conducted other interventions for diabetic patients to change their health behaviors such as walking three times weekly for 45 minutes supervised by a personal trainer, but the results are effective only for those who attended more than 50% of the program.[10] Others compared the outcomes of using telephone peer mentoring and financial incentives for 6 months, although peer mentoring is more effective than monetary reward, and some individuals preferred face-to-face contact with their mentor, even though the participant did not previously know the mentor.[11] A group-based counseling program led by either psychologists or social workers for patients and their families has been proven to be effective; however, changes due to the effect of intervention on HbA_{1c} results for patients with poor diabetic control were more apparent than those for patients with lower initial scores.[12]

The definition of telehealth, sometimes called telecare, differs according to the development goals of various countries. Telecare and telemedicine deliver health and social care services and thus are also called telehealthcare.[7,13,14] In addition to providing patients with warnings of abnormal parameters, telehealth enables the real-time Internet transmission of these measured physiological signals, blood pressure, and blood glucose levels to healthcare providers. These physiological data are then stored, analyzed, and processed, thereby allowing medical professionals to understand patient physiological parameters and provide emergency treatment when required.[4,15,16] Although the terms of telehealth and telecare appear interchangeably in this article, the study intervention is defined and referred to as a telehealth program.

Positive perceptions and attitudes of patients toward the advantages and disadvantages of telehealth influence patient acceptance of telehealthcare. Telehealth can improve patient personal healthcare management, and a positive response toward this service reduces anxiety and patient reliance on care providers. Fursse et al[17] and Green et al[18] have investigated the usage of electronic communication and home blood pressure monitoring and found that Internet communication, self-monitoring, and integrated care enhance control over high blood pressure and particularly the regulation of systolic and diastolic blood pressure. Nevertheless, evaluating the effects of telehealth from the patient perspective can further increase telehealth promotion and user satisfaction.[8,16,19,20] Regarding cost benefits, telehealth increases the independence and life quality of elderly patients. In addition, patients are able to monitor their health status and control their blood glucose levels and blood pressure at home, which subsequently improves patient treatment compliance, reduces traveling and medical costs, conserves the working time of medical workers and nurses, and shortens patient therapy cycles.[2,21,22]

Because of aging populations and the increasing prevalence of chronic diseases, combining wireless communication and healthcare has gradually gained widespread attention. Therefore, telehealth can fulfill patient healthcare needs. This study evaluated the effectiveness of telehealth and examined the following factors from the patient perspective: overall satisfaction and practical needs, and the differences in blood pressure, heart rates, blood glucose levels, and HbA_{1c} values before and after telehealth intervention.

METHODS

Research Design and Framework

The study used a cross-sectional and single-group pretest and posttest research design to obtain demographic data of telehealth users and current intervention procedures. In addition, descriptive statistics were used to analyze the differences in patient blood pressure, blood glucose levels, and HbA_{1c} values and to subsequently evaluate overall user satisfaction and user experiences. A summary of the research framework is presented in the Figure 1.

Research Questions and Relevant Definitions

RESEARCH QUESTIONS

1. What is the overall experience of telehealth service users?
2. What are the variations among participant blood pressures, blood glucose levels, and HbA_{1c} values before and after using telehealth?

RELEVANT DEFINITIONS

Telehealth. Telehealth allows people at home and in communities and institutions to transmit their physiological signals through remote communication technologies and

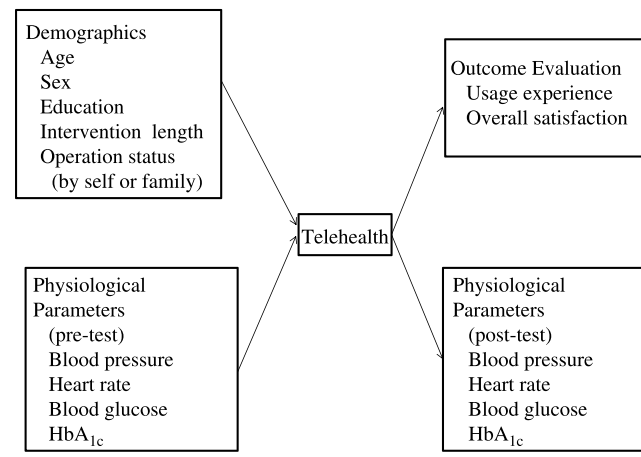

FIGURE 1. Study framework: the evaluation of telehealth program.

