Original Article

Effects of Re-measurements of Health Literacy, Health Behavior, and Hemoglobin A1c With Qualitative Confirmation in Patients with Type 2 Diabetes Mellitus

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Abstract

Objective: This study aimed to investigate the effects of health literacy measures on health behaviors and cumulative glucose levels in patients with type 2 diabetes mellitus (T2DM). **Method:** Particularly, this mixed-method study investigated the effects of repeated measurement of knowledge about health, health behaviors, and glycemic control in T2DM patients, along with validating the program's effectiveness. The quantitative research design used a quasi-experimental approach with a sample group of 30 participants selected through purposive sampling who received the health knowledge program. Qualitative data were gathered through interviews with a simple random sample of 10 participants and a snowball sample of seven participants until data saturation was achieved. The research tools used in this study included a health knowledge program, a health knowledge assessment questionnaire, and the results of glycemic control tests from the hospital. The quantitative statistics included percentages, means, standard deviations, and One-way ANOVA with repeated measures. **Results:** The quantitative research findings revealed that 1) T2DM patients showed significant improvements in health knowledge, health behaviors, and glycemic control with each repeated measurement, which was statistically significant at 0.01. 2) The developed health knowledge program, which included activities to enhance knowledge, demonstrate and practice health data access skills, exchange learning experiences, problem solving, analyzing health-related advertisements, and case studies for decision-making, led to improved experiences and informed decision-making in health behavior selection. This results in a reduction in glycated hemoglobin (HbA1c) levels, congruent with the context of the patient's lifestyle. **Conclusion:** The results of the health knowledge program showed significant improvements through repeated measurements of health knowledge, health behaviors, and glycemic control in patients with T2DM. Therefore, relevant organizations can utilize health knowledge programs to enhance the capabilities of health service systems in alignment with the context and lifestyle of patients with diabetes.

Keywords: Type 2 Diabetes, Health Behaviors, Glycemic Control, Quality Confirmation.

Introduction

Health literacy is an intellectual and social process that motivates individuals to consistently access, understand, and use health information to maintain well-being. During the 7th Global Conference on Health Promotion in Nairobi, Kenya, the World Health Organization called on member countries to prioritize the development of health literacy among their populations.[1] Health literacy encompasses seeking, evaluating, and integrating diverse health information within different contexts, including understanding health-related terminology and the cultural aspects of the healthcare system.[2] Having sufficient and appropriate health literacy and engaging in healthy

Access this article online

Quick Response Code:

Website: www.jnsbm.org

DOI: https://doi.org/10.4103/jnsbm.JNSBM_15_1_18

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Submitted: 02nd April, 2024 **Received:** 16th April, 2024
Accepted: 20th May, 2024 **Published:** 24th May, 2024

How to cite this article: Visuttranukul A, Thamrongworakun P, Visuttipukdee K, Thanaphonganan N, Panyasaisophon T. Effects of Re-measurements of Health Literacy, Health Behavior, and Hemoglobin A1c With Qualitative Confirmation in Patients with Type 2 Diabetes Mellitus. J Nat Sc Biol Med 2024;15:148-158

behaviors can help individuals with type 2 diabetes mellitus (T2DM) effectively manage their blood sugar levels and reduce complications from other diseases, even though diabetes treatment is challenging.[3] This is achieved by empowering individuals to seek health information, comprehend it, apply health knowledge, share information with others, and make informed decisions regarding suitable health practices. Such characteristics enable diabetic patients to control their blood sugar levels, reduce the disease's severity, and minimize complications from other diseases despite the incurable nature of diabetes.[4] Thailand's 13th National Health Development Plan aims to establish the country as a medical and high-level healthcare service center.[5] This involves transforming the production and service sectors into an innovative-based economy by utilizing innovation to produce goods and to provide medical and health services to create added value. In addition, the plan focuses on developing emergency healthcare management and health service systems to improve accessibility to healthcare. To achieve these goals, the project emphasizes the development of highly competent medical and public health professionals in the new era, ensuring that they can enhance medical and health services and reduce the impact on the Thai population's access to healthcare. This is closely linked to Thailand's essential strategies for improving competitiveness.[2,4]

Diabetes is a chronic, non-communicable disease characterized by consistently high blood sugar levels and is a global health issue.[6] The incidence of diabetes has been increasing worldwide. Complications of diabetes, such as stroke, chronic kidney disease, cardiovascular disease, and diabetic retinopathy, can adversely affect the body. The 20-Year National Health Strategy of Thailand aims to achieve a "Smart Thailand" and "Smart Thai Citizens," where all Thai people of all ages should have high health literacy, be able to manage their health, and undergo a health reform.[7] A sub-district health-promoting hospital is a primary healthcare unit that provides comprehensive health services at the sub-district level and is the first line of defense in delivering public health services ranging from health promotion, disease prevention and control, medical treatment, health rehabilitation, environmental health, and consumer protection services.[8] This includes services for patients with diabetes, which are contextually adapted to the community's way of life, with a limited number of factors owing to the shortage of specialized personnel and a lack of clear patient guidelines. Based on literature reviews, research works, surveys of health knowledge, and the context of sub-district health-promoting hospitals, it was found that there is still no health knowledge system for patients with diabetes because of the limited number of staff and lack of expertise, and there is no system for developing health knowledge for patients.[9] Therefore, researchers are interested in studying the results of repeated measurements of health knowledge, health behaviors, and glycemic control quality in T2DM patients using a mixed-method research approach to develop and manage the health knowledge system in a sub-district healthcare unit. This study aimed to examine the effects of repeated measurements of health knowledge, health behaviors, and glycemic control quality in patients with T2DM, along with the validation of the quality assessment. This research conducted using the health knowledge perspective[10] to develop the research framework (Figure 1).

