Available *online* at : http://ejurnal.upnb.ac.id/

Jurnal Kesehatan

| ISSN (Print) 2085-7098 | ISSN (Online) 2657-1366 |

DiaCal Mobile Application: A Pilot Study on Diabetes Risk Perception Improvement

Dita Hanna Febriani [1] , Scholastica Fina Aryu Puspasari [2]

[1]Department of Nursing, Sekolah Tinggi Ilmu Kesehatan Panti Rapih, Yogyakarta Indonesia

ARTICLE INFORMATION

Received: 14 January 2026
Revised: 28 May 2026
Accepted: 28 July 2026
Available online: 31 July 2026

KEYWORDS

Diabetes, diacal, mobile-application, risk perception.

CORRESPONDING AUTHOR

***Corresponding author, email:**

dhitahanna@gmail.com

ABSTRACT

Background: Diabetes is a metabolic disease characterized by hyperglycemia caused by defects in insulin action, insulin secretion, or both. Early identification of patients with undiagnosed T2DM or those at higher risk of developing T2DM is crucial. Mobile applications are believed to help individuals prevent type 2 diabetes and change their lifestyle habits. **Objectives:** The main objective of this study was to determine the preliminary effect of a diabetes risk calculator mobile application (DiaCal) on the perceived risk of diabetes score of residents in Mejing Lor Hamlet, Ambarketawang Village, Gamping, Sleman, Yogyakarta. **Methods:** The study was conducted using a one-group pre-test post-test design. The number of respondents involved was 50 respondents. Respondents were recruited using a purposive sampling technique. Risk perception survey for developing-diabetes (RPS-DD) used to collect the data. **Results:** The results of this study indicate a difference between the perception of diabetes risk in the pretest and posttest in respondents after being given the intervention ($p < 0.001$). **Conclusion:** An education intervention through Diacal was associated with an improvement of diabetes risk perception among the participants. Therefore, increased awareness of the risk of type 2 diabetes mellitus among the general population, accompanied by the adoption of healthy lifestyles, is critical for effective prevention**.**

INTRODUCTION

In type 2 diabetes mellitus (T2DM), insulin resistance—characterized by a diminished cellular response to insulin—impairs glucose regulation. Initially, this resistance is compensated by increased insulin secretion to maintain glucose homeostasis; however, over time, pancreatic β-cell function declines, leading to insufficient insulin production and the onset of T2DM (1). The prevalence of diabetes has increased over the past few decades. The International Diabetes Federation estimates that 588,7 million people will suffer from diabetes in 2040, and this number is projected to reach 852.5 million by 2050. Type 2 diabetes constitutes the predominant form of diabetes globally, representing over 90% of all diagnosed

DOI: http://dx.doi.org/10.35730/jk.v17i2.1591

cases. Indonesia is in the top 5 countries with the highest number of diabetes sufferers in the world, reaching 20,4 million people (2). The data from the Indonesian Health Survey showed that the proportion of types 2 based on doctor's diagnosis in the population of all ages in Yogyakarta reached 50.6% (3). It is estimated that 3 out of 4 people with diabetes in Indonesia (73.9%) are unaware of their condition (4).

Given the high costs and other negative impacts, there are many initiatives at the global and local levels to prevent the increasing prevalence of diabetes by promoting healthy lifestyles. These important approach to influencing lifestyle changes in the broader population includes population screening to identify people at risk (5). Early identification of patients with undiagnosed type 2 diabetes (T2DM) or those at higher risk of developing T2DM is crucial (6). A systematic review that synthesized 20 studies found that even though respondents had high risk of diabetes, they still rated their personal risk as low to moderated (7).Therefore, diabetes prevention strategies should emphasize the need to raise awareness of diabetes risk.

Many people use the internet to obtain information aimed at enhancing their understanding of personal health (8). In Asia, health information-seeking behavior among smartphone users in Asia is shaped by factors such as socioeconomic status, openness to technological innovation, and the frequency of smartphone usage (9). A Systematic Review and Meta-Analysis study found that smartphone applications show potential in the prevention of type 2 diabetes by facilitating weight loss (10). Preliminary evidence from a systematic review also indicates that health technologies aimed at diabetes prevention are effective in improving risk-related outcomes, including weight reduction, lower blood glucose levels, and decreased incidence of type 2 diabetes (11). Previous research found that smartphone-based education is effective in improving diabetes risk perception. Participants in the intervention group demonstrated greater knowledge of diabetes risk factors following the intervention, compared to those in the control group. Respondents with higher awareness of the benefits of chronic disease prevention behaviors and associated risk factors were more likely to adhere to preventive practices (12).

Risk calculator is a mobile application that is used to estimate the risk of desired outcomes in real time (5). In this condition, the risk calculator will not only identify how high a person is at risk of suffering from diabetes but also increase the perceived diabetes risk in that individual. Previously, we developed the mobile application namely Diabetes Risk Calculator (Diacal). This application aimed to simplify the early detection or screening for type 2 diabetes risk and provide educational information based on user’s diabetes risk score (13). Currently, in Indonesia, there are limited smartphone applications serving as educational tools aimed at enhancing diabetes risk perception among the general population. The main objective of this study was to determine the preliminary effect of the Diacal on the perceived risk of diabetes score in residents of Mejing Lor Hamlet, Ambarketawang Village, Gamping, Sleman, Yogyakarta. The second

DOI: http://dx.doi.org/10.35730/jk.v17i2.1591

objective was to determine the fasting blood glucose of the respondents after the intervention through DiaCal.

METHOD

This study is a one group pre-test post-test study to determine the preliminary effect of the diabetes risk calculator mobile application (DiaCal) on the diabetes perceived risk score and fasting blood glucose of the residents in Mejing Lor Hