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DEVELOPMENT, VALIDITY AND RELIABILITY OF WEB-BASED EDUCATION PROGRAMS AND DIABETIC SELF-EFFICACY MANAGEMENT INSTRUMENT AMONG TYPE 2 DIABETES MELLITUS PATIENTS IN PUBLIC HOSPITAL

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Development, validity and reliability of web-based education programs and diabetic self-efficacy management instrument among type 2 diabetes mellitus patients in public hospital

ABSTRACT

Due to an unsuitable patient environment factor and suboptimal preferred information sources for type 2 diabetic mellitus patients, web-based education programs Diabetic-N-Care was generated as a moderator for diabetic self-efficacy management (DSEM), as well as an alternative approach for face-to-face education. The study was based on three objectives, the development of web-based education programs, the validity and reliability of Diabetic-N-Care and DSEM questionnaire. This web-based education program on

DSEM, developed based on Kurt Lewin's model of change theory (1947) and self-efficacy theory (1977), involves three phases of behavior change. SPSS-v25 software was used for analysis of Content Validity Index (I-CVI), Cohen Kappa Index (CKI), and exploratory factor analysis (EFA). The analyzed results have shown, CKI=0.78 and a value of I-CVI > 0.79, which shows significant agreement. Meanwhile, EFA and Cronbach's alpha tests were performed, where there are five components in DSEM, 15 items explaining 73.0% of the variance in the pattern of relationships among the items. Five components had high reliability (α =.57 – α =.95). This shows that these web-based education programs and DSEM questionnaire have a high value against validity and reliability tests.

Keywords: *Web-Based Education, Face Validity, Content Validity, Exploratory Factor Analysis, Reliability*

1.0 Introduction

Technology offers accessible support for educational interventions to improve health outcomes for Type 2 Diabetes Mellitus (T2DM) patients, but its use still needs to expand (Zuhaida et al., 2021). T2DM has become a global challenge and reached alarming levels with technological development. Several factors have contributed to T2DM and caused metabolic disorders with various complications (Hameed et al., 2015).

According to statistics, the Asian population has been diagnosed with diabetes as early as 18 years old (Hu, 2011). Most future cases of T2DM will occur in developing countries such as India and China. These countries will contribute to 85%–90% of T2DM cases, compared to only 10%–15% for Type 1 Diabetes Mellitus (T1DM) (Fagninou et al., 2019). The Second National Health and Morbidity Survey showed that, in 2010, more than 3.4 million Malaysians were diagnosed with T2DM. This number represents about 11.8% of the total population in Malaysia. By 2020 and the following year, there will be a sudden increase of 4.5 million cases (dan Analisis, J. P. K., 2018). Multiracial harmony in Malaysia, in terms of customs and culture, is a factor. These cultural practices and existing factors have influenced the T2DM problem (Hussein et al., 2015). The complications often associated with T2DM significantly increase the risk of cardiovascular disease. Cardiovascular disease accounts for 35% of the total deaths in Malaysia (dan Analisis, J. P. K., 2018). The rate is 1.5–2.5 times higher than in the general population, which can cause a decrease in life expectancy among T2DM patients (Fagninou et al., 2019).

Previous researchers believed that the application and combination of Kurt Lewin's model of change theory (1947) and self-efficacy theory by Albert Bandura (1977) can increase motivation to change to increase life goals (Hidrus et al., 2020; Hurst, Rakkapao, & Hay, 2020; Khademian, Ara, & Gholamzadeh, 2020; Lee et al., 2015).

Low knowledge and confidence in self-treatment for diabetes management (Sari et al., 2020) can reduce self-efficacy, which in turn impacts self-care behavior among T2DM patients. Current methods of communicating self-efficacy are insufficient and lead to education rejection (Karimy, Koohestani, & Araban, 2018; Nguyen, Jiang, & Poo, 2015). Conventional education interventions have not achieved desired outcomes because

they lack theoretical reform (Jiang et al., 2019). To address this, web-based education programs have been introduced to strengthen core diabetes self-management skills, diet, physical activity, glucose monitoring, medication, and foot care through diabetic self-efficacy management (DSEM).

This transformation to web-based use reflects the increasing use of smartphones, especially among individuals aged 30-49 years old. This shift is a strong factor identified for implementing educational technology-based interventions as a new initiative in health care (Al Raimi et al., 2022). These developments began when the pandemic hit, triggering technological changes and closing past digital gaps such as digital poverty, poor access to technologies, and poor digital literacy (Gopika & Rekha, 2023; Khunti et al., 2022). Faster delivery of information tailored to individual needs also addresses the limitations of conventional education in the past. This improvement directly supports self-efficacy, which is a key predictor of changes in self-care behaviour among T2DM patients (Dehghan et al., 2017; Lee, Lee, & Chae, 2020; Sarkar, Fisher, & Schillinger, 2006).

Therefore, it is important to understand the factors that affect the management of T2DM in the long term by knowing the driving factors for behavior, such as self-efficacy management. The health education model based on web-based technology, Diabetic-N-Care, was built to increase self-efficacy and change self-care behavior among T2DM patients.

Researchers have adapted Kurt Lewin's change theory model (1947) as a whole to form a web-based education program. They applied the self-efficacy theory (1977) to the change phase of Lewin's model. This aims to develop a conceptual framework describing the relationship between DSEM and diabetes management elements: diet, physical activity, glucose level, medication, and foot care. Promoting self-efficacy in the change phase is a cognitive process that builds confidence to learn new behaviors. These behaviors affect the ability to improve future events (Farley, 2020) and are determinants of quality of life (Wu et al., 2016).

Figure 1 presents the conceptual framework for this study, beginning with the development and use of the web-based education program Diabetic-N-Care. The change process includes three main phases: Unfreeze (Input), Change (Process), and Freeze (Output). Finally, the study measures changes in the self-efficacy of T2DM patients using the adapted DSEM questionnaire.

This study aims to develop and test the validity and reliability of the web-based education program Diabetic-N-Care and the DSEM questionnaire among T2DM patients at Hospital Sultanah Nur Zahirah (HSNZ), Kuala Terengganu.

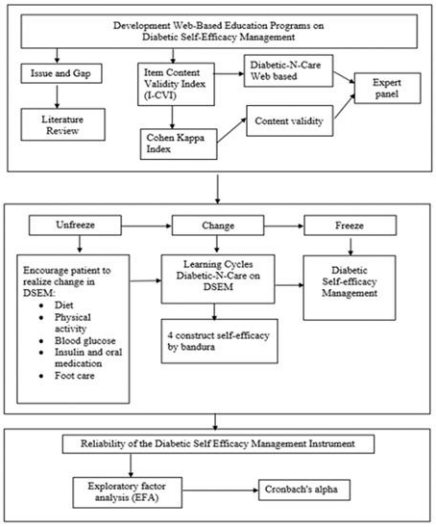

Figure 1: Illustration of conceptual framework of the research

2.0 Methodology

The Statistical Package for Social Science Version 25.0 software (SPSS-v25) was used for this study's quantitative approaches. This study employs three phases of change, namely unfreezing (pre-intervention), change (intervention), and freeze (post intervention), based on Kurt Lewin's change theory model (1947) and self-efficacy theory (1977). Meanwhile, web-based education Diabetic-N-Care, was a medium for education based on web technology.

Pre-Intervention

The unfreeze phase (Input), which is the first phase, was where the survey assessment was done. This is supported by the research problem identified through a review of relevant literature and existing knowledge among T2DM patients. During this phase, T2DM patients also received initial introductory exposure to this web-based educational program.

Intervention

The second phase of the change (Process) was where the web-based education program Diabetic-N-Care was put into practice according to the elements set out in this study. This phase provides advantages by applying four self-efficacy constructs by Bandura, namely, performance outcomes, vicarious experiences, physiological feedback, and verbal persuasion. For this change process, the first change starts with the process of thinking and belief, and will be interpreted as practice and behavior. Among the elements

of DSEM that are emphasized for the change phase are diet management elements such as knowledge of the importance of confidence in dietary control outside the home, confidence in not being influenced by peers, and reading labels on packaged foods that give confidence in nutrition management.

Post-Intervention

The freeze phase (Output) was the final phase in the web-based education process of the Diabetic-N-Care program. In this phase, we evaluated the program's impact using statistical analysis to measure outcomes.

We calculated the validity of the Diabetic-N-Care web-based education program using the Item-Content Validity Index (I-CVI) based on feedback from five diabetes management experts. We also used the Cohen Kappa Index (CKI) with input from two experts. Additionally, exploratory factor analysis (EFA) and Cronbach's alpha were performed for the five subscales in DSEM. The reliability test included T2DM patients from the Orthopedic department of HSNZ Kuala Terengganu. We applied purposive sampling to select a representative sample and avoid irrelevant responses (Oribhabor, & Anyanwu, 2019).

3.0 Results

Content Validity web-based education

Item Content Validity Index (I-CVI)

The evaluation scale for content validity was four scales, from scale 1 (not relevant) to scale 4 (very relevant). Five professionals in the field of diabetes care were purposefully selected for their relevant expertise, consisting of a lecturer (1), an orthopedic doctor (1), and diabetes nurse educators (3). Based on the I-CVI value, approaching 1 should be obtained for three to five experts (Polit, & Beck, 2006) and values range from 0 to 1 where I-CVI > 0.79, the item is relevant, and < 0.79, the item needs revisions, and if the value is < 0.70, the item is eliminated (Zamanzadeh et al., 2015). This opinion has been taken into account and shows the results of evaluation from experts showing I-CVI values of 0.92 (Table 1) and 0.88 (Table 2) for this web-based education program. This shows that this research program was relevant to be implemented.

Table 1: Validity of the web-based education program Diabetic-N-Care

Items	Professionals					I-CVI average
	1	2	3	4	5	
Accuracy of constructing	1	1	1	1	1	1
Study instrument format	1	1	1	1	1	1
Clarity of meaning of each item	0	1	1	1	1	0.8
Appropriateness of language used	1	1	1	1	1	1

Appropriate font size	1	0	1	1	1	0.8
Clarity about the instructions given	0	1	1	1	1	0.8
Use of writing distance	1	1	1	1	1	1
Instructions for measurement scale	1	1	0	1	1	0.8
Clarity of instrument objectives	1	1	1	1	1	1
Correct spelling	1	1	1	1	1	1
I-CVI value	**0.8**	**0.9**	**0.9**	**1**	**1**	**0.92**

Table 2: Table 2- Content validity of the web-based

Items	**Professionals**					**I-CVI average**
	1	**2**	**3**	**4**	**5**	
Objective	1	1	0	1	1	0.8
Understanding what T2DM is	1	1	1	1	1	1
Management of T2DM:						
Balanced food intake	1	1	1	1	1	1
Medication compliance	1	1	1	1	1	1
Exercise	1	1	1	1	1	1
Physical Examination	1	1	1	1	1	1
Mental management	0	1	0	0	1	0.4
Adherence to appointments	1	1	1	1	1	1
Complications you need to know	1	0	1	1	1	0.8
I-CVI value	**0.8**	**0.8**	**0.7**	**0.8**	**1**	**0.88**

Therefore, the use of I-CVI to measure content validity has a weakness in terms of inflated value, which is due to the possibility of mutual agreement (possibility of chance agreement). The Cohen Kappa Index (CKI) calculation needs to be taken into account to eliminate random chance agreement (Shrotryia & Dhanda, 2019).

Cohen Kappa Index

This study used the Cohen Kappa Index (CKI) analysis to evaluate the degree of agreement between two experts on this web-based education: one expert in orthopaedics, assessing the clinical/medical content, and one expert in multimedia, evaluating the digital and usability aspects. The usability and content validity of the web-based education were examined using a 10-item evaluation form. A Likert scale of 1 (disagree) to 4 (strongly agree) was used to represent each expert's agreement score. The data obtained were analyzed using SPSS-v25 software and showed a value of CKI=0.78. According to Altman (1990), this value indicates a very good significant agreement, and therefore was considered to demonstrate high validity, making the instrument suitable for this study.

Reliability of the Diabetic Self-Efficacy Management Instrument

The Diabetic Self-Efficacy Management Instrument for this study was adapted, and changes were made in terms of sentence structure according to the suitability of this study population in terms of cultural factors (Sangruangake, Jirapornkul, & Hurst, 2017). Therefore, reliability testing is important to see high internal consistency to obtain stable and consistent results (Taherdoost, 2016). The researcher also explores instruments from past studies to improve and adapt the study. This questionnaire requires T2DM patients to determine their level of confidence throughout this web-based learning process. This questionnaire contains three parts, namely Part A related to demographic data of T2DM patients, Part B related to clinical data, and Part C related to DSEM using a Likert scale of 1 (Not sure) to 2 (Very sure). A total of 15 items were constructed and divided into 5 subscale domains for the DSEM. The number and division of DSEM are described in Table 3.