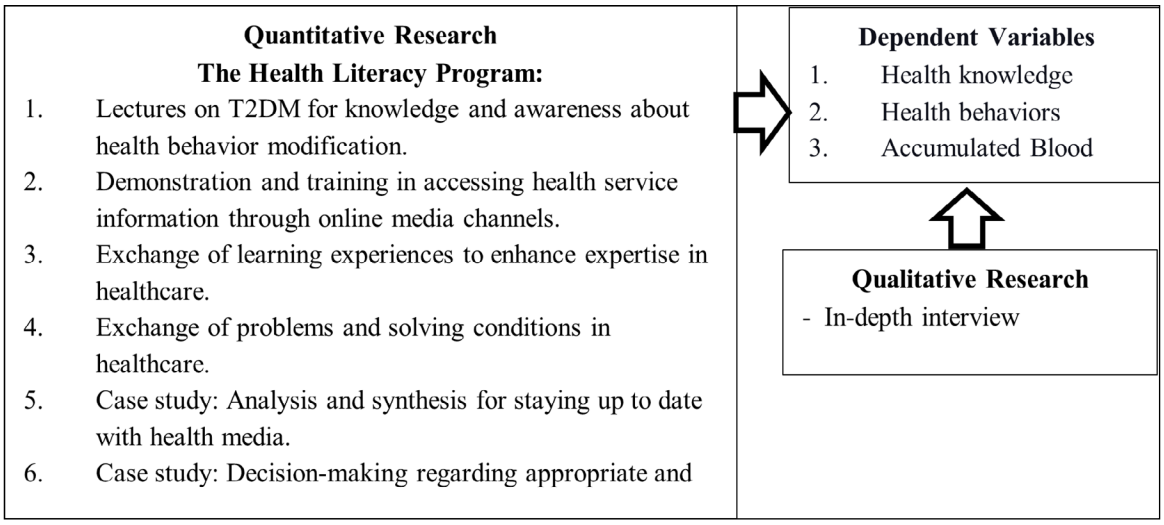

Figure 1: The Health Literacy Program: An Exploration of Quantitative and Qualitative Research Methods.

Material and Methods

This research employed a mixed-methods approach, combining quantitative analysis through a quasi-experimental design, followed by qualitative research through group discussions and individual interviews to validate the results of a quantitative study on health behaviors and accumulated blood sugar levels.

Ethical approval**:** The research procedure was approved by

the Nakhon Ratchasima Provincial Public Health Office (reference number NRPH 032) on May 14, 2021. As the corresponding author's affiliation, Nakhonratchasima College, was relatively new and had not formed the IRB at the time of the study, we obtained ethical approval from the Nakhon Ratchasima Provincial Public Health Office's IRB. This office supervises all health-related organization in the province. The research team received training in human research ethics, in accordance with the Declaration of Helsinki. Written informed consent was obtained from all the participants before their voluntary participation in the study. Data collection was conducted confidentially, and the aggregated results are presented. The potential benefits of participating in the study were explained and communicated clearly to the participants before deciding to participate or decline.

Population and sample: The population and sample used in the quantitative research were T2DM patients who had received continuous healthcare services for at least six months and had moderate to low levels of health knowledge, as evaluated at a sub-district health-promoting hospital in Saraburi province. The sample size was determined using Cohen's formula for a large effect size (effect size = 0.8) with a 95% confidence level[11] resulting in 17 participants. In this case, the research team adjusted the sample size to 30 patients per hospital to prevent sample loss during the research process, using purposive sampling[12] to select participants based on predetermined characteristics.

The research was mainly conducted at Saraphi Sub-district Health Promotion Hospital. Data was collected from July 1 to October 30, 2022 (16 weeks). Nong Bua Mak Hospital is a secondary referral center that receives patients from primary care centers such as Saraphi Sub-district Health Promotion Hospital. Only hemoglobin A1c (HbA1c) measurements were performed in the Nong Bua Mak Hospital laboratory.

Inclusion and exclusion criteria: Male and female patients with T2DM, aged 20 years or above, who had received continuous treatment for at least six months with moderate to low levels of health knowledge were included. Patients with T2DM who had participated in less than four out of six sessions or withdrew from the research for any reason were excluded. All participants voluntarily participated in the study.

Participants for qualitative data: Qualitative data were gathered from 10 male and female participants with T2DM who had participated in the research activities for the entire 12-week duration. They were selected using simple random sampling by drawing lots and were further interviewed through snowball sampling[13] until data saturation was reached, resulting in seven participants. Patients with T2DM, aged 20 years or above, who had participated in the study for the entire 12 weeks were included, while those who had attended fewer than four out of six sessions were excluded.

Research tools: A health knowledge program for T2DM patients was developed based on the health knowledge framework.[14] It includes lectures on diabetes and self-care, principles of psychology in behavior modification[15] demonstrations, and skill training in accessing health service information through online media channels.[16] To develop the health knowledge program, we referred to various sources, including published research papers, textbooks, and guidelines on diabetes management. We also consulted with medical professionals, including endocrinologists, diabetes educators, and nurses, to ensure that the program's content was accurate and effective.

The tools also involve exchanging learning experiences to enhance expertise in healthcare, exchanging problems and problem-solving conditions in healthcare, and case studies for analysis and synthesis to stay updated with the health media. Additionally, case studies were conducted to make appropriate and suitable decisions and supervise and monitor health behaviors through online channels (diet, exercise, emotions, smoking, alcohol, and medication) The case studies used in this study were designed to help participants analyze and synthesize health-related information that they had learned through the health knowledge program. They involved presenting participants with a hypothetical health-related scenario and asking them to make appropriate and suitable decisions based on the information they had acquired. The media used included videos, personal media, brochures, PowerPoint, the Internet, and mobile phones. Five qualified experts verified the validity of the tools' content validity indices of 0.95, 1.00, 1.00, 0.97, 1.00, and 0.96, respectively, for content, the feasibility of implementation, duration, media and equipment, methods, and activities

Health knowledge questionnaire: The research team created a questionnaire based on the health knowledge framework.[14] It was presented to five experts for content validation, and after adjustments were made, it was pilot-tested with a sample group that represents the actual sample, consisting of 30 participants. The questionnaire included general information such as gender, age, marital status, education level, monthly income, religion, and duration of illness. The questionnaire was in a checklist format with additional open-ended questions. The Food, Exercise, Mood, Smoking, Alcohol, and Medication Knowledge Test (14 items) scored 1 for correct answers and 0 for incorrect answers.[5] The interpretation criteria for the total score were as follows: Excellent (80.00-100.00%), Moderate (50.00-79.99%), and Need Improvement (0.00-49.99%). The reliability coefficient (KR-20) is 0.78. The Health Service Access Questionnaire (five items), Communication for Increased Expertise (six items), Condition Management (seven items), Media Awareness (five items), and Decision-making (four items) are in a Likert scale format with five levels: Always, Often, Sometimes, Rarely, and Never. The interpretation criteria for the total score[17] were divided into four levels: needs improvement (1.00-2.00), moderate (2.01-3.00), good (3.01-4.00), and Very Good (4.01-5.00). The reliability coefficients are 0.75, 0.89, 0.90, 0.91, and 0.88, respectively. The Behavioral Health Promotion Questionnaire (20 items) uses a five-point Likert scale format with five levels:

Regularly (0-4 days/week), Often (5-6 days/week), Sometimes (3-4 days/week), Rarely (1-2 days/week), and never. The interpretation criteria for the total score[15] are divided into four levels: needs improvement (0.00-1.00), Moderate (1.01-2.00), Good (2.01-3.00), and Very Good (3.01-4.00). The reliability coefficient was found to be 0.99. For Hemoglobin A1c (HbA1c) Measurement, the HbA1c values of the sample group were collected from laboratory records at Nong Bun Mak Hospital in Nakhon Ratchasima province.

Data collection: The research tools used in this study included a health knowledge program, a health knowledge assessment questionnaire, and the results of glycemic control tests from the hospital. The study was conducted with experimental implementation following the health knowledge system plan for 16 weeks. During the first session, the researchers explained the details of the health knowledge assessment form and scheduled an experimental implementation with the sample group. Data was collected during the second session in the 6th week, and health knowledge was assessed after the experiment during the third session in the 12th week. Follow-up data from the 16th week was used to provide details and assess health knowledge. The interviews were conducted after the completion of the health knowledge program and aimed to explore the participants' experiences and perceptions of the program's effectiveness. The interviews were audio-recorded, transcribed verbatim, and analyzed thematically. The quantitative statistics included percentages, means, standard deviations, and One-way ANOVA with repeated measures. The statistical analysis was performed using SPSS version 22.0.

Data analysis: The quantitative data analysis included percentages, mean values, standard deviations, and inferential statistics. They compared the differences in health knowledge and accumulated sugar levels from each repeated measurement using One-way ANOVA with repeated measures due to the normal distribution and categorical data analysis by categorizing the data.

Results

The patients with T2DM at the Saraphi Sub-district Health Promotion Hospital were predominantly female (80.00%). The average age of the participants was 45.63 years (SD=7.13, max =59, min =30). Regarding marital status, 60.00% were married and 53.30% had completed primary education. The average income is 7916.67 Baht (SD=3879.84, Max=20000, Min=2000). The average duration of illness was 9.57 years (SD=4.19, Max=17, Min=3). For patients with T2DM at the Saraphi Sub-district Health Promotion Hospital who received the developed health knowledge system through repeated measurements in rounds 1 to 4, it was found that their understanding, access to health services, communication expertise, problem-solving management, media literacy, decision-making, and health-promoting behaviors improved, as illustrated in Figures 2 to 8.

The study confirms the impact of health behaviors and HbA1c levels in patients with Type 2 diabetes. It was found that patients with type 2 diabetes who underwent the health knowledge development program demonstrated improved health knowledge and health behaviors across each measurement. Moreover, HbA1c levels showed statistically significant improvement ($p < 0.01$). Qualitative research confirmed that from an in-depth interview about health behaviors, it was found that the development of health knowledge includes activities such as providing information, demonstrating, and practicing health information access skills through online channels, exchanging experiential learning among self-care individuals, problem-solving, analyzing health-related advertisements, and decision-making based on experiential learning from case studies. These activities can help patients gain health knowledge through positive experiences, leading to informed decisions in adopting appropriate healthcare behaviors.

Moreover, analysis and synthesis of information also contribute to increasing knowledge and expertise. This occurs under the framework of knowledge development combined with applying psychological principles for behavior change in stimulating and monitoring desired behaviors. Some of these desirable behaviors include selecting and avoiding non-sweet, fatty, and salty foods, choosing suitable exercise activities, engaging in emotional relaxation activities such as gardening, listening to music, and having conversations, deciding to reduce cigarette and alcohol consumption, and ensuring proper and timely medication intake

By engaging in these activities, individuals with diabetes can apply and integrate them into their lifestyles, aligned with their contexts. This is facilitated by a supportive healthcare team closely monitoring and providing online counseling, particularly addressing health issues and self-care. These activities help diabetic patients adopt healthy and appropriate health behaviors, positively reducing their glycated hemoglobin (HbA1c) levels during each measurement. The participants' views in the group conversation align with the in-depth information, stating, "I'm feeling much better now. My blood sugar has decreased. Before, no one was there to remind me, and as I got older, I became forgetful. I couldn't remember how to follow whatever advice people gave me. But since I joined these activities, there are doctors to guide and warn me. Now, I've started exercising little by little every day and cut down on sweet and fried foods. I'm not giving in to my cravings like before."

Other participants also shared their thoughts on their health behaviors, saying, "In the past, I sometimes took my medication on time and sometimes didn't because I thought taking it on an empty stomach would be the same. But I realized it was not true when I listened to the doctor. I must take it as the doctor advises. Thinking on my own won't work; it won't get better. As for alcohol and smoking, I've reduced them too."

From the feedback given by the participants regarding their health behaviors, it can be observed that the development of health knowledge through engaging in activities and applying psychological techniques for behavior change helps individuals with diabetes recognize their previous unhealthy habits and fosters learning for adopting appropriate new health behaviors. These changes align with their lifestyles effectively.

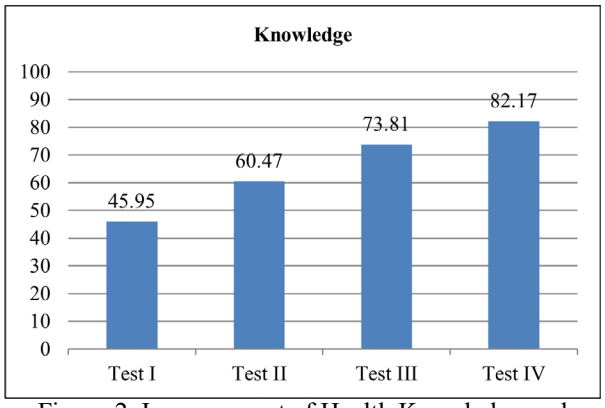

Figure 2: Improvement of Health Knowledge and Understanding of Type 2 Diabetes Mellitus Through Repeated Measurements.

Figure 2 shows that patients with Type 2 diabetes at the Saraphi Sub-district Health Promotion Hospital who received the developed health knowledge system through repeated measurements in rounds 1 to 4 showed improved knowledge and understanding of 2 diabetes.

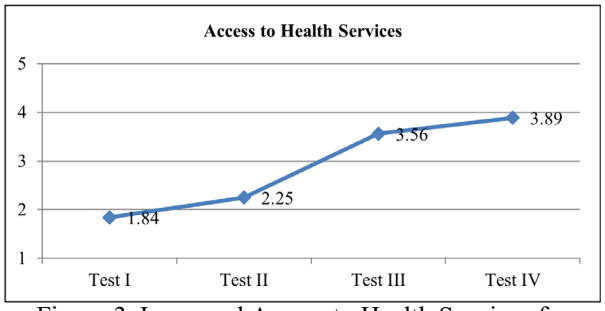

Figure 3: Improved Access to Health Services for Patients with Type 2 Diabetes Mellitus Through Repeated Measurements.

Figure 3 illustrates that patients with T2DM at Saraphi Sub-district Health Promotion Hospital, who received the developed health knowledge system through repeated measurements in rounds 1 to 4, showed improved access to health services.

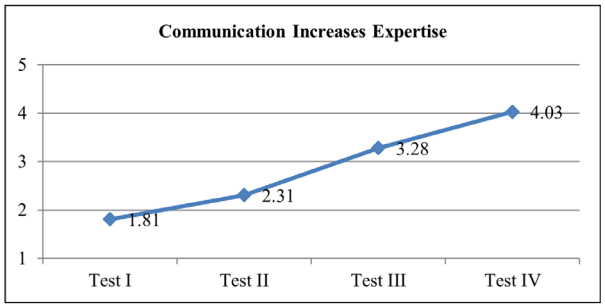

Figure 4: Improved Communication and Expertise among Patients with Type 2 Diabetes Mellitus Through Repeated Measurements.

Figure 4 shows that patients with T2DM at the Saraphi Sub-district Health Promotion Hospital who received the developed health knowledge system through

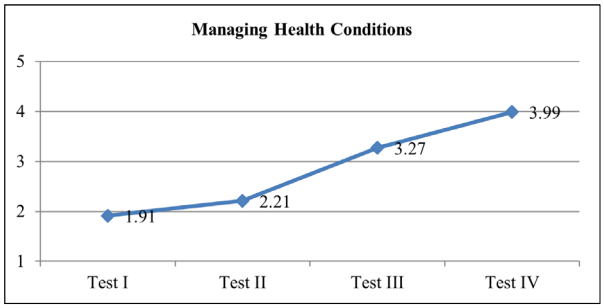

Figure 5: Improved Health Condition Management among Patients with Type 2 Diabetes Mellitus Through Repeated Measurements.

Figure 5 demonstrates that patients with T2DM at the Saraphi Sub-district Health Promotion Hospital who received the developed health knowledge system through repeated measurements in rounds 1–4 improved their health condition management.

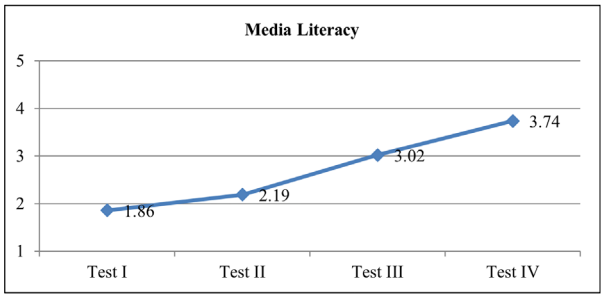

Figure 6: Improved Decision-making among Patients with Type 2 Diabetes Mellitus Through Repeated Measurements.

Figure 6 shows that patients with T2DM at the Saraphi Sub-district Health Promotion Hospital who received the developed health knowledge system through repeated measurements in rounds 1 to 4 showed improved decision-making.

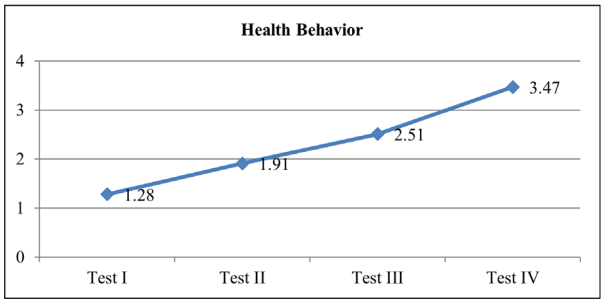

Figure 7: Improved Direction of Health Behaviors among Patients with Type 2 Diabetes Mellitus Through Repeated Measurements.

Figure 7 shows that patients with T2DM at the Saraphi Sub-district Health Promotion Hospital, who received the developed health knowledge system through repeated measurements in rounds 1 to 4, showed improvement in the direction of health behaviors

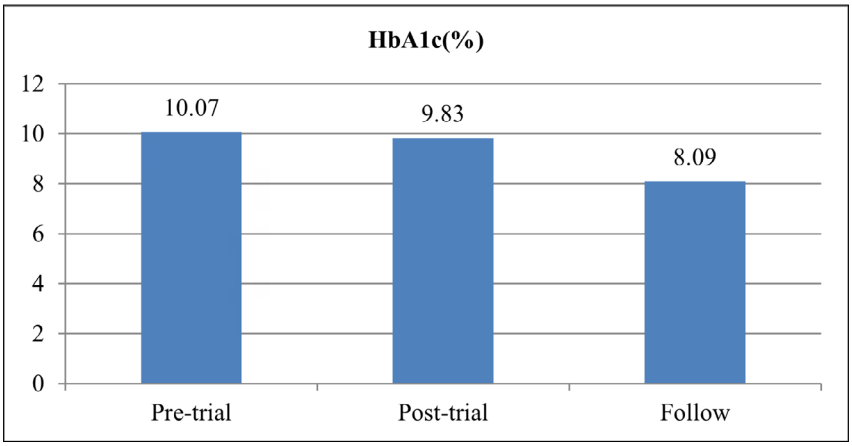

Figure 8: Improved Accumulated Blood sSugar Levels among Patients with Type 2 Diabetes Mellitus Through Repeated Measurements.

Figure 8 demonstrates that patients with T2DM at Saraphi Sub-district Health Promotion Hospital, who received the developed health knowledge system through repeated measurements in rounds 1 to 3, showed improvement in accumulated blood sugar.

Table 1: Comparing the Differences in Health Knowledge from each Measurement.

Variables	df	SS	MS	F	p
1. Knowledge and Understanding Measurement Deviation	1 29	22600.34 7909	11553.54 139.43	82.86	≤0.01
2. Access to Health Services Measurement Deviation	1 29	88.65 5.75	37.48 0.08	446.88	≤0.01
3. Improved Communication Expertise Measurement Deviation	1 29	89.08 8.50	40.28 0.13	304.38	≤0.01
4. Health Problem Management Measurement Deviation	1 29	82.47 6.73	27.49 0.07	355.03	≤0.01
5. Keeping up with Health Information Measurement Deviation	1 29	64.17 11.22	29.24 0.17	165.86	≤0.01
6. Decision-Making Measurement Deviation	1 29	60.18 9.55	29.02 0.15	182.67	≤0.01
7. Health Behaviors (Diet, Exercise, Emotions, Smoking, Alcohol, and Medication) Measurement Deviation	1 29	78.48 2.62	41.01 0.04	868.41	≤0.01

From Table I, it was found that patients with Type 2 diabetes who received health knowledge development comprised knowledge and understanding, access to health services, improved communication expertise, keeping up with health information, decision-making, and health behavior reinforcement. When comparing the repeated measurements from rounds 1 to 4, each aspect showed a statistically significant improvement, with a significant level of 0.01.