computer applications to relevant medical units for analysis and evaluation. Telehealth services incorporate telehealth education, member visiting services, life resource referral services, emergency treatment, and disease prevention. Daily healthcare and social services are also provided based on a people-centered integrated care model to enhance the accessibility of healthcare services.[10,17]

Telehealth User Experiences. User experiences regarding the telehealth program and service were collected by administering an open-ended questionnaire.

Overall Satisfaction. This study referenced the telehealth overall satisfaction evaluation questionnaire adopted by Chou et al.[23] The study questionnaire contained 20 items, which were divided into three categories: "user satisfaction" (items 1–10), "overall satisfaction" (items 11–16), and "willingness to continue to use" (items 17–20). Scoring was based on a 5-point Likert scale where 1 = "strongly disagree" and 5 = "strongly agree." A high score indicated strong satisfaction, and overall scores ranged between 19 and 95 points. Item 20 was not scored and inquired about fee range acceptable to users. The fee range was divided into five levels, which started from less than NT $500 (US $17) to more than NT $2000 (US $67).

PARTICIPANT BLOOD PRESSURE, BLOOD GLUCOSE LEVELS, AND HBA_{1C} VALUES

1. This study defined normal blood pressure as lower than 130/80 mm Hg. The American Diabetes Association[24] proposed that diagnoses can be confirmed providing that any one of the following criteria is present: (*a*) a fasting plasma glucose greater than or equal to 126 mg/dL at two successive times, (*b*) normal HbA_{1c} values are between 4% and 6%, and diabetic patients do not control their HbA_{1c} to a value less than 7%.
2. In this study, the researchers compiled the last blood pressure reading, blood glucose level, and HbA_{1c} value before patients began using telehealth and the final values at the end of the study period.

Research Site and Cases

The research site was a 511-bed community hospital in Northern Taiwan, providing approximately 2000 daily outpatient consultations, and care to patients primarily from medium- and low-income families. This medical institution participated in a shared care network. Dietitians and diabetes educators taught patient health education classes, promoted the telehealth program, and recruited participants. Participants were patients who met the following criteria: (1) blood pressure levels greater than 130/80 mm Hg and HbA_{1c} levels greater than 8.0%, (2) could communicate in Mandarin or Taiwanese, (3) referred by a diabetes case manager, (4) signed the telehealth letter of consent and received telehealth monitors and blood glucose test strips, and (5) were willing to learn to operate the two-in-one (blood pressure and blood glucose) monitor.

Introduction and Operation of Telehealth Monitor

The designated telehealth physiological monitor weighed approximately 1 kg (2.2 lb). Case managers typically preset personal accounts for each participant. After participants had measured their blood glucose and blood pressure, the data were uploaded to the hospital telehealth information platform. This hospital used a blood pressure and blood glucose two-in-one monitor as the primary telehealth device. In July 2011, the two-in-one monitor was introduced. After being tested for 3 months, the monitor was officially prescribed to telehealth patients in September 2011. This study was subsidized, and the telehealth program services were complimentary for all participants. Participants were allowed to take the monitor home and operate the two-in-one monitor by themselves or with family assistance. After the participants measured their blood glucose levels, the digit number was displayed on the screen, and an indicator located at the upper-right side of the monitor would flash. The monitor would automatically shut down after the data were stored. Furthermore, the monitor automatically transmitted a text message regarding abnormal levels to mobile phones of the primary care provider, the participant, and diabetes case manager. The case manager would then contact a family member or the participant to verify the reason for the abnormality and subsequently recommend specific diet and exercise programs and provide medication counseling. If necessary, the patient was advised to visit the outpatient clinic and undergo a detailed examination.