Table 3: DSEM Subscale Domains

Variable	Subscale	Item
DSEM	Diet management	5
	Physical activity management	3
	Blood glucose control	2
	Insulin and oral medication management	3
	Foot care management	2
	Total	**15**

Table 4 shows the normality test of the data distribution on the questionnaire aimed at determining the normality of the data. The table shows the findings of the Kolmogorov-Smirnov and Shapiro-Wilk analysis, which means that the data distribution is normal ($p > 0.05$). This result shows that this data meets the factorability requirement to perform factor analysis.

Exploratory Factor Analysis (EFA) for DSEM questionnaire instrument

EFA analysis was performed on the DSEM questionnaire instrument using SPSS-v25 to find items and constructs with high and good validity by examining the factor structure of the assessed items. EFA is a statistical technique used to derive the set of uncorrelated variables (Cohen, 2005). EFA analysis has involved 65 T2DM patients under the Orthopedic department of HSNZ Kuala Terengganu, and can be considered significant with the loading factor set to be >0.5 (Hair et al., 2009; Stevens, 2002).

At the initial stage, the DSEM questionnaire instrument has five categories and subscales of different domains, namely; Nutrition Management (5 items), Physical Activity (3 items), Blood Sugar Level Management (2 items), Medication Management (3 items), and Foot Care (2 items). The Table 5 has show the significant value of the Kaiser Meyer Olkin (KMO) test and Bartlett's Test of Sphericity of this study ($X^2 = 303.485$, df = 105, $p < 0.05$). The results have proven that these data meet the factorability conditions to perform factor analysis.

Total Variance Explained (TVE), as shown in the Table 6, shows the cumulative percentage of variance used in determining the number of components related to the questionnaire instrument. For the study of health science and information technology, 70% of the cumulative percentage of the total variance is explained by the factors retained in identifying the number component (Venkatesh, Thong, & Xu, 2012). The Table 6 has show the results for the Total Variance Explained for the DSEM questionnaire, the total cumulative frequency is 73.006% which exceeds the 70% value that has been set.

Generally, in research, scree plots are used to identify the number of factors or components for retention (Zainuddin et al., 2021). The scree plot in Figure 2 shows that the first four columns show that the eigenvalues just above the next factor are almost flat until the last factor because the eigenvalues are decreasing. This shows that four factors can be maintained in this analysis.

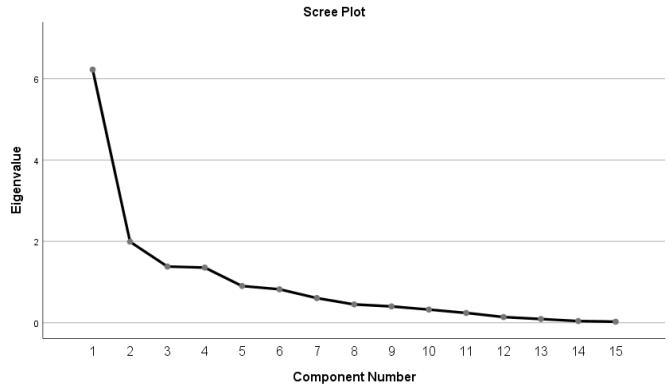

Figure 2: Scree plot diagram

Table 7 shows the factor loading for each item in each component and the number of items in each component that have been successfully extracted. It was found that the

number of items per component meets the recommendation from Pallant (2005), which is a minimum of three items to explain one component or factor. Stevens suggested factor loading values greater than 0.4 for interpretation purposes, while Hair et al. argue that all standardized factor loadings are between 0.5-0.7. This is because a value over 0.5 is considered very good practically in determining the factor in a measurement scale. Overall, the factor loading for each item is in the range of 0.568 to 0.974, therefore, no questionnaire should be dropped from this study.

Table 4: The normality test

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
DSEM	.133	30	.188	.942	30	.100

a. Lilliefors Significance Correction

Table 5: Value of the Kaiser Meyer Olkin (KMO) test and Bartlett's Test of Sphericity

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.602
Bartlett's Test of Sphericity	Approx. Chi-Square	303.485
	df	105
	Sig.	.000

Table 6: Results of Number of Components and Total Variance Explained DSEM questionnaire

Total Variance Explained						
Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.222	41.479	41.479	3.760	25.064	25.064
2	1.992	13.279	54.758	2.998	19.985	45.049
3	1.381	9.208	63.966	2.273	15.150	60.200
4	1.356	9.040	73.006	1.921	12.806	73.006

Extraction Method: Principal Component Analysis.