Table 2: Compares the Differencing in HbA1c Measurements between each Assessment Round.

Source of Variation	df	SS	MS	F	p
AbA1c					
Mean	1	162.20	81.10	90.98	≤0.01
Standard Deviation	29	51.69	0.89		

Table 2 shows that patients with T2DM who received health knowledge development through repeated measurements of HbA1c at rounds 1, 2, and 3 showed significant improvement in their health behavior. The activities that contributed to this improvement included knowledge and understanding enhancement; better access to health services; improved communication skills and expertise; better problem-solving and decision-making abilities; and healthier behaviors related to food, exercise, emotions, smoking, alcohol, and medication. These activities aligned well with the patients' living context. The healthcare team effectively guided, monitored, and advised them, mainly through online channels, for close interaction, addressing health issues, and self-care. As a result of these activities, patients with type 2 diabetes exhibited improved and appropriate health behaviors,

positively impacting their HbA1c levels, which decreased favorably at each measurement round.

This study confirmed the impact of health behaviors and HbA1c levels on patients with T2DM. Patients with T2DM who underwent the health knowledge development program demonstrated improved health knowledge and health behaviors across each measurement. Moreover, HbA1c levels showed statistically significant improvement ($p < 0.01$). Qualitative research confirmed that, from an in-depth interview about health behaviors, it was found that the development of health knowledge includes activities such as providing information, demonstrating and practicing health information access skills through online channels, exchanging experiential learning among self-care individuals, problem-solving, analyzing health-related advertisements, and decision-making based on experiential learning from case studies. These activities can help patients gain health knowledge through positive experiences, leading to informed decisions regarding the adoption of appropriate healthcare behaviors.

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By engaging in these activities, individuals with diabetes can integrate them into their lifestyles, aligned with their contexts. This is facilitated by a supportive healthcare team that closely monitors and provides online counseling, particularly addressing health issues and self-care. These activities help patients with diabetes to adopt healthy and appropriate health behaviors, resulting in a positive reduction in glycated hemoglobin (HbA1c) levels during each measurement. The participants' views in the group conversation aligned with the in-depth information, stating, *"I'm feeling much better now. My blood sugar has decreased. Before, no one was there to remind me, and as I got older, I became forgetful. I couldn't remember how to follow whatever advice people gave me. But since I joined these activities, there have been doctors to guide and warn me. Now, I've started exercising little by little every day and cut down on sweet and fried foods. I'm not giving in to my cravings like before."*

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From the feedback given by the participants regarding their health behaviors, it can be observed that the development of health knowledge through engaging in activities along with the application of psychological techniques for behavior change helps individuals with diabetes recognize their previous unhealthy habits and fosters learning to adopt appropriate new health behaviors. These changes were aligned with their lifestyles.

Discussion

The research team developed a health knowledge development program in the context of a health-promoting sub-district hospital, considering the lifestyles of patients with T2DM. These issues were used to create a health knowledge development program with responsible personnel, participation in knowledge development operations, and guidance on implementing the health knowledge development system developed by the research team. Knowledge development activities included lectures, demonstrations, physical exercise skill training, online group line interactions, follow-up, home visits, and online problem and obstacle exchanges to support health behavior reinforcement for 16 weeks. The research results are consistent with the objectives of this study.

Effects of the Educational Health Literacy Development Program on Health Literacy, Health Behaviors, and Clinical Outcomes in T2DM Mellitus Patients in Thailand: A mixed-method study showed that the post-trial health literacy level in the quantitative experimental group was significantly higher than that of the control group ($p<0.01$). In addition, fasting blood sugar levels were considerably reduced, but HbA1c levels were stable. The qualitative experimental group understood the basic technical terms used in diabetes and laboratory results. Moreover, they decided to choose the appropriate health behaviors. Based on the findings of the study, it was concluded that EHLDP could help reduce fasting blood sugar levels and accumulate HbA1c. The present study builds on previous research conducted by the authors, which focused on developing and validating a health literacy program for patients with T2DM. The aim of this study was to investigate the effects of repeated measurements of knowledge about health, health behaviors, and glycemic control in T2DM patients, as well as to validate the program's effectiveness. In comparison to previous studies.[3,5,6,18]

this study integrated qualitative data to gain a deeper understanding of the experiences and perspectives of the patients who participated in the health knowledge program. The qualitative data collected through interviews with participants provided insight into the program's impact on their health behaviors and overall well-being. Additionally, this study used a quasi-experimental approach with a sample group of 30 participants selected through purposive sampling. This allowed for the evaluation of the effectiveness of the health knowledge program through repeated measurements of health knowledge, health behaviors, and glycemic control over time. The

study findings suggest that the health knowledge program resulted in significant improvements in health knowledge, health behaviors, and glycemic control in T2DM patients. The program's activities, such as problem-solving and case studies, were effective in enhancing patients' knowledge and skills in accessing and analyzing health-related information, leading to informed decision-making and improved health behaviors.