Research Tools

The questionnaire used in this study was modified, and the reliability of the overall satisfaction evaluation questionnaire was analyzed. Overall, the questionnaire items exhibited a Cronbach's α of .87, indicating that the questionnaire had satisfactory consistency.

The following three open-ended items were asked:

1. How do you think telehealth can help you?
2. What difficulties did you experience when using the telehealth monitor?
3. What are your suggestions and expectations regarding the telehealth monitor?

Research Ethics

The experiments began on May 28, 2012, after this study received approval from the Medical Ethics and Institutional Review Board of the case hospital.

Data Collection

Data collection was divided into two parts. The first part involved conducting a questionnaire survey to assess participant perceptions regarding the telehealth program. The second part involved collecting blood pressure, blood glucose level, and HbA_{1c} values from before and after subject participation in the telehealth program. The formal questionnaire survey was conducted between August 2012 and January 2013. The questionnaire survey was distributed in the diabetes healthcare education classroom after participants had completed their outpatient clinical visits. The completed questionnaires were then collected, and a small gift was given to the participants after they returned their questionnaires. Overall, 20 questionnaires were collected. Subsequently, we obtained the measured physiological values (ie, blood pressure, blood glucose, and HbA_{1c} levels) from the hospital database.

Data Processing and Analysis

The open-ended questionnaires were analyzed using qualitative data analysis. First, descriptive comments were coded and used to categorize the data, and then themes were identified to compare participant response similarities and differences.[25] Inferential statistics were conducted using nonparametric statistics because of the small sample size. The following statistical methods were applied in this study: the Spearman rank correlation coefficient was used to calculate the correlations between age (ie, a continuous variable) and test values; the Mann-Whitney *U* test was used to examine the differences between the categorical variables (ie, gender, education levels, and operation of physiological monitors) and test values; the Kruskal-Wallis *H* statistic was used to compare the differences between the telehealth participating duration and test values; and the Wilcoxon signed-rank test was applied to determine the differences in test values before and after participation in the telehealth program.

RESULTS

Participant Basic Demographics

Overall, 20 participants joined this study, and their demographic data are provided in Table 1. The average participant age was 59.3 years, and the majority of the participants were men, possessed high school or vocational school education levels, had participated in the telehealth program for 3 or more months, and had operated the monitors personally.

Results of the Open-Ended Questions

The number of participants who answered each open-ended question (Table 2) was 32, 12, and 11, and the results are summarized as follows:

1. advantages of using telehealth: enhances self-health management habits, facilitates effective disease control, and supplies professional care services;

Table 1

Basic Participant Demographics (N = 20)

Variables	n	%	Mean	SD	Min	Max
Age, y			59.30	9.34	41	78
≤50	3	15				
51–64	13	65				
>65	4	20				
Sex			1.35	0.49		
Male	13	65				
Female	7	35				
Education level			3.95	1.40		
Uneducated	2	10				
Primary school	5	25				
Junior high school	5	25				
High/vocational high school	6	30				
College/university	2	10				
Length of telehealth service, mo			2.35	0.75		
1	3	15				
2	7	35				
≥3	10	50				
Device usage			1.15	0.49		
Self-operation	18	90				
Family assistance	2	10				

Table 2

Participant Comments Regarding the Telehealth Program

How do you think the telehealth program can help you?
(1) Cultivate self-health management habits
Provided warning function, increased attention to health, and prompted diet control
(2) Control disease effectively
• My case manager communicated with my doctor and adjusted my medication as necessary.
• Blood glucose and HbA_{1c} values improved after 2 mo of participation.
(3) Obtain professional care services
• When blood glucose and blood pressure levels increased, calls were received from nurses.
• Dietitians and nurses notified me of my blood glucose and blood pressure values.

What difficulties did you experience when using the telehealth monitor?
(1) Unfamiliar with monitor operation
• Uncertain on how to use the test strips after placing the blood in blood glucose meter
• A specific posture is required to absorb the blood using the test strips.
• Data could not be measured because the test strip was inserted improperly.
• My case managers taught me how to use the monitor, but I forgot once I returned home.
• Don't understand what the flashing light means for data transmission.
(2) Poor monitor quality
• Poor transmission signal. Data transmission was occasionally successful.
• The monitor battery cannot be charged fully, and the parameter readings were unstable.
• Unstable blood pressure readings (ie, first measurement as 180 and the second was 120)
• After using the monitor for 2–3 mo, the battery would no longer charge.
• The blood collection needle was too tight, and air leaked when I used the blood pressure cuff

What are your suggestions for and expectations of telehealth monitors?.
(1) Human interface design
• I do not read English. Mandarin labels should be provided.
• Mandarin-labeled memory tab should be provided to enhance clarity.
• The blood collection needle design should be improved for easy detachment.
• The reminder function in Mandarin and Taiwanese language was convenient for me to use.
• Signal transmission must not be influenced by location.
(2) Operation consultation
• I can use pen and paper to record the values based on case manager's instruction.
(3) Portability
• The monitor can be made smaller and should be portable.
• The combined blood glucose and blood pressure meter is useful.
(4) Reasonable cost
• If the program requires a fee in the future, users should purchase their own monitor.
• Users can buy a monitor, but a transmission is not necessary because money can be saved.
• I hope that the program remains free, but a fee within NT $500 is acceptable.
(5) After-sales service
• In cases when the monitor fails to function, calibration service should be offered.
• The blood pressure meter can be calibrated.

2. difficulties with using the telehealth monitors: unfamiliar with operating the monitor and poor-quality monitors; and
3. suggestions and expectations regarding the use of telehealth monitors: human interface design, provide consultations (to teach how the monitors operate), portability, reasonable cost, and after-sales service.

Overall Satisfaction With Telehealth

The user evaluation reached an average score of 4.50, which indicates a medium satisfaction level. Table 3 shows that the means of satisfaction of the three questionnaire categories ranged between 4.60 and 4.37 points in the following descending order: overall satisfaction, satisfaction with the effectiveness of telehealth, and willingness to continue use. Regarding the results for the 19 questionnaire items, among the 10 items in the first category on the questionnaire (ie, satisfaction on the effectiveness of telehealth), item 6 achieved the highest score, "The telehealth program enabled me to understand my health problems," followed by item 7, "Participating in the telehealth program helped me control my health problems (eg, blood pressure, blood glucose level)." The lowest-scoring items (both scoring <4 points) were item 8, "Using the telehealth programs

Table 3

Single-Item Analysis of Telehealth Participant Satisfaction Evaluations (N = 20)

Item	Question	Mean	SD	Rank
Satisfaction on the effectiveness of telehealth (10 items)		*4.52*	*0.59*	
1	The user guide for the telehealth physiological monitors is easy to understand.	4.60	0.68	6
2	The physiological monitors were user friendly.	4.75	0.44	3
3	The physiological monitors enabled me to check my blood pressure values and blood glucose levels easily.	3.95	0.95	9
4	The physiological monitors enhanced my understanding of my health status.	4.75	0.44	3
5	The blood pressure, heart rate, and blood glucose levels provided by the telehealth program assisted me in discussing my health problems with medical professionals.	4.40	0.75	8
6	The telehealth program enabled me to understand my health problems.	4.90	0.31	1
7	Participating in the telehealth program helped me control my health problems (eg, blood pressure and blood glucose levels).	4.80	0.52	2
8	Using the telehealth program reduced the numbers of time that I required hospital treatment.	3.55	0.82	10
9	I am willing to use the physiological monitors.	4.70	0.57	7
10	Overall, participating in the telehealth program was necessary.	4.75	0.44	3
Overall satisfaction (6 items)		*4.60*	*0.62*	
11	I am satisfied with the quality of the physiological monitors.	4.40	0.94	6
12	I am satisfied with health-related knowledge provided by the nurses working in the telehealth program.	4.85	0.37	1
13	I am satisfied with the availability of nurses when I had health-related questions.	4.50	0.76	5
14	I am satisfied with receiving solutions when I had health-related problems.	4.55	0.51	3
15	I am satisfied with the privacy and security policy regarding personal data, such as measurements and health problems.	4.45	0.69	4
16	I am satisfied with the professional performance of the nurses providing telehealth service.	4.85	0.49	1
Willingness to continue use (4 items)		*4.37*	*0.79*	
17	I am willing to continue participating in the telehealth program if it remains free of charge.	4.80	0.52	1
18	I am willing to introduce the telehealth program to my relatives and friends if it remains free of charge.	4.20	0.89	2
19	Within an acceptable range, I remain willing to participate in the telehealth program.	4.10	0.97	3
20	I can afford to pay the following range to participate in this program	n	%	
	<NT $500	13	65	
	NT $501–$1000	5	25	
	NT $1001–$1500	1	5	
	NT $1501–$2000	1	5	

reduced the number of times I required hospital consultation," and item 3 "The physiological monitors enabled me to check my blood pressure and blood glucose levels easily."

Among the six items of the second category (ie, overall satisfaction), the two highest-scored items were item 12, "I am satisfied with the health-related knowledge provided by the nurses working in the telehealth program," and item 16, "I am satisfied with the professional performance of the nurses providing telehealth services." Item 11 received the lowest score, "I am satisfied with the quality of the physiological monitors." In the third category (ie, willingness to continue to use), item 17, "I am willing to continue participating in the telehealth program if it remains free of charge," followed by item 18, "I am willing to introduce the telehealth program to my relatives and friends if it remains free of charge," received the highest scores, whereas item 19, "Within an acceptable fee range, I remain willing to participate in the telehealth program," scored the lowest.

Telehealth Fees Result Analysis

The results presented in Table 3 indicate that when payment was required, the average value of those willing to continue participating in the telehealth program was 4.10 (approximately 82%). The majority of participants considered an affordable monthly fee to be within NT $500 (US $17) (65%) followed by NT $501 to $1000 (US $33) (25%).

The Influence of Telehealth Intervention on Participant Health Status

As mentioned, nonparametric statistics were conducted because of the small sample size. The results indicated that excluding age and systolic blood pressure, which exhibited positive correlations (r = 0.04, $P < .05$), no significant differences were identified between gender, education level, and operation of physiological monitors and physiological

measurements. In addition, these variables (ie, gender, education level, and operation of physiological monitors) and telehealth participation duration exhibited no significant differences. Table 4 shows the Wilcoxon signed-rank test for the changes of systolic pressure, diastolic pressure, blood glucose, and HbA_{1c} values. The results show that after participating in the telehealth program, both blood glucose and HbA_{1c} values were reduced; specifically, HbA_{1c} presented the most significant reduction.

DISCUSSION

The average score for overall telehealth program satisfaction was 4.50, which was higher than the median score (2.50), indicating that participant overall satisfaction level was medium to high. The two highest-scored items in the scale for satisfaction with the effectiveness of telehealth were associated with understanding and controlling health problems. Of these, understanding health problems achieved the highest score. On the open-ended questionnaires, several participants stated that because they possessed the monitors, they knew their blood glucose and blood pressure values instantly, which assisted them with control of their diet and increased their attention to personal health. This result corresponded to that obtained by Chou et al.,[23] who evaluated the perceived usefulness (maintaining health) of participant technology acceptance. The results demonstrated the effectiveness of the telehealth program in benefiting and managing patient health. In addition, although most participants did not convey having difficulties with operating the physiological measuring monitors, several claimed they experienced operating issues, which necessitated learning by trial and error. Moreover, previous studies have indicated that participants easily accepted easy to operate and functioning monitors, demonstrating that perceived ease of use of the monitors positively influenced telehealth outcomes.[8,26]

Table 4

Variance Analysis Results of Systolic and Diastolic Pressure, and Blood Glucose and HbA_{1c} Values (Wilcoxon Signed-Rank Test [N = 20])

Variable	n	Mean	*Z* Test	*P*
Systolic pressure				
Posttest	8	143.35	−2.17[a]	.03
Pretest	12	131.90		
Diastolic pressure				
Posttest	7	80.60	−1.59	.11
Pretest	12	76.80		
Blood glucose level				
Posttest	13	167.10	−1.69	.09
Pretest	6	199.85		
HbA_{1c} level				
Posttest	18	8.17	−3.55[b]	<.001
Pretest	2	9.65		

The lowest-scoring items in the category, satisfaction on the effectiveness of telehealth, were in the following order: the reduction of the number of hospital visits and ease of checking blood pressure and blood glucose levels. Participants did not reduce their number of hospital visits because the telehealth program was provided as a supplementary service and did not replace their habit of seeking medical advice. Most patients consider face-to-face contact and health education extremely crucial.[16,27] The participants stated on the open-ended questionnaires that they desired a consultation service by which they could learn to operate the monitor and check their blood pressure and blood glucose levels personally. Therefore, applying a combination of information technology and personal care in telehealth program facilitates mutual interactions and trust between patients and care providers. However, satisfying the need for individualized healthcare and equipment operation assistance is a challenge for telehealth nurses.[28] Nevertheless, effective telehealth programs could support nurses in understanding the advantages and disadvantages of this technology and encourage them to seek methods of integrating technology into their practice to increase patient care efficiency.[13,29,30]

The highest score for the item in overall satisfaction was receiving the health guidance and professional services of nurses. Based on the open-ended questionnaires, participants expressed that the dietitians and nurses notified them of their blood glucose and blood pressure levels, which comforted and enabled them to feel they were receiving professional care. Chou et al[23] indicated that compared with their previous lifestyles, patients who participated in telehealth programs and received professional healthcare guidance acquired increased health-related knowledge, which enhanced their ability to control personal health conditions. The results showed that satisfaction toward overall healthcare needs, health-related guidance, nurses' service performance, and problem resolution was above the medium level. Several participants stated that they were generally contacted by the case managers frequently. They seldom called the case managers to inquire about health questions unless the managers failed to contact them. Consequently, patient expectation of nurses to actively manage their personal health problems could increase care burdens.[16,28] Therefore, methods of enhancing patient self-care and management abilities and reducing patient reliance on the telehealth program enable this service to benefit patients, thereby achieving the goal of resource sharing.

Monitor quality ranked the lowest in overall satisfaction. The questionnaire results indicated that several participants experienced problems with the battery, blood pressure cuffs, and finger-pricking needles. They also thought the monitor was bulky, and signal transmission was easily influenced by geographic locations, and thus they recommended providing monitor calibration and maintenance services regularly. However, they expressed willingness to continue using this

monitor because the monitor possesses a two-in-one function (blood glucose and blood pressure can be measured), voice prompt function, and transmission platforms. Case managers could therefore mail the printout measured parameters to patients regularly, and doctors could evaluate physiological fluctuations and adjust medication dosages. Previous participant evaluations of information technology use have revealed that the monitor quality is typically assessed based on user perception regarding the usability of the monitor. In addition, effective system designs, functional properties, and monitoring effectiveness could increase user satisfaction.[29,31] Currently, despite the increasing prevalence of technology, the information literacy of users is generally inadequate compared with healthcare professionals. In addition, most participants were from low- and middle-income families, and their level of information literacy requires improvement. Consequently, designing user-friendly information equipment can increase user technology acceptance.

The item that scored the highest in the willingness to continue use category was free use of the telehealth program. Almost all participants were willing to continue participating in the telehealth program if it was offered at no additional charge. Because most participants were either retired or unemployed and their chronic health conditions required extensive lifelong management, requiring users to pay for the telehealth program would cause an economic burden. However, if the program was affordable, participants were willing to continue using the program and introduce their relatives and friends to the program. Participants who were willing to pay to continue using the program considered less than $500 NT (US $17) as an acceptable amount. Only when the program cost did not exceed the market value would patients consider using the zero-distance health service.[23] In a study investigating cardiovascular promotional measures for women of low-income families, the results indicated that health and hygiene education did not alter unhealthy behaviors, such as poor nutrition and lack of exercise, but could lower systolic and diastolic blood pressure, blood glucose levels, and cholesterol. This shows that socioeconomic factors influenced patients when seeking healthcare resources.[32]

After participants used the telehealth program for 3 months, HbA_{1c} levels decreased significantly. The results showed that 90% of participants paid more attention to diet and blood pressure control after joining the program. When participants returned for their follow-up visit and blood collection after 2 months, they exhibited substantially reduced HbA_{1c} values and weight because of the care and timely health education provided by case managers. Participants gradually learned self-management habits; thus, the goals of effectively controlling chronic diseases and reducing medical costs were achieved.[26] Compared with other studies' interventions for behavior change,[10–12] telehealth may be an alternative. These studies have varied results because behavior change could be affected by different factors. For example, walking may require subjects' long-term dedication, and self-paced speed may not be effective[10]; telephone peer mentoring is more effective than financial incentives, but trust relationship is vital for two strangers to share their diabetes control experiences.[11] Finally, behavioral counseling may have to consider subjects' prior physical or mental illness history to enhance the outcomes of designed interventions.[12] Telecare may be a more accessible and economical means of maintaining healthy behaviors because patients are contacted by their case manager who is already familiar with their health status and can make follow-up calls to remind them whenever needed.

Regarding the blood pressure results for elderly patients, no significant blood pressure reductions were exhibited, but the systolic pressure increased after using telehealth. This is potentially related to the sample collection period, because the longest duration of time participants engaged in telehealth services was 7 months, and the shortest was 1 month. The open-ended questionnaire results also indicated that most participants were satisfied with the assistance received through the telehealth program in controlling blood pressure. However, a few participants expressed that they did not observe a decreasing trend in blood pressure readings after participating for 2 months, and their blood pressure values remained unstable.

During the study period, the first blood pressure measurements were collected in the morning; however, this time point may differ to that at which participants recorded their readings, such as before or after meals. Furthermore, measurements may be influenced by external factors, such as sleep, exercise, medicine, or comorbidities. Therefore, increased measurement values could be recorded during the data collection period. Various studies have indicated that short- and long-term blood glucose monitoring of patients with type 2 diabetes did not induce blood pressure reductions because most study periods were approximately 6 months, and thus the effects were not significant.[9,33] However, another study found that appropriate exercise improves cardiovascular function, including heart rate and blood pressure.[34] In addition, telehealth interventions could improve physiological parameters, such as blood pressure and blood glucose levels, in patients with newly diagnosed chronic diseases such as diabetes and high blood pressure.[17] Currently, researchers have yet to determine the period over which monitoring should be conducted before the effectiveness of telehealth interventions can be observed.[5]

Research Limitations and Suggestions

This study was a cross-sectional analysis on a small sample, selecting participants from only one community hospital, and no control group could weaken the result interpretation. Because each medical institution uses differing physiological monitors and offers varying services, differences must be considered before applying the results obtained in this

study to other healthcare institutions. Blood pressure values were influenced by external factors, such as measurement times and locations; thus, the measurement parameters frequently fluctuated. Future studies can collect the physiological data at 1, 2, and 3 months, separately, and evaluate the results by conducting repeated-measure analyses or control-group selection to verify the effects of this treatment on chronic disease treatment. Moreover, a comprehensive analysis of changes in participant attitudes and behaviors toward self-care management should be conducted by using qualitative interviews.

CONCLUSION

Although all of the participants appreciated receiving free telehealth services, a minority thought that users should pay for this service. The majority of participants also thought that using the telehealth monitor effectively improved their diet control, blood glucose levels, blood pressure values, and HbA_{1c} values. The greatest difficulties in using the monitor were operational problems and equipment quality. Most participants were satisfied with the equipment but expected to receive additional assistance with equipment operation. Finally, after the 3-month study period, it was concluded that the telehealth program was beneficial for increasing HbA_{1c} control. Thus, the ultimate goal of the telehealth program was to encourage patients with chronic diseases to adopt a proactive behavior, actively monitor their health, and receive medical supervision at all times, thereby enhancing the healthcare behaviors of the patients.

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