Table 7: Rotated Component Matrix

Item	Factor			
	1	2	3	4
Diet management				
I can choose to eat good and healthy foods that are beneficial to my health	.587	-	-	-
I am sure I can maintain my diet when attend parties.	.787	-	-	-
I follow the recommendations of nutritionists and nurses.	.724	-	-	-
Reading labels on packaged foods gives confidence in nutrition management	.645	-	-	-
Self-cooking gives me a chance to stay healthy	.528	-	-	-
Physical activity management				
I can control my body weight and maintain appropriate weight ranges.	.925	-	-	-
In the case that I exercise more, I can modify my healthy diet plan.	.907	-	-	-
I am confident that by doing exercise I can do glucose management	.660	-	-	-
Blood glucose control				
I can check blood glucose levels by myself if necessary.	-	.858	-	-
I can do a self-blood glucose assessment according to doctor recommendations.	-	-	.568	-
Insulin and oral medication management				
I can take medication as prescribed, observing dosage and time regularly.	-	-	.621	-
I can apply insulin using correct technique.	-	-	-	.822
I confident diabetic treatment does not interfere with my daily routine.	-	-	-	.861
Foot care management				
I can do foot examinations at any time without assistance	-	-	-	.881
I can keep my feet clean without help.	-	-	-	.974

Cronbach's alpha after exploratory factor analysis (EFA)

After the EFA analysis was done and a value on the DSEM instrument was obtained, it has high reliability to prove that this questionnaire successfully measures the aspects that should be measured in this study. A total of 30 T2DM patients underwent a pilot study to obtain Cronbach's alpha value. Cronbach's alpha reliability analysis was done to show an indication of internal consistency (Lee et al., 2015). Each of the five DSEM subscales shows Cronbach's alpha values ranging from α =.57 to α =.95 and a total α =.88. This shows that all items under each construct provide high reliability values, indicating that all items are acceptable and suitable for use in the study. The reliability coefficient values for each construct and as a whole are shown in Table 8.

Table 8: Reliability Coefficient Value of DSEM Instruments

Subscale	**Item**	α	**Internal Consistency**
Diet management	5	.81	Good
Physical activity management	3	.85	Good
Blood glucose control	2	.95	Excellent
Insulin and oral medication management	3	.57	Acceptable
Foot care management	2	.83	Good
Total	**15**	**.88**	**Good**

5.0 Discussion

The developing web-based education program Diabetic-N-Care was successfully developed and used during the extensive change process in Kurt Lewin's model of change theory (1947) and self-efficacy theory (1977) after going through the process validity and reliability test. In addition, reliability testing of the DSEM instrument was also carried out to see the effect on the measured variables involving the five elements in the DSEM. The results of the analysis obtained confirm that all the items are valid with good validity and reliability values to be used in conducting the study. Values indicate I-CVI > 0.79 as defined by Zamanzadeh et al. (2015) and the value of CKI = 0.78 according to Altmen (1991) shows a high expert agreement and a very good significant agreement. Meanwhile, the factor loading results for each item are in the range of 0.568 to 0.974 as set (Hair et al., 2009). In addition, the reliability value of the instrument shows a Cronbach's alpha value between α =.57 - α =.95, which is very good and effective.

Conclusion

In order to realize technology-based education, the use of web-based education is a shift to change that can help T2DM patients obtain information and perform self-treatment with more confidence. Consequently, Diabetic-N-Care was developed as an

innovation in T2DM health education. In order to ensure that the web-based education can be used repeatedly, the development of this web-based education must be done accurately and correctly in terms of validity and reliability in the field of T2DM treatment and multimedia. Furthermore, in order to measure the effectiveness of the web-based delivery, the instrument has gone through a reliability test to see that DSEM has included five elements (diet management, physical activity management, blood glucose control, insulin and oral medication management, and foot care management) that can provide a comprehensive effect through evaluation of T2DM patients.

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The study was conducted according to guidelines and approved by the Medical Research Ethics Committee of the Ministry of Health Malaysia (NMRR-NMRR-21-1446-59624/KKM/NIHSEC/P21-1403, approval date: 9 September 2021).

Author Contribution

Tengku Mohd Mizwar: Original Manuscript Preparation, Conceptualization, Methodology& Data Analysis. Aini Ahmad; Editing & Manuscript preparation. All authors read and approved the final manuscript.

Conflict of Interest

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission and declare no conflict of interest on the manuscript.

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