Based on quasi-experimental research to study the effectiveness of the health knowledge program in patients with T2DM, the sample group comprised 60 participants selected through purposive sampling and voluntary participation. The experimental group received a health knowledge program, whereas the control group received standard care. The intervention lasted 20 weeks. After the program, patients with T2DM in the experimental group demonstrated improved health knowledge compared to those in the control group. Additionally, blood glucose levels from fingertip measurements and HbA1c levels after the intervention were significantly higher than those before the program and in the control group ($p < 0.01$).[8] Consistent with the results of the study on the use of health education and mixed media related to self-care in T2DM patients, it was found that after receiving the health knowledge program, there was a significant increase in health knowledge scores about diabetes ($p < 0.01$). This aligns with the findings of activities that enhance health-related skills in elderly individuals who actively participate in self-care.[18] The research supported elderly patients in accessing health information through online media and acquiring the necessary health knowledge. The program developed self-management skills ($p < 0.01$).

Moreover, the study supported the use of high-quality health information on the Internet to promote health knowledge and exercise in making health decisions.[19] Providing support for seeking health information could help patients make informed self-care decisions ($p < 0.01$). Furthermore, the study applied learning to behavioral change by developing basic health knowledge among elderly patients with diabetes.[20-23] This emphasizes enhancing health knowledge and skills, and it was found that the experimental group had significantly improved basic health knowledge and knowledge about diabetes ($p < 0.01$).

Additionally, the research on health knowledge programs for T2DM patients consisted of two sample groups: the regular treatment group (n=30) and the experimental group (n=30), who received the health knowledge program developed by the researchers. Participants were selected through purposive sampling and voluntary participation, and the intervention lasted 20 weeks. The research tools included a health knowledge questionnaire, blood glucose levels from fingertip measurements, and HbA1c levels from the medical records. The results showed that after receiving the health knowledge program, patients with T2DM in the experimental group demonstrated significantly improved health knowledge compared with those in the control group ($p < 0.01$). Additionally, HbA1c levels after the intervention were considerably higher than those before the program and in the control group ($p < 0.01$).

The health knowledge program utilized in the study aimed to boost health literacy levels, enhance health behaviors, and lower glycemic control levels in T2DM patients. The program consisted of a face-to-face group intervention conducted over ten weeks, with each session lasting two hours. The program incorporated various activities, including group discussions, role-playing, and interactive learning exercises. Educational brochures, videos, and handouts were utilized as materials in the program. The activities were designed to improve knowledge, demonstrate and practice health data access skills, exchange learning experiences, problem-solving, analyze health-related advertisements, and engage in case studies for decision-making. The program facilitators were healthcare professionals with expertise in diabetes management and health literacy interventions. They underwent training on the program's objectives, activities, and materials, as well as on how to effectively lead group discussions and interactive learning exercises. The program's effectiveness was assessed through pre- and post-intervention surveys, focus group discussions, and HbA1c tests. The surveys evaluated health literacy levels, health behaviors, and satisfaction with the program. The focus group discussions provided insights into the participants' experiences with the program, while the HbA1c tests measured the participants' glycemic control levels. Moreover, the study provided health education to different groups and individuals regarding self-care and problem solving in controlling and preventing complications from diabetes. After the intervention, patients with diabetes had a significantly increased knowledge of diabetes ($p < 0.01$). Furthermore, the results of the self-management program for diabetes patients included knowledge development, counseling, medication management, problem solving, and phone reminders, and it was found that patients' health knowledge increased and their HbA1c levels decreased ($p < 0.01$).[9] The study did not find any significant differences in age, sex, ethnicity, education level, socioeconomic status, duration and severity of T2DM, medication type and dosage, presence of comorbidities, or environmental factors among the participants that could have influenced the outcomes. This suggests that the outcomes were not impacted by these potential confounding variables.

Understanding the relationship between health literacy, health behavior, and hemoglobin A1c levels is crucial for effectively managing type 2 diabetes mellitus (T2DM). The multifaceted nature of this disease necessitates meticulous monitoring and management, making it imperative to gain a deeper understanding of the factors contributing to its progression.[20,24] In recent years, studies investigating the effects of the re-measurement of health literacy, health behavior, and hemoglobin A1c (HbA1c) have emerged as a significant area of interest among researchers in the field.[25] Comparative analyses have indicated that several studies have focused on health literacy, exploring its relationship

with health behavior and clinical outcomes in patients with type 2 diabetes mellitus. These investigations highlight the crucial role of adequate health literacy in promoting positive health behaviors, medication adherence, and improved glycemic control. Furthermore, studies have found that low health literacy levels are associated with poorer diabetes self-management skills, increased hospitalizations, and higher healthcare costs.[26]

The effects of re-measuring health literacy, health behavior, and HbA1c levels with qualitative confirmation have been widely examined. These studies aim to corroborate quantitative findings using qualitative methods, thereby capturing a more comprehensive understanding of the experiences and challenges faced by individuals with type 2 diabetes mellitus. Qualitative confirmation offers valuable insights into patients' perspectives, barriers to self-care, and potential strategies for improving health outcomes.[27] Consolidating quantitative measures with qualitative confirmation in diabetes research provides a holistic approach to understanding the intricate interplay between health literacy, health behavior, and clinical markers such as HbA1c. This multidimensional understanding enriches patient care and facilitates the development of targeted interventions to improve health outcomes in individuals with type 2 diabetes mellitus.[28] Ongoing studies examining the effects of re-measuring health literacy, health behavior, and HbA1c levels with qualitative confirmation in patients with type 2 diabetes mellitus offer valuable insights into the intricate dynamics of this complex disease. The amalgamation of quantitative and qualitative approaches empowers healthcare practitioners to develop personalized strategies to address the specific needs and challenges faced by individuals with diabetes.[29] Healthcare professionals can significantly improve patients' overall well-being with type 2 diabetes mellitus by enhancing health literacy levels, fostering positive health behaviors, and achieving optimal glycemic control.[30]

