



# Transforming Diabetes Management: A Study on the Effectiveness of Smartphone Applications in Enhancing Knowledge, Attitudes, and Behavior of People with Diabetes Mellitus

Najib Budhiwardoyo, Mahendro Prasetyo Kusumo\*

Masters of Hospital Administration Program, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia

## Abstract

**Edited by:** Sasho Stoleski  
**Citation:** Budhiwardoyo N, Kusumo MP. Transforming Diabetes Management: A Study on the Effectiveness of Smartphone Applications in Enhancing Knowledge, Attitudes, and Behavior of People with Diabetes Mellitus. Open Access Maced J Med Sci. 2023 Oct 30; 11(E):388-393. https://doi.org/10.3889/oamjms.2023.11601  
**Keywords:** Application; Diabetes mellitus; Knowledge; practice, attitudes  
**\*Correspondence:** Mahendro Prasetyo Kusumo, Masters of Hospital Administration Program, Universitas Muhammadiyah Yogyakarta, Indonesia. E-mail: mahendro\_prasetyo@umy.ac.id  
**Received:** 14-Mar-2023  
**Revised:** 31-Mar-2023  
**Accepted:** 29-Apr-2023  
**Copyright:** © 2023 Najib Budhiwardoyo, Mahendro Prasetyo Kusumo  
**Funding:** This research did not receive any financial support.  
**Competing Interests:** The authors have declared that no competing interests exist.  
**Open Access:** This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0)

**BACKGROUND:** Smartphone-based applications are important for increasing knowledge, attitudes, and behavior in people with diabetes mellitus (DM).

**AIM:** This study was measuring the effectiveness of the smartphone-based Electronic-Muhammadiyah Chronic Disease Monitoring (E-MMCD) application to change knowledge, attitudes, and behavior in people with DM.

**METHODS:** This study used quantitative methods with an explanatory design. This study begins with a preliminary study using secondary data from international journals from 2020 to 2023. The sample size in the quantitative study was 84 people with DM. The sampling technique uses the randomized control trial with a computer machine. The instrument used to determine differences in knowledge, attitudes, and behavior after the intervention is a valid and reliable questionnaire. Paired t-test was used to determine the difference before and after the intervention.

**RESULTS:** The results of the normality test for the intervention group concluded that the distribution of knowledge data ( $p = 0.000$ ) and the distribution of attitude data ( $p = 0.000$ ) were not normal ( $p < 0.05$ ) so the statistical test used was the Wilcoxon test. While the practice in the intervention group after the normality test was carried out, the data distribution was normal ( $p > 0.05$ ), so the test used was the paired t-test. The results of the analysis test concluded that  $p = 0.019$ . This value indicates a difference in the average PSP before and after the E-MMCD intervention.

**CONCLUSION:** The E-MMCD application effectively changes the knowledge and attitudes of people with DM in hospitals. A longer E-MMC intervention is needed to improve the behavior of people with DM.

## Introduction

Diabetes mellitus (DM) is a non-communicable disease whose number continues to increase [1]. This disease causes high morbidity that causes a decrease in quality of life, especially in low- and middle-income countries [2]. Low knowledge about healthy living practice causes a higher risk of DM. The causes of DM are unhealthy eating patterns, lack of physical activity, tobacco use, and alcohol consumption [3].

In Indonesia, it was reported that in 2018, the prevalence of DM increased by 2% from 2013 [4]. The International Diabetic Federation (IDF) reported in 2021 Indonesia is ranked fifth with the highest number of DM, which is around 19.5 million [5], [6]. The high prevalence of DM in Indonesia is accompanied by various problems related to efforts to overcome it [7]. Diet patterns an important role in controlling blood glucose and preventing obesity. Regular consumption of drugs can also help patients control blood glucose [8].

Collaboration of health workers, patients, and families is very important to increase the success

of DM treatment. Education for patients and families is needed to understand the importance of healthy living practice to prevent complications [9]. Awareness about the prevention and control of DM disease is needed [10]. Health education is an important part of the DM management program. Knowledge, attitudes, and behavior are important factors in evaluating the results of health education in people with DM [11].

Education to patients and families about the prevention and control of DM to prevent complications needs to be done [12]. Lack of motivation is the main cause of low public awareness in preventing DM. This condition is the reason for not doing physical activity and controlling your diet regularly. High motivation is needed to implement healthy living practices. Patients will feel motivated after receiving education and sharing experiences to adopt a healthy lifestyle [13].

In the era of digital technology, innovations in Information Technology-based monitoring of people with DM have been developed to increase knowledge, attitudes, and practices for healthy living. The use of smartphone-based applications (mHealth) plays a role in the prevention and control of blood glucose [13]. The

previous research explained that providing education through video increases the knowledge of people with DM [14]. Education through short message service (SMS) can increase the knowledge of people with DM. The long-term benefit of this education is that it can improve hemoglobin A1C (HbA1c), low-density lipoprotein, cholesterol, blood urea nitrogen, and microalbumin levels in people with DM [15].

Each patient can carry out daily monitoring and treatment independently. The results of previous research explained that the Electronic-Muhammadiyah Chronic Disease Monitoring (E-MMCD) application can be used as a tool for monitoring healthy living behavior. This application is designed according to the needs and wishes of the patient. Patients can install and download the Google app for free. Patients who fill out survey data related to their health status will get an overview of their health condition. The patient will receive an initial assessment whether the condition in question is not at risk, is at moderate risk, or is at high risk. People with DM need to get recommendations to maintain or improve healthy living practices. The purpose of this study was to measure the effectiveness of the E-MMCD application in changing the knowledge, attitudes, and behavior of people with DM in hospitals.

## Methods

The research method used is quantitative methods with an explanatory sequential design. This design was carried out through six stages and the target population of this study was people with DM (Figure 1).

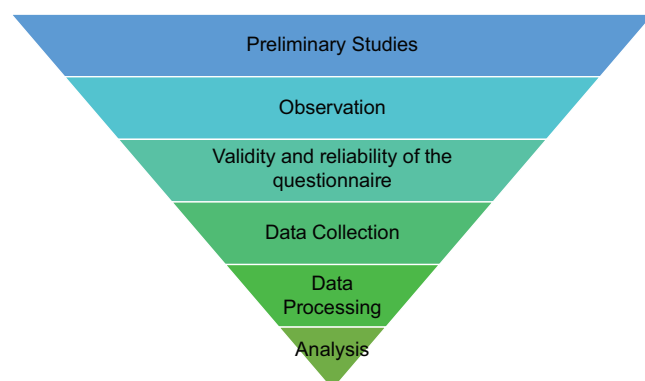


Figure 1: Study Stages

This study begins with a preliminary study using secondary data from international journals from 2020 to 2023. The next stage, researchers conducted observations to identify the problem of people with DM in the hospital. The researcher tested the validity and reliability of the instruments to be used. The questionnaire was prepared based on recommendations from endocrinologist and previous studies. Based on the result of the validity and reliability test, all questions

in the questionnaire were declared valid ( $p < 0.05$ ) and reliable ( $p > 0.6$ ). The next stage is data collection. Data collection was carried out using a questionnaire about healthy living behavior. Questionnaires were distributed to all samples in the control and intervention groups using the Google Form. This study involved people with DM without complications who routinely went to Aisyiyah Hospital. All samples stated that they agreed and were aware of participating in the research until it was completed.

The technique of determining the sample size was carried out by random control sampling (RCT). The RCT procedure is performed by randomizing numbers from 1 to 38. Every DM patient who is outpatient at the hospital before being examined by a doctor takes a lottery that has been randomized using a computer machine. The inclusion criteria for this study were as follows: (1) People with DM aged 18–60 years, (2) did not experience complications both microvascular and macrovascular, (3) had an Android-based smartphone that could be connected to the internet network, (4) accustomed to using smartphones independently, and (5) willing to be the subject of research until completion.

Pre-test was done in both groups before the intervention. The intervention group was given the E-MMCD application and face-to-face education, while the control group was given face-to-face education by doctors. The E-MMCD application intervention was carried out for 1 month. The sample sizes in the intervention group and the control group were 42 people with DM. During the intervention, there were two samples in the intervention group and two samples in the control group who dropped out. The next step is data processing. The data processed using Statistical Product and Service Solution application with normality test performed. If the data are normally distributed, data analysis is performed using paired t-test statistical test. The paired t-test statistical test was used to determine their difference in the mean of each group after receiving treatment. However, if the data are not normally distributed, an analysis is performed using a non-parametric test.

## Results

This study was conducted at Aisyiyah Hospital, Kudus Regency, Central Java, Indonesia. More than 30% of the total outpatients per day are dominated by people with DM.

Based on respondents' characteristics shown in Table 1, most of the intervention group was women (60.5%) with a junior high school education level (60%). In control group, the majority of people with DM were male (57.9%) with a high school education level (44.7%). The researcher determined the age limit

of the respondents, between 18 and 60 years old. The consideration for choosing this age is that, globally, the prevalence of DM in 2021 will occur in the age group 20–79 years as many as 536.6 million cases [6]. This estimate will increase to 783.2 million in 2045. Based on the gender of the study subjects, 51.3% (39 people) were female, and 48.6% (37 people) were male.

Based on the level of education, there are differences in the level of knowledge in the two groups. In control group, most of the respondents (50%) had a low level of education, 39.5% had a secondary education level, and 10.5% had higher education. While in the intervention group, most of the respondents had a high level of education (44.7%), 31.6% had low education, and 23.7% had secondary education.

Formal education is a structured and tiered education path consisting of basic education (elementary to junior high school), secondary education, and higher education (diploma and bachelor's degree) [16]. Differences in one's educational level can affect one's level of knowledge. The higher the level of education, the easier it is to receive and develop knowledge and technology. A good education will produce positive practice. This affects the attitude of openness and objectivity in receiving information, especially information about the management of DM.

The results of the normality test for knowledge, attitudes, and behavior of the control group showed that the data distribution was not normal based on the Shapiro–Wilk test ( $p < 0.05$ ). The intervention group for the knowledge and attitude normality test showed abnormal data distribution based on the Shapiro–Wilk test ( $p < 0.05$ ), while the behavior normality test showed normal data distribution ( $p > 0.05$ ) (Table 2). Statistical tests for abnormal data distribution use the Wilcoxon test, while normal data distribution uses the paired t-test.

Based on Table 3, the results of the post-test analysis in the control group showed that 16 patients had less knowledge, 18 patients had increased knowledge,

and four patients had no change in knowledge. In the attitude variable, 18 people had a less attitude, 19 people had an increased attitude, and one patient did not experience a change in attitude. In the practice variable, 12 patients had less good behavior than before. Nineteen people experienced an increase in good practice and seven patients did not experience a behavior change. The results of the Wilcoxon test for each variable obtained  $p = 0.296$  for knowledge, 0.756 for attitudes, and 0.099 for practice ( $p > 0.05$ ), meaning that there were no significant differences in the knowledge, attitudes, and behavior of the control group before and after the intervention in the form of monitoring carried out by hospital.

Based on Table 4, the results of the post-test analysis in the intervention group showed that six patients had less knowledge, 27 patients had increased knowledge, and five patients had no change in knowledge. The results of the Wilcoxon test obtained  $p = 0.000$  ( $p < 0.05$ ), meaning that there was a significant difference in knowledge between before and after being given the intervention through the E-MMCD application. These results also show a comparison of the attitudes of the intervention group before and after being given the intervention through the E-MMCD application. As many as one person had a less good attitude than before the intervention, 35 people had a better attitude before the intervention, and two people had a fixed attitude after the intervention. The Wilcoxon test results obtained a  $p = 0.000$  ( $p < 0.05$ ). This means that there is a significant difference in attitude before and after being given an intervention through the E-MMCD application.

In the behavioral variable, after being given the intervention, an average of 36.03 was found to experience an increase in behavior, meaning that there was a change in the practice of people with DM who received education through the E-MMCD application. The results of the paired sample t-test showed a significant difference in mean practice before and after education through the E-MMCD application, namely,  $p = 0.019$  ( $p < 0.05$ ) (Table 5).

Based on Table 6, there were significant differences in knowledge and attitudes between the control group and the intervention group using the E-MMCD ( $p < 0.05$ ). In the behavior aspect, there was no significant difference between the control and intervention groups ( $p > 0.05$ ). In this study, it can be seen that the level of education in the control group on the variables of knowledge, attitudes, and behavior has a  $p > 0.05$ . This

**AQ10** Table 1: Characteristics respondents

Criteria	Control group, n (%)	Intervention group, n (%)
Sex		
Male	15 (39.5)	22 (57.9)
Female	23 (60.5)	16 (42.1)
Total	38 (100)	38 (100)
Education		
Elementary education	19 (50)	12 (31.6)
Middle education	15 (39.5)	9 (23.7)
Higher education	4 (10.5)	17 (44.7)
Total	38 (100)	38 (100)

Source: Primary data, 2022.

**AQ10** Table 2: Normality test

Variable	Control group			Intervention group								
	Kolmogorov–Smirnov <sup>a</sup>			Shapiro–Wilk			Kolmogorov–Smirnov <sup>a</sup>			Shapiro–Wilk		
	Statistic	df	Significant	Statistic	df	Significant	Statistic	df	Significant	Statistic	df	Significant
Preknowledge	0.215	38	0.000	0.850	38	0.001	0.129	38	0.114	0.893	38	0.002
Postknowledge	0.165	38	0.010	0.913	38	0.006	0.262	38	0.000	0.818	38	0.001
Preattitude	0.159	38	0.016	0.956	38	0.139	0.203	38	0.000	0.847	38	0.001
Postattitude	0.202	38	0.000	0.942	38	0.048	0.377	38	0.000	0.730	38	0.001
Prebehavior	0.150	38	0.030	0.937	38	0.034	0.193	38	0.001	0.920	38	0.010
Postbehavior	0.145	38	0.042	0.900	38	0.003	0.101	38	0.200*	0.974	38	0.505

<sup>a</sup>This is a lower bound of the true significance, \*Lilliefors significance correction.

**Table 3: Analysis of control group data with Wilcoxon**

Wilcoxon rank	n	Mean rank	Sum of ranks	Asymptotic significant (two-tailed)
<b>Knowledge</b>				
Negative rank	16 <sup>a</sup>	14.74	236.50	0.295
Positive rank	18 <sup>b</sup>	19.92	358.50	
Ties	4 <sup>c</sup>			
Total	38			
<b>Attitude</b>				
Negative rank	18 <sup>d</sup>	18.39	331.00	0.756
Positive rank	19 <sup>e</sup>	19.58	372.00	
Ties	1 <sup>f</sup>			
Total	38			
<b>Behavior</b>				
Negative rank	12 <sup>g</sup>	13.67	164.00	0.099
Positive rank	19 <sup>h</sup>	17.47	332.00	
Ties	7 <sup>i</sup>			
Total	38			

Source: Primary data, 2022. <sup>a</sup>Postknowledge\_control < Preknowledge\_control, <sup>b</sup>Postknowledge\_control > Preknowledge\_control, <sup>c</sup>Postknowledge\_control = Preknowledge\_control, <sup>d</sup>Postattitude\_control < Preattitude\_control, <sup>e</sup>Postattitude\_control > Preattitude\_control, <sup>f</sup>Postattitude\_control = Preattitude\_control, <sup>g</sup>Postbehavior\_control < Prebehavior\_control, <sup>h</sup>Postbehavior\_control > Prebehavior\_control, <sup>i</sup>Postbehavior\_control = Prebehavior\_control

means that there are no significant differences in the aspects of knowledge, attitudes, and behavior based on the level of low, middle, and high education. Similar results were also obtained in the intervention group, where the knowledge, attitude, and behavior variables had  $p > 0.05$ . Most respondents already understand about DM, and they even understand what must be done to prevent complications. The problem is that they are lazy and don't know the right way.

**Table 4: Analysis of intervention group data with Wilcoxon**

Wilcoxon rank	n	Mean rank	Sum of ranks	Asymptotic significant (two-tailed)
<b>Knowledge</b>				
Negative rank	6 <sup>a</sup>	14.17	85.00	0.000
Positive rank	27 <sup>b</sup>	17.63	476.00	
Ties	5 <sup>c</sup>			
Total	38			
<b>Attitude</b>				
Negative rank	1 <sup>d</sup>	33.00	33.00	0.000
Positive rank	35 <sup>e</sup>	18.09	633.00	
Ties	1 <sup>f</sup>			
Total	38			

Source: Primary data, 2022. <sup>a</sup>Postknowledge\_intervention < Preknowledge\_intervention, <sup>b</sup>Postknowledge\_intervention > Preknowledge\_intervention, <sup>c</sup>Postknowledge\_intervention = Preknowledge\_intervention, <sup>d</sup>Postattitude\_intervention < Preattitude\_intervention, <sup>e</sup>Postattitude\_intervention > Preattitude\_intervention, <sup>f</sup>Postattitude\_intervention = Preattitude\_intervention

Statistical tests in both groups were carried out directly to see differences in post-test scores in the intervention group and the control group using the Mann–Whitney test. The results obtained indicated that there were significant differences in knowledge and attitudes between the intervention group and the control group. This is indicated by the value of knowledge and attitude variables  $p < 0.05$ . In the behavioral variable, there was no significant difference between the intervention group that used the E-MMCD application and the control group that did not use the E-MMCD application ( $p > 0.05$ ).

## Discussion

The theory of the health belief model explains that to change behavior, patients must feel threatened

**Table 5: Analysis of intervention group data with paired t-test**

Variable	Mean (SD)		CI 95%		p
	Before	After	Lower	Upper	
Behavior	33.18 (5.061)	36.03 (4.309)	-5.186	-0.496	0.019

Source: Primary data, 2022. SD: Standard deviation, CI: Confidence interval.

by complications due to DM and believe in the benefits of taking action. Monitoring physical activity, controlling eating patterns, taking the medication regularly, seeing a doctor, and managing stress are interventions that are urgently needed to control glucose and HbA1c levels in people with DM. Methods that can be used to carry out these interventions can be done face-to-face, remote discussion, or a combination and can be done in groups or individually [17]. The results of study conducted on student explained that low knowledge, attitudes, and behavior about DM. This condition occurs because the education system that has been implemented does not focus on health literacy [18]. Health literacy is a person's access to obtain and understanding information about various basic health services to make decisions [19]. The role of health literacy is very important to improve health. This literacy can be trained through the skills in reading, listening, analyzing, making decisions, and the ability to apply them to specific health situations [20].

**Table 6: Differences in the knowledge, attitude, and behavior**

Rank	E-MMCD	n	Mean rank	Sum of ranks	Asymptotic significant (two-tailed)
Knowledge	Intervention	38	31.17	1184.50	0.003
	Control	38	45.83	1741.50	
	Total	76			
Attitude	Intervention	38	24.00	912.00	0.000
	Control	38	53.00	2014.00	
	Total	76			
Practice	Intervention	38	36.17	1374.50	0.357
	Control	38	40.83	1551.50	
	Total	76			

Source: Primary data, 2022. E-MMCD: Electronic-Muhammadiyah Chronic Disease Monitoring.

The World Health Organization reported that health literacy is one of the determining factors for one's health [21]. Implementation of people with DM monitoring through E-MMCD-based healthy lifestyle education is urgently needed. The results of this study help people with DM in monitoring their health conditions. People with DM need to increase knowledge, attitudes, and healthy behavior to reduce the risk of complications due to DM [22]. This study concluded that there were no significant differences in behavior of people with DM without E-MMCD intervention. This condition was caused by the limited intervention time for the E-MMCD application, which was only 1 month. It takes at least 3 months to change healthy behavior in people with DM. The doctor's limited time and the patient's fear of asking a doctor are the main problems. No social support also causes low healthy living behavior in people with DM.

Knowledge is obtained after sensing certain objects. Most people knowledge is obtained through the senses of sight and hearing [23]. The educational obstacle when consulting at a doctor's practice is the limited time for the consultation. There is no educational media that meets the needs of patients to gain knowledge about health which is also a problem for most people with DM. This situation will certainly worsen the health condition of people with DM in the future. The results of this study are in line with previous study that the level of knowledge and attitudes was low in DM sufferers before intervention using audio-visual media [24].



The results of this study also concluded that there were differences in the average knowledge, attitude, and practice of respondents before and after being given an intervention using the E-MMCD application. Education for DM patients through the E-MMCD application indirectly trains patients to regulate their physical activity, eating patterns, examinations, medication adherence, and spirituality in their daily life. Patients who routinely fill out their daily activities in this application will add to their knowledge, making it easier for patients to change their habits. When the patient's knowledge and awareness increases, the patient can gradually improve their lifestyle as expected. Based on the findings in this study, it can be seen that the E-MMCD application is effective in changing patient knowledge and attitudes.

This is in line with previous study on the effect of health education on the knowledge and attitudes of people with DM in the wound-healing process [25]. The use of SMS messages through mobile phones in people with DM is very effective. Mobile phones can be used as an educational medium for DM patients. Mobile phones play a role in improving the quality of services that require routine treatment, such as DM, hypertension, stroke, cancer, and heart disease. Health service providers must have the ability to take advantage of technological developments. The results of this study strengthen the results of the previous studies regarding the effectiveness of health services and costs in people with DM. Various health services can use this application by adapting to the environment. Smartphone equipped with voice and text messages can be used anywhere and anytime. This convenience is an opportunity to design and provide health service interventions according to the needs of the community [15].

There is a relationship between the level of knowledge and the behavior of preventing diabetic wounds. The higher the level of knowledge, the better the practice of preventing diabetic injuries. Behavior to prevent wound recurrence can be improved by attending lectures, direct caring experiences, and sharing between patients and patient families. This can be done by optimizing access to electronic media and social media [26]. The results of a similar study also found significant differences in the knowledge of people with DM before and after being given an intervention through the use of SMS [27].

This study shows that people with DM who are given the E-MMCD intervention experience increased knowledge and attitudes about healthy living behaviors. The E-MMCD intervention effectively changes the knowledge and attitudes of people with DM. Educational programs with group discussions can change the behavior of people with DM [28]. The use of the E-MMCD application requires a big commitment to report physical activity, healthy eating patterns, schedule to see a doctor, take regular medication, and patient spirituality every day.

### Limitation of the study

This study has limitations in terms of the duration of the intervention. Intervention should be carried out for a longer time, at least 3 months to find out changes in behavior in people with DM.

### Conclusion

The results of this study indicate that the use of the E-MMCD application is effective in changing the knowledge and attitudes of people with DM at Aisyiyah Hospital. Consistency in the use of the E-MMCD application is the key to success in increasing knowledge and attitudes about management of DM. Socialization is needed regarding the profile of the application and the benefits of the application for people with DM.

### Acknowledgment

We thank all people with DM, families, doctors, nurses and hospital leaders. We also thank Universitas Muhammadiyah Yogyakarta and Aisyiyah Hospital.

### References

1. Chand SS, Singh B, Kumar S. The economic burden of non-communicable disease mortality in the South Pacific: Evidence from Fiji. *PLoS One*. 2020;15(7):e0236068. <https://doi.org/10.1371/journal.pone.0236068> PMID:32702003
2. World Health Organization. Noncommunicable Diseases Country Profiles 2018. Switzerland: World Health Organization; 2018.
3. Kemenkes R. Survei Kesehatan Nasional Tahun 2020. Laporan Data Susenas. Jakarta: Kemenkes R; 2020.
4. Riskesdas T. Laporan Nasional RISKESDAS 2018. Jakarta: Badan Penelitian dan Pengembangan Kesehatan; 2019.
5. Kemenkes RI. Indonesian Ministry of Health Data and Information Center. Stay Productive, Prevent and Manage Diabetes Mellitus. 2020.
6. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, *et al*. IDF diabetes atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract*. 2022;183:109119. <https://doi.org/10.1016/j.diabres.2021.109119> PMID:34879977
7. Ogurtsova K, da Rocha Fernandes JD, Huang Y, Linnenkamp U, Guariguata L, Cho NH, *et al*. IDF Diabetes atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes Res Clin Behav*. 2017;128:40-50. <https://doi.org/10.1016/j.diabres.2017.03.024>

- PMid:28437734
8. Gillani AH, Islam FM, Hayat K, Atif N, Yang C, Chang J, *et al.* Knowledge, attitudes and practices regarding diabetes in the general population: A cross-sectional study from Pakistan. *Int J Environ Res Public Health*. 2018;15(9):1906. <https://doi.org/10.3390/ijerph15091906>  
PMid:30200534
  9. Mantas J. Knowledge, attitude and practice tools or health education among diabetic patients. *Inform Empowers Healthc Transform*. 2017;238:250.
  10. Yamaoka K, Nemoto A, Tango T. Comparison of the effectiveness of lifestyle modification with other treatments on the incidence of Type 2 diabetes in people at high risk: A network meta-analysis. *Nutrients*. 2019;11(6):1373. <https://doi.org/10.3390/nu11061373>  
PMid:31248094
  11. Murad M, Mahapatra R, Dantu R, Alenius MT. An mHealth Application to Promote Diabetes Self-care Behavior among Medically Underserved Population. Atlanta: Association for Information Systems; 2020.
  12. Bell AM, Fonda SJ, Walker MS, Schmidt V, Vigersky RA. Mobile phone-based video messages for diabetes self-care support. *J Diabetes Sci Technol*. 2012;6(2):310-9. <https://doi.org/10.1177/193229681200600214>  
PMid:22538140
  13. Goodarzi M, Ebrahimzadeh I, Rabi A, Saedipoor B, Jafarabadi MA. Impact of distance education via mobile phone text messaging on knowledge, attitude, practice and self efficacy of patients with Type 2 diabetes mellitus in Iran. *J Diabetes Metab Disord*. 2012;11(1):10. doi: 10.1186/2251-6581-11-10  
PMid:23497632
  14. Republic of Indonesia. Law of the Republic of Indonesia National Education System. Directorate of General Secondary Education. Jakarta; 2003.
  15. Akter F, Rashid SM, Alam N, Lipi N, Qayum MO, Nurunnahar M, *et al.* Knowledge, attitude and practice of diabetes among secondary school-going children in Bangladesh. *Front Public Health*. 2022;10:1047617. <https://doi.org/10.3389/fpubh.2022.1047617>  
PMid:36466517
  16. Boren SA. A review of health literacy and diabetes: Opportunities for technology. *J Diabetes Sci Technol*. 2009;3:202-9. <https://doi.org/10.1177/193229680900300124>  
PMid:20046666
  17. Liu C, Wang D, Liu C, Jiang J, Wang X, Chen H. What is the meaning of health literacy? A systematic review and qualitative synthesis. *Fam Med Community Health*. 2020;8(2):e000351. <https://doi.org/10.1136/fmch-2020-000351>  
PMID: 32414834
  18. Arbabi H, Mansouri A, Nooshirvani S. The relationship between health literacy and general health in patients with Type II diabetes referring to diabetes clinic of Zabol in 2016. *J Diabetes Nurs*. 2017;5(1):29-39.
  19. Mehrtak M, Hemmati A, Bakhshzadeh A. Health literacy and its relationship with the medical, dietary adherence and exercise in Patients with Type II diabetes mellitus. *J Health Lit*. 2018;3(2):137-44. <https://doi.org/10.22038/JHL.2018.32829.1003>
  20. Pakpahan M, Deborah S, Andi S, Tasnim M, Radeny R, Evanny M, *et al.* Promosi Kesehatan dan Perilaku Kesehatan. Indonesia: Yayasan Kita Menulis; 2021.
  21. Siswanto S, Kamba I, Aminah S. Differences in Knowledge and Attitudes of Diabetes Mellitus Patients Inpatients at Samarinda Islamic Hospital Before and After Nutrition Counseling Using Audiovisual Media. *Manuntung Scientific Journal*. 2016;2(1):8-14.
  22. Yunita Thresia Eleventina Siagian. Pengaruh Pendidikan Kesehatan Terhadap Pengetahuan Dan Sikap Pasien Diabetes Mellitus Dalam Proses Penyembuhan Luka Diklinik Asri Wound Care Center Medan Tahun. Indonesia: Yunita Thresia Eleventina Siagian; 2019.
  23. Juwariah T, Priyanto A. Relationship between level of knowledge and behavior to prevent recurrence of diabetic wounds. *Journal of Nursing and Midwifery*. 2018;5(3):233-240.
  24. Ridwan A, Barri P, Nizami NH. The effectiveness of diabetes self-management education via SMS on the knowledge of diabetes mellitus sufferers: a pilot study. *Idea Nursing Journal*. 2018;9(1):65-71.
  25. Kusumo MP, Rosa EM. Community empowerment model to improve healthy living behaviors in rural areas: Qualitative study. *Bali Med J*. 2021;10(3):1098-102. <https://doi.org/10.15562/bmj.v10i3.2839>
  26. Kusumo MP, Hendrartini J, Sufro ZM, Dewi FS. Theater performing arts (TPA): Community empowerment to improve blood glucose control behavior in Yogyakarta. *Int J Endocrinol Metab*. 2020;18(4):e103106. <https://doi.org/10.5812/ijem.103106> PMID:33613677
  27. Kusumo MP, Kusumawati W. Barriers to understanding health education in patients with diabetes mellitus (DM) in Yogyakarta: Qualitative study. *Unnes J Public Health*. 2022;11:14-22.
  28. Kusumo MP, Hendrartini J, Sufro ZM, Dewi FS. A qualitative study to explore the preception of patients towards diet in Javanese culture. *Enferm Clin*. 2020;30:183-7.