Journal of Current Science and Technology, January-March, 2025 Vol. 15 No. 1, Article 83

ISSN 2630-0656 (Online)

Cite this article: Reamrimmadun, Y., Jaidee, W., Wattanaburanon, A., & Rojpaisarnkit, K. (2025). Effectiveness of a web-based application on health literacy, self-efficacy, self-care, and glycemic control in elderly patients with type 2 diabetes: a randomized controlled trial. *Journal of Current Science and Technology*, *15*(1), Article 83. https://doi.org/10.59796/jcst.V15N1.2025.83

Journal of Current Science and Technology

Journal homepage: https://jcst.rsu.ac.th

# Effectiveness of a Web-based Application on Health Literacy, Self-Efficacy, Self-Care, and Glycemic Control in Elderly Patients with Type 2 Diabetes: A Randomized Controlled Trial

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Received 23 August 2024; Revised 11 September 2024; Accepted 21 September 2024; Published online 23 December 2024

## Abstract

The web-based application serves as a technology platform that enhances health literacy by providing diabetes-related content, activities, and quizzes. It boosts self-efficacy by enabling users to set health goals, promote self-care through practical activities, and use data collection and reminders to help regulate blood sugar and adopt healthy habits for elderly patients. This research study is experimental and includes a randomized controlled trial. The objectives of this study were to compare the effectiveness of using web-based applications in developing health literacy, self-efficacy, self-care behaviors, and blood sugar levels. The sample group consisted of 60 elderly individuals with type 2 diabetes and uncontrolled blood sugar levels, made up of 30 people in the experimental group and 30 people in the control group. In the experiment, the web-based application was utilized over a period of 12 weeks to carry out a health literacy assessment. Self-efficacy, self-care, and blood sugar levels (FBS and HbA1C) were assessed before the experiment (Week 0, T1), immediately after the experiment (Week 12, T2), and during the follow-up period (Week 24, T3). The data were analyzed using two-way repeated measures ANOVA statistics. The results indicated that in T2 and T3, the experimental group achieved an average health literacy score, accompanied by an increase in self-efficacy, enhanced self-care, and a reduction in FBS and HbA1C that was greater than in T1, with statistical significance ($p<.05$). Moreover, the experimental group showed a greater increase in average health literacy scores, self-efficacy, and self-care compared to the control group, with fasting blood sugar (FBS) and HbA1C levels decreasing more significantly than in the control group, at a statistically significant level ($p<.05$). In conclusion, the web-based application was able to promote health literacy among patients as it improved self-efficacy, self-care behavior, and the ability to regulate glycemic control in T2 and T3.

***Keywords*****:** *web-based application; health literacy; self-efficacy; self-care; glycaemic control; elderly patients with type 2 diabetes*

## 1. Introduction

Diabetes has been identified as the primary factor contributing to the decline in healthy years among elderly individuals in Thailand. In 2019, the Ministry of Health reported over 5.1 million elderly males (19.90% of the total) and more than 6.4 million elderly females (30.97% of the total) with the highest prevalence of diabetes (Bunnak et al., 2020). Since diabetes is a chronic disease, it has no cure. If a diabetic is unable to control their blood sugar levels, it can lead to complications that can be severe, including the loss of organs or death. Two out of three individuals with diabetes die from cerebrovascular disease. It also causes other complications, such as macular degeneration, nervous system disorders, and arterial constriction (Singhakowin, 2021). As a result, blood sugar management is an approach that aims to treat diabetes. The blood sugar levels during fasting

typically range from 80 to 130 mg/dl. Elderly individuals, who are above the age of 65 and do not have any medical conditions, aim to achieve a target HbA1C level of less than 7% (The Thai Diabetes Association, 2017; The Thai Diabetes Association, 2023).

The concept of health literacy is gaining increasing interest due to the changes experienced by older individuals during their lifetimes and the challenges posed by chronic illnesses. These challenges include limited access to information, social services, and health care due to physical, mental, and social decline. Health literacy is an important concept and indicator that influences health behaviour and outcomes (Techavijitjaru, 2018). Enhanced health literacy among the elderly corresponds with improved self-care behaviour (Boonsatean, & Reantippayasakul, 2020). According to a review of recent studies and the inclusion of factors related to controlling blood sugar levels in people with diabetes, much of the research has shown that health literacy (Ministry of Public Health, 2014) and self-efficacy, as defined by the self-care theory (Orem, 2001), are two traits that affect glycaemic control. Research has also revealed a correlation between a more positive assessment of overall performance and lower levels of blood sugar and HbA1C. Furthermore, the self-efficacy theory (Bandura, 1986) identifies specific self-care aspects that successively influence the regulation of the blood sugar levels in individuals with diabetes.

Additionally, there is a noticeable trend toward using mobile phone applications or self-tracking devices in health care to serve older individuals, thanks to recent advancements in information technology (Srisupak et al., 2019). Elderly individuals prioritize healthcare-related applications for their mobile phones as they seek to enhance their self-care management (Tshering, & Thippaya, 2014). There has also been progress in developing web application technology for predicting type 2 diabetes (Luangruangrong et al., 2013). According to Kebede, et al. (2018), an analysis of previous studies reveals that applications mostly concentrate on generic data tracking capabilities. However, there are still difficulties in developing applications that explicitly cater to the requirements of particular user groups. The applications were not explicitly designed to meet the specific needs of elderly patients. Additionally, it was found that there are many applications available to choose from, but only a few have been developed based on systematic and clear behavioral theories. Furthermore, there has been no assessment of the ability to perceive or study the behavioral changes over different periods (King et al., 2016). Therefore, the development of health literacy, self-efficacy, self-care, and blood sugar control via smartphone-based information is particularly promising for older adults due to the ease of access and the potential for reliable, accurate information delivery. Web-based applications could provide a modern and effective means of improving glycaemic control and promoting healthy behaviors.

A web-based application for controlling blood sugar levels in elderly patients with type 2 diabetes is an innovative development based on an analysis of the causal relationship model of health literacy, self-efficacy, and self-care behaviors concerning blood sugar levels. The characteristics of the identified relationships were utilized to design methods or guidelines for managing elderly patients with type 2 diabetes who are unable to control their blood sugar levels (Reamrimmadun, 2024; Reamrimmadun et al., 2024a). Following relevant health concepts, the web application was developed through the internet network, using open-source development tools and undergoing quality checks of the content by specialized doctors working in community hospitals. The assessment results showed a high level of completeness, and elderly patients with type 2 diabetes expressed a high level of satisfaction with the web application (Reamrimmadun et al., 2024b). Therefore, this web-based application has been systematically designed to meet the specific needs of elderly individuals with diabetes, utilizing relevant health concepts and assessing changes in perception and behavior. The content, effectiveness, and satisfaction among users have been evaluated, making it ready for broader implementation.

In 2022, a study conducted in Chachoengsao Province revealed that there were 22,355 cases of diabetes among the older population, which accounted for 20.84% of the total number of elderly individuals in the province. Diabetes continues to be the primary health concern in the province. In addition, in the years 2020 to 2022, there were statistical reports of elderly people who were unable to control their sugar levels, which tended to continually increase each year, numbering 1,004 people, 1,069 people, and 1,165 people, respectively. Bang Pakong District has a significant number of elderly people who are unable to control their sugar levels, reaching a peak number of 571 (Public Health

Strategy Development, 2022). In 2018, a segment of the elderly people in the province acquired digital technology skills and began using smartphones for communication and primary health care. This enabled them to engage in online learning, access information, and adapt to contemporary changes (Huajai, 2019). However, there is currently no connection between the use of health information technology and addressing the health issues faced by older individuals in the region.

Based on this situation, the emerging problems and potential availability of the elderly in the area led the researchers to become interested in using web-based applications developed from the concept of health care in experimental research to study their effectiveness in helping to control blood sugar levels. This could alternatively allow older people to have improved glycaemic control, which will help them continue to have a better quality of life.

## 2. Objectives

The objectives of this study were to compare the effectiveness of using web applications in developing health literacy, self-efficacy, self-care behaviors, and blood sugar levels at the pre-experimental (week 0, T1), post-experimental (week 12, T2), and follow-up periods (week 24, T3).

## 3. Materials and Methods

A randomized controlled trial (RCT) assessed the pre-experimental (week 0, T1), post-experimental (week 12, T2), and follow-up periods (week 24, T3) of the third trimester. The trial period is from December 2023 to May 2024.

### 3.1 Population and Sample

*3.1.1 Population*

The elderly aged 60 years and over, with type 2 diabetes, who are unable to control their sugar levels. There are 571 people receiving treatment at the primary health care hospital in Bang Pakong District, Chachoengsao Province.

*3.1.2 Sample*

Using G*Power, the sample size was determined using power analysis, which calculated the effect size using Cohen's formula (Cohen, 1988) and the means from related research. According to Chiangkhong (2018), the calculated effect size was 0.8 due to its large magnitude, α err. prob. = 0.05, and Power (1-β err. prob.) = 0.8, indicating a sample size of 52 participants. During the study, the researchers accounted for a potential 15% loss of the total sample of 60 participants. The participants in this study were recruited through multiple channels: posters displayed in the primary health care hospital, public announcements made through community loudspeakers, local administrative organizations, and important religious sites in the Bang Pakong District. The researchers then considered 98 interested volunteers and screened them based on the inclusion criteria. The 60 people who met the criteria, the sample was then allowed to register and enter the restricted randomization process. To ensure each of the two groups had an equal number of participants, block randomization was used, and participants were randomly assigned to one of groups using allocation concealment, resulting in an experimental group of 30 people and a control group of 30 participants.

*3.1.3 Inclusion Criteria*

1) Elderly people with type 2 diabetes who cannot control their sugar levels, who have been treated for at least 5 years but not more than 15 years, 2) are able to read, write, and communicate normally, 3) have been treated with any type of blood glucose medication that a doctor prescribes, 4) have a smartphone, desktop, or portable computer that can connect to the Internet and be used, 5) indicates at least 6 months of basic competency in using smartphones or computers for the purpose of finding information. 6) are able to make contact with the researchers by phone or LINE chat application, and 7) provided consent to participate in the research project.

*3.1.4 Exclusion Criteria*

1) During the study, patients who experienced complications that required treatment which affected blood sugar control. 2) patients who experienced an emergency while conducting the research, and 3) patients who requested withdrawal from the study were excluded from the research.

### 3.2 Research Tool

*3.2.1 The Experimental Tool*

The experimental tool is a web-based application that comprises three stages, encompassing a total of eight primary actions with a duration of 12 weeks. The web-based application activities and media include knowledge about diabetes, instructional videos, exercises, situational media examples, games, self-management data recording forms, self-assessment tools, communication with medical personnel, model

learning, guidelines for proper behavior, behavioral assessment reports, and resources for diabetes patients.

A panel of five qualified physicians thoroughly tested the web-based program to ensure the accuracy and appropriateness of its content. The evaluation form for accuracy consists of the aspects of consistency, clarity, completeness, and academic correctness, using a Likert scale (1-4 points) with a content validity index (CVI) of 1.00. Additionally, five information technology experts evaluated it using a completeness assessment of the web application and a 30 elderly patients satisfaction questionnaire, scoring at the highest level on a Likert scale (1–5 points) (Reamrimmadun et al., 2024a).

*3.2.1 Instruments used for Data Collection*

1. The general information questionnaire included gender, age, educational status, income, and illness duration (years).

2. The Health Literacy Assessment evaluates the level of health literacy in senior individuals and measures diabetes-related factors in diabetics (Thummakula et al., 2021; Chiangkhong et al., 2017). There are a total of 21 items assessed using a 5-point rating scale. The Cronbach's alpha coefficient had a confidence level of 0.95.

3. The self-efficacy perception questionnaire was developed from the self-efficacy measuring tool of the Thai Version of the Diabetes Management Self-Efficacy Scale: T-DMSES (Sangruangake, & Borisut, 2017) with 19 questions using a 5-point rating scale. Cronbach's alpha had a confidence value of 0.94.

4. The self-care behaviour questionnaires from the Self-Care Behaviour Assessment tool (Siangdung, 2017) and the Thai version of the Summary of Diabetes Self-Care Activities Measure: T-DSMS (Sangruangake, & Borisut, 2017), totalling 20 questions. The questionnaire features a 5-point rating scale and the Cronbach's alpha had a confidence value of 0.84.

5. Measurement of FBS and HbA1C, From the clinical chemistry analyzer, Roche Analyzers model cobas integra 400 plus. Experts in charge of medical device inspections conducted a thorough evaluation of the clinical chemistry analyzer's functionality.

**3.3 Research Process**

*3.3.1 Preparation Steps*

1. The researchers contacted the relevant authorities to request permission to enter the field and sought cooperation from Bang Pakong district's public health department, as well as the medical team, nurses, and personnel involved in the health promotion hospital in Bang Pakong district, Chachoengsao province. They invited and publicized the search for volunteers to participate in the research project and requested assistance in using facilities and locations for conducting the research.

2. The researcher communicated and clarified the objectives and details of the research process with the sample group to enquire about their willingness to participate in the research project.

3. Once volunteers interested in participating in the research project were obtained, the researchers proceeded to screen the volunteers for inclusion in the project based on the inclusion criteria in order to select 60 participants for the trial and register them.

4. Conduct randomization using the process of restricted randomization (block randomization) and assign participants to either the control group or the experimental group. In this randomization, the researcher did not know which group the volunteers belong to. The researcher has appointed one research assistant, who is not involved in the research process, to create the subject log with restricted access to prevent bias. In this study, only two individuals are aware of the actual information: 1) The person who creates the code and maintains the subject log; and 2) software developers and computer system specialists who install web applications and manage their usage for the 60 research participants.

5. The researcher scheduled the date, time, and location and requested cooperation from the sample group to conduct the experiment and collect data.

*3.3.2 Procedure Steps*

1. The introduction of the web application includes the steps and processes for its usage, to ensure that both the experimental group and the control group have the necessary foundational knowledge for using the web application.

2. This is the process of data collection before starting the experiment, where all participants are asked to complete a questionnaire measuring health literacy, self-efficacy, self-care, and blood sugar levels from the patients' medical records.

**3.4 Experimental Processes**

The functioning of the experimental group involved the utilization of an online application, which was carried out in three separate phases covering eight activities over a period of 12 weeks.

*3.4.1 Step 1 Enhancement of Health Literacy*

1. Access: The goal is to determine where information comes from. Information surveys and health services can select and verify information from multiple

sources in order to obtain reliable, accurate, and up-to-date information. Activities include knowledge acquisition, information-search training, and training in comparison and information verification.

2. Cognitive function: The goal is to identify the crucial aspects related to diabetes so as to be able to guide proper behaviour and perform a logical analysis and comparison of the facts regarding effective self-care strategies for managing blood sugar levels. Activities involve enhancing knowledge and responding to numerical inquiries in order to manage diabetes and examine self-care policies based on certain situations.

3. Communication skills: The goal is to enable elderly people to memorize important points about communication in order to share information and interact with others regarding their illnesses, learn how to deal with medical personnel, and provide information to persuade others to accept self-care guidelines to control their blood sugar levels. Activities include providing knowledge, answering questions based on examples of situations, and training for online communication with medical staff.

4. Decision-making skills: The goal is to enable elderly people to analyse the causes of their inability to control their blood sugar levels so that they can choose or reject the self-care methods to control blood sugar based on a reasonable analysis of the advantages and disadvantages, and they can decide how to do so with minimal effects. Activities include analysing the reasons that blood glucose levels cannot be controlled, identifying options, evaluating alternatives, and making decisions.

5. Self-management (2 weeks): The goal is to enable elderly people to memorize the key points about self-management, set goals, plan for self-care, follow the schedule, and review the practices of modifying methods for healthy behaviour. Activities include knowledge training targeting behaviours and self-tracking in sugar control through the use of self-management logs and practicing self-assessment in glucose control.

6. Media literacy: The goal is to enable elderly people to memorize important points about media awareness regarding verifiable and reliable information, to compare information from multiple sources, to evaluate accuracy and reliability, and to share self-care guidelines with others. Activities include providing knowledge, undergoing training, reviewing information, and answering questions.

*3.4.2 Step 2 Self-efficacy Refers to the Confidence-Building Processes that may Result in Changes in Behaviour*

The self-efficacy method focuses on enhancing self-assurance, dietary habits, physical activity, and adherence to medication. The components comprise manifestations of unease, anticipation, and contemplation. Knowledge on modelling health behaviour and health care is acquired by studying a video demonstration featuring an individual with diabetes. Afterwards, participants demonstrate their understanding by answering related questions.

*3.4.3 Step 3 Self-care Behaviour Training for Successful Outcomes*

The self-care behaviour training aims to educate elderly individuals about suitable self-care behaviours and provide help in implementing them for improved health results. Activities encompass self-assessment and examination of supplementary instructions in situations where implementation is not feasible and engaging in a 4-week training regimen by documenting daily behaviours in the system.

The experimental group had the flexibility to use the web-based application at any time of the day for convenience. They spent an average of 20 to 30 minutes per day using it for a duration of 12 weeks. The web-based application will provide progress reports for each activity, allowing users and developers to track usage frequency and duration. If volunteers aren't consistently accessing the system, an SMS alert system will be implemented. The application also features a technical support system for volunteers to resolve issues through chat or hotline. After utilizing the web application, they were tested for sugar levels based on the treatment plan, together with the documentation of the blood sugar data. The outcomes were assessed upon the conclusion of the trial.

**3.5 Control Processes**

The control group was more closely observed and adhered to a standard treatment regimen, which they had access to and utilized during the evaluation phase. Once the T2 and T3 periods were reached, the control group was tested for sugar, together with the documentation of the blood sugar data and an assessment was conducted. After the final assessments, the researchers will grant rights to the control group by activating the web application system for developing health literacy, just like the experimental group. The control group will receive the same benefits as the experimental group in every aspect.

**3.6 Evaluation Process**

1. The evaluation of outcomes for both groups was conducted using assessments of health literacy, self-efficacy, self-care behaviors, and blood sugar levels. The individuals conducting the outcome assessments were not involved in this research study and were unaware of which

group the participants belonged to. They were responsible for evaluating and exporting the data collected by the software developers from the database.

2. The study results were analyzed to examine whether the web application was effective in improving health literacy, self-efficacy, self-care behaviors, and blood sugar levels compared to providing health education and adhering to treatment plans, as well as tracking the performance of the web application after a 12-week trial.

### 3.7 Statistical Analysis

The ANOVA was used to evaluate the two-way repeated measurement data. If a sphericity violation occurs during Mauchly's Test of Sphericity, Greenhouse-Geisser can adjust the analysis results. The use of Bonferroni correction in pairwise comparisons between different time periods can account for Type I errors. The chosen significance level was 0.05.

### 3.8 Ethical Considerations

This research successfully underwent a research ethics evaluation conducted by the Board of Ethics in Human Research at Burapha University (IRB3-037/2566). The research project with code G-HS015/2566 was approved by the Full Board on 25 April 2023. The first renewal (IRB3-021/2567) was approved on April 25, 2024 - April 25, 2025. The researchers protected participants rights by clearly explaining the study. Participants had the right to accept or decline to provide information without losing benefits or facing any negative consequences from their involvement in the research. The researchers provided consent documents and arranged facilities, such as a user manual for the web application. The researchers ensured privacy during data collection by not disclosing participant names or surnames. The researchers kept the collected information confidential, restricted access to the data, and presented only aggregated data.

## 4. Results

### 4.1 Characteristics of the Participants

The general data on the experimental and control groups revealed that both groups were predominantly composed of female. The average age for the experimental group was 71 years, and the average age for the control group was approximately 70 years. Most of the experimental group and control group were married. High school graduates accounted for 36.67% and 40.00%, respectively. Both the experimental and control groups had average incomes of between 10,000 and 14,999 Baht, and both had an average illness duration of 7 years. The results of the comparison of the differences between the trial group and the control group were classified by individual factors. The comparison, using Chi-square, Fisher's exact test, and independent t-test statistics, found that the individual factors of the trial group and control group were not significantly different.

### 4.2 Results Assessment

The mean and standard deviation of health literacy, self-efficacy perception, self-care behaviour, and blood sugar levels (FBS and HbA1C) in the experimental and control groups at each period (T1, T2, and T3) are presented in Table 1.

**Table 1** The mean and standard deviation of health literacy, self-efficacy perception, self-care behaviour, and blood sugar levels (FBS and HbA1C) in the experimental and control groups at each period (T1, T2, and T3)

| Variable | Time | Intervention (n = 30) | | Control (n = 30) | |
|---|---|---|---|---|---|
| | | $\overline{X}$ | S.D. | $\overline{X}$ | S.D. |
| Health literacy | T1 | 1.876 | .593 | 1.906 | .459 |
| | T2 | 3.417 | .279 | 1.920 | .431 |
| | T3 | 3.347 | .290 | 1.915 | .370 |
| Self-efficacy | T1 | 2.147 | .531 | 2.142 | .544 |
| | T2 | 3.447 | .298 | 2.117 | .497 |
| | T3 | 3.391 | .209 | 2.133 | .427 |
| Self-care | T1 | 3.160 | .462 | 3.176 | .451 |
| | T2 | 3.871 | .317 | 3.138 | .447 |
| | T3 | 3.838 | .224 | 3.143 | .346 |
| FBS | T1 | 166.133 | 26.100 | 165.300 | 22.410 |
| | T2 | 126.700 | 19.438 | 164.366 | 24.189 |
| | T3 | 126.866 | 15.867 | 166.566 | 23.085 |
| HbA1C | T1 | 7.555 | .516 | 7.616 | .426 |
| | T2 | 6.946 | .410 | 7.670 | .452 |
| | T3 | 6.966 | .614 | 7.690 | .394 |

The two-way repeated measure ANOVA showed that there were statistically significant differences ($p<.05$) between the experimental and control groups in terms of health literacy, self-efficacy perception, self-care behaviours, FBS, and HbA1C across all three time periods (T1, T2, and T3). Thus, the web-based application had an influence on health literacy (66.5%; $\eta^2 = 0.665$), self-efficacy perception (59.3%; $\eta^2 = 0.593$), and self-care behaviour (32.6%; $\eta^2 = 0.326$). Also, FBS (30.9%; $\eta^2 = 0.309$) and HbA1C (26.6%; $\eta^2 = 0.266$) were affected. These $\eta^2$ values indicate a large effect size, suggesting that the web application is effective in enhancing health literacy, boosting self-efficacy, improving self-care behaviors, and significantly helping to control FBS and HbA1C for elderly patients. When comparing the intervals in each group, it was found that the time interval changes in the measured cycle, including health literacy, self-efficacy perception, self-care behaviours, FBS, and HbA1C, had statistically significant differences ($P<0.05$), as presented in Table 2.

The findings of the pairwise comparisons using the Bonferroni technique revealed significant differences in health literacy, self-efficacy perception, self-care behaviour, FBS, and HbA1C between periods T1 and T2. However, there were no significant differences between time periods T2 and T3, which led to significant progress. This will gradually stabilize over time, reflecting the development of health literacy, confidence, behavior change, and blood sugar control, which began with the continuous receipt of information and various activities through the web-based application, as presented in Table 3.

**Table 2** Results of the comparative analysis of the levels of health literacy, self-efficacy perception, self-care behaviour, FBS, and HbA1C in the experimental and control groups during the T1, T2, and T3 periods

| Source | SS | Df | MS | F | *p*-value | $\eta^2$ |
|---|---|---|---|---|---|---|
| Health literacy | | | | | | |
| between sample | | | | | | |
| groups | 42.008 | 1 | 42.008 | 115.242 | .000 | .665 |
| Error | 21.142 | 58 | .365 | | | |
| Within subject | | | | | | |
| Time | 23.095 | 1.381 | 16.720 | 144.365[a] | .000 | .713 |
| Group X Time | 22.367 | 1.381 | 16.193 | 139.819[a] | .000 | .707 |
| Error time | 9.279 | 80.115 | .116 | | | |
| Self-efficacy | | | | | | |
| between sample | | | | | | |
| groups | 33.618 | 1 | 33.618 | 84.361 | .000 | .593 |
| Error | 23.113 | 58 | .398 | | | |
| Within subject | | | | | | |
| Time | 15.769 | 1.202 | 13.117 | 90.981[a] | .000 | .611 |
| Group X Time | 16.644 | 1.202 | 13.845 | 96.027[a] | .000 | .623 |
| Error time | 10.053 | 69.725 | .144 | | | |
| Self-care behaviour | | | | | | |
| between sample | | | | | | |
| groups | 9.964 | 1 | 9.964 | 28.043 | .000 | .326 |
| Error | 20.608 | 58 | .355 | | | |
| Within subject | | | | | | |
| Time | 4.351 | 1.664 | 2.615 | 48.937[a] | .000 | .458 |
| Group X Time | 5.352 | 1.664 | 3.216 | 60.198[a] | .000 | .509 |
| Error time | 5.157 | 96.514 | .053 | | | |
| FBS | | | | | | |
| between sample | | | | | | |
| groups | 29286.756 | 1 | 29286.756 | 25.918 | .000 | .309 |
| Error | 65538.556 | 58 | 1129.975 | | | |
| Within subject | | | | | | |
| Time | 15395.344 | 1.628 | 9454.993 | 45.873[a] | .000 | .442 |
| Group X Time | 15646.678 | 1.628 | 9609.349 | 46.622[a] | .000 | .446 |
| Error time | 19465.311 | 94.440 | 206.113 | | | |

**Table 2** Cont.

| Source | SS | Df | MS | F | *p*-value | $\eta^2$ |
|---|---|---|---|---|---|---|
| HbA1C | | | | | | |
| between sample groups | 11.370 | 1 | 11.370 | 21.021 | .000 | .266 |
| Error | 31.372 | 58 | .541 | | | |
| Within subject | | | | | | |
| Time | 2.878 | 1.736 | 1.658 | 20.946[a] | .000 | .265 |
| Group X Time | 4.382 | 1.736 | 2.524 | 31.897[a] | .000 | .355 |
| Error time | 7.969 | 100.688 | .079 | | | |

[a] Greenhouse-Geisser correction

**Table 3** The health literacy, self-efficacy perception, self-care behaviour, FBS, and HbA1C of the experimental group compared among the T1, T2, and T3 pairs using the Bonferroni method

| Variable/ Time | $\overline{X}$ | Mean Difference | | |
|---|---|---|---|---|
| | | T1 | T2 | T3 |
| Health literacy | | | | |
| T1 | 1.876 | - | -1.541* | -1.471* |
| T2 | 3.418 | - | - | .069 |
| T3 | 3.347 | - | - | - |
| Self-efficacy | | | | |
| T1 | 2.147 | - | -1.300* | -1.244* |
| T2 | 3.447 | - | - | .056 |
| T3 | 3.391 | - | - | - |
| Self-care | | | | |
| T1 | 3.160 | - | -.712* | -.678* |
| T2 | 3.871 | - | - | .033 |
| T3 | 3.838 | - | - | - |
| FBS | | | | |
| T1 | 166.133 | - | 39.433* | 39.266* |
| T2 | 126.700 | - | - | -.166 |
| T3 | 126.866 | - | - | - |
| Hba1C | | | | |
| T1 | 7.555 | - | .608* | .588* |
| T2 | 6.946 | - | - | -.020 |
| T3 | 6.967 | - | - | - |

## 5. Discussion

The research findings suggest that the web-based application effectively improved health literacy, self-efficacy, self-care, fasting blood sugar, and levels of HbA1C to achieve glycaemic control. Furthermore, the web-based application demonstrates durability, indicating that it not only develops health literacy, self-efficacy, self-care, FBS, and HbA1C in the initial stages but also helps the elderly achieve long-term excellent outcomes.

### *Health Literacy*

The web-based application group had a higher level of health literacy (66.5%) than the control group, probably because the group experienced regular daily use of the web-based application, with an average length of 30 minutes a day, and participated in activities such as reading, learning from video media, playing games, and answering questions in various formats. As the group developed personal health literacy, it was possible to bring both self-benefit and advice to others. The group also cultivated self-management skills that enable the elderly to pursue goals and plans while also allowing them to assess, adjust, and regulate their actions to manage blood sugar levels effectively. Consistent and ongoing utilization ensures that they do not forget the information and allows for the development of a wide range of abilities that result from acquiring knowledge, gaining experience, and engaging in regular training. During the T3 period, there was no difference in health literacy. Consistent with a previous study's findings, the use of a web-based application to promote health literacy made it

accessible to diabetic patients, who were then able to decide to use the health information to individually develop good health behaviour benefits for themselves (Saedkong et al., 2020), and the outcomes of the awakening development programme also caused the trial group average to increase with regard to health awareness in the post-trial period. Furthermore, the influence of the programme was found to affect the health consistency of the patients with type 2 diabetes (Chiangkhong, Duangchan, & Intarakamhang, 2017).

***Self-efficacy***

The experimental group using the web-based application had a higher performance perception (59.3%) than the control group, possibly due to internal web applications that have been developed using the self-efficacy theory (Bandura, 1986) to build confidence in their ability to change behaviour (Bandura, 1997) . When the experimental group completed the training in expressing anxiety and expectations, reflecting on results, learning models from prototype videos of individuals suffering from diabetes, discussing healthcare practices, adjusting health behaviours, and answering questions, it ensured that the experimental group could control their eating habits, assured themselves of their ability to choose the best way to exercise that suits themselves and their illnesses or perform adequate physical activities, and assured them of the aptitude to take their medication appropriately.

During the T3 period, the findings of their performance perception analysis indicated a decrease; however, this decrease was not statistically significant. The self-assurance of the individuals fluctuated depending on the specific situations in which they had taken action. During the use of the online web-based application, the trial group gained experience and assessed their competencies based on prior activities. In addition to the average score during the follow-up period, the experiments demonstrated persistent confidence in their capacity to regulate nutrition and exercise as well as firmly believe that discontinuing the medication on one's own should be avoided. As a result, there were no discrepancies in the performance evaluations. According to the findings of the study on their performance cognition programme, it was discovered that patients with type 2 diabetes experienced heightened self-awareness after completing the trials. In addition, individuals were able to manage their weight and regulate their blood sugar levels (Gilcharan Singh et al., 2020).

***Self-care Behaviour***

The experimental group had 32.6% higher self-care behaviours than the control group, which may have been the result of internal use of the web-based application. The experimental group also had increased self-care behaviour, resulting from the self-assessment practices in stress management, exercise, eating, and use of medication. In the practices, some behaviours that were regularly practiced and some behaviours that could not be practiced were identified. Also, patients could study the guidance on proper behavioural practices, practice following this guidance, conduct follow-ups, and read feedback after reporting correct self-care behavioural records through the web-based application. During the T3 period, self-care behaviour analysis results may have been lower, but they were not statistically different from those of the post-experimental stage. This may have occurred because activities within the web-based application are characterized by learning and recording behaviours, whereas if no web-based application is used for tracking health records, some behaviours become less practical. Consistent with other research findings, the trial group had higher average behavioural scores than those recorded before the experiment. Blood glucose levels were lower than those recorded before the experiment and were significantly lower than the control group statistically ($p<.001$) (Potipak et al., 2017). Furthermore, the study found higher levels of self-caring behaviours and self-awareness after participating in the research (Shaban et al., 2024).

***FBS and HbA1C***

The experimental group using the web-based application had FBS levels that were 30.9% lower than the control group and HbA1C levels that were 26.6% lower than the control group. The experimental group aimed to manage blood sugar levels by focusing on both fasting blood sugar (FBS) and blood sugar accumulation (HbA1C). These goals were achieved via use of the web-based application created by combining health literacy, self-efficacy perception, self-care behaviour, FBS, and HbA1C, the variables that influence health outcomes. The research consistently shows that patients with a greater level of health literacy experience favourable health outcomes when there is a strong connection between their health consciousness, interactions, and reviews ( Ishikawa, Takeuchi, & Yano, 2008). In addition to the linkage of the variables in the web application development, web application performance indicates that the trial

groups using the web-based application had higher health consciousness. In this study, their performance in health literacy, self-efficacy perception, and self-care behaviour compared with the non-use group reached 66.50%, 59.30%, and 32.60%, respectively, as a result of the development of higher health awareness after using the web application, which can be linked to a higher perception of their own performance and self-care conduct in the trial group. Thus, it may be considered to have an impact on blood sugar levels.

This is consistent with the results of causal analysis, which found that health care affects blood glucose levels, with self-care behaviours acting as a transmitter (Lee, Lee, & Moon, 2016). This is also aligned with the results of the development of health literacy to manage the health of the elderly with diabetes, which resulted in a better reduction in HbA1c levels than normal care. The experimental group had a higher level of health literacy than the control group, and the mean cumulative blood sugar level of the experimental group was significantly lower than that of the control group (Sriyasak et al., 2021). Furthermore, a study discovered that enhancing health literacy can effectively help with management of FBS and HbA1C to a greater extent compared to the pre-experiment period and the control group (Seesun & Panyasaisophon, 2021). Moreover, the findings of this study indicate that the web application had an impact on blood sugar levels in both categories of individuals. Despite its limited impact, the prevalence of diabetes among the elderly is primarily observed in the age group of 70–79 years, with a duration of illness ranging from 5 to 12 years. As a result, the pathology of the disease, combined with the degradation of the blood vessels in older age, prevents the body from effectively utilizing the sugar in the blood vessels. This results in higher than normal residual levels of blood sugar (Goyal, Singhal, & Jialal, 2024; Yanase et al., 2018). However, during the T3 period in this study, both blood sugar levels increased but were not statistically significant. This was because the experimental group still lacked health literacy. They were confident in their ability to control their diets and continued to eat well. Additionally, exercise and stress management were good; therefore, they presented sugar levels in the follow-up phase that were no different from the post-experimental stage. This is consistent with the performance studies of remote medical technology for managing type 2 diabetes, which found that the experimental group, using remote medical technology, accumulated and controlled blood sugar during fasting more effectively than the control group at a statistically significant level ($p<.05$) (Zhou et al., 2014). However, changes in blood sugar levels (FBS) and glucose levels (HbA1C), both in the post-trial period and follow-up periods, remained consistent with regard to the control of blood sugar.

Therefore, the web-based application that was developed as a tracking tool supported and helped older adults control their blood sugar more effectively. It reduced complications and enabled older people to continue to have a better quality of life. This is in line with the results of the literature review, in which it was found that health applications could be applied as worthwhile tools to help keep track of self-management support for type 2 diabetes (Saidi et al., 2023).

This research has limitations, which are: 1) Research participants provided information for the assessment of self-care behavior, which may lead to discrepancies or inaccuracies, such as incomplete recall of information or documentation of behavior that is better than reality. Therefore, to ensure the accuracy of the data reported by the research participants, future studies should design the behavior assessment to compare data from multiple sources, including doctors and caregivers. 2) Since elderly individuals need to use web applications, some may have more experience and proficiency than others. Those with less experience or skill may find it more challenging to use, which could lead to unequal benefits. Therefore, in future studies, it is essential to assess the level of technological competence and categorize users for planning and support based on their needs.

## 6. Conclusion

The results of this study show that web-based applications are both useful and long-lasting for improving patients' health literacy, enhancing their self-efficacy and self-care behavior, and controlling their blood sugar levels during both the T2 and T3 periods. As a result, elderly people with type 2 diabetes can use web-based applications for glycaemic control in conjunction with taking medication according to their doctor’s treatment plan. In order to reduce possible complications, healthcare professionals may use web-based applications in conjunction with their treatment plans. Moreover, the Ministry of Public Health can leverage data, procedures, and activity to improve or create patient care policies that support the future use of health technology. Moreover, the ability of patients

to regulate their blood sugar levels in order to prevent problems, thereby enhancing their quality of life, can alleviate the responsibility of caregivers and family members in nurturing senior individuals. This includes a reduction in the workload and expenditure of public health resources.

## 7. Conflicts of Interest

There are no conflicts of interest among the researchers. The study findings were obtained through an objective and unbiased research process.

## 8. Acknowledgements

The researchers would like to express their gratitude to Rajabhat Rajanagarindra University for providing a research grant. Additionally, they extend their appreciation to all of the participants for their willingness and cooperation in contributing valuable information to this research study.

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