This article delves into the effects of re-measuring health literacy, health behavior, and hemoglobin A1c levels in patients with T2DM, providing qualitative confirmation of their interconnections. By focusing on these essential factors, health care professionals can gain valuable insights into the complexities of T2DM management and develop tailored strategies for patient care. This study found that remeasuring these factors and confirming them through qualitative analysis can lead to better management of diabetes and improved health outcomes for patients. Several studies have emphasized the need for healthcare providers to address the social determinants of health that can impact a patient's ability to manage their diabetes, such as access to healthcare and resources, education, and socioeconomic status. By considering these factors and working with patients to improve their health literacy and behaviors, healthcare providers can help patients manage their diabetes better and prevent complications.[31-33] A recent study underscores the importance of accurate and thorough measurements of health factors in diabetes management and the need for a patient-centered approach to healthcare that addresses the social determinants of health.[34] The study found that patients who received the developed health knowledge system through repeated measurements in rounds 1 to 4 showed improvements in various aspects including knowledge and understanding, access to health services, communication expertise, problem-solving management, media literacy, decision-making, and health-promoting behaviors. These improvements are illustrated in Figures 1–6, which show significant improvements throughout the study.

Additionally, Tables 1 and 2 show that patients with T2DM who received the health knowledge development program showed significant improvements in health behaviors and HbA1c levels. This study supports the use of health information to promote health knowledge and exercise in making health decisions. This can help patients make informed decisions regarding self-care and improve their overall health outcome. The results of this study suggest that health knowledge development programs can be effective tools for improving health outcomes in patients with type 2 diabetes. A longer follow-up period is crucial to assess the lasting impact of a health knowledge program on health behaviors and glycemic control in T2DM patients. While initial results showed improvements in knowledge, behaviors, and glycemic control, the sustainability of these effects remains uncertain due to the short follow-up period. Extending the follow-up would offer valuable insights into the program's effectiveness and potential lifestyle changes among patients, enhancing the development of effective health literacy interventions for T2DM patients. Using a standardized health literacy assessment tool is crucial for determining participants' health literacy levels in a study. The study aimed to explore the impact of health literacy on health behaviors and glucose levels in T2DM patients. The study successfully measured health literacy levels in participants using a health knowledge assessment questionnaire focused on diabetes, healthy eating, physical activity, medication adherence, and self-monitoring. The results showed significant improvements in health knowledge, behaviors, and glycemic control. The program led to informed decision-making and reduced HbA1c levels, aligning with patients' lifestyles. The findings suggest the questionnaire effectively assessed health literacy and the program was beneficial for T2DM patients, highlighting the importance of tailored interventions for improving health outcomes. Implementing health knowledge programs for T2DM patients can be cost-effective in the long run. Studies show that such programs can improve glycemic control, reduce healthcare costs, and lower the risk of complications and hospitalization. Further research is needed to fully assess the cost-effectiveness of these programs.

The resent study has several implications for future research. Firstly, the sample size for this study is relatively small, with 30 participants selected through purposive sampling. While the study's findings suggest significant improvements

in health literacy, health behaviors, and glycemic control, the small sample size may limit the generalizability of the findings to the broader population of patients with type 2 diabetes mellitus. Future studies may benefit from larger sample sizes or more diverse participant populations to increase the generalizability of the findings. However, it is important to note that a small sample size does not necessarily invalidate the study's findings. Instead, it limits the scope of the study's generalizability and requires careful consideration of the results' applicability to other populations. Secondly, the study used a quasi-experimental design, which limits the ability to establish causal relationships between variables. Future research could use experimental designs to investigate the causal effects of health literacy programs on health behaviors and glycemic control. Thirdly, the study focused on the short-term effects of health literacy programs. Future research could explore the long-term effects of health literacy programs on patient outcomes. Finally, the study focused on the effects of health literacy programs in Thailand. Future research could explore the effectiveness of health literacy programs in other countries and cultures to establish the generalizability of the findings.

Conclusion

From this study, interesting and significant findings emerged concerning health management in T2DM patients by implementing a knowledge program that involves repeated measurements to study the impact of changes in health knowledge, health behaviors, and blood sugar levels. This program provides a clear picture of its effects on improving health behaviors and diabetes control, with promising results. The quantitative data showed that patients who underwent repeated measurements experienced positive changes in their behavior and blood sugar control, which were statistically meaningful and clinically relevant. Therefore, the developed health knowledge program is important for enhancing knowledge and skills in accessing health information, enabling patients to make informed decisions about suitable health behaviors aligned with their lifestyles. Furthermore, the program reduces hemoglobin A1c (HbA1c) levels, which are crucial for blood sugar management.

The recommendation of this research is to utilize the obtained results to develop a healthcare program for T2DM patients in hospitals and related organizations. In addition, conducting further studies to examine the long-term effects on health knowledge and behaviors is essential to enhance the understanding of the process and effectiveness of the developed program. This will allow for continuous improvement and development of the program to maximize its efficiency in promoting health among T2DM patients, ensuring that they have improved health knowledge, health behaviors, and blood sugar levels.

Conflict of Interest

The authors declare that there is no conflict of interest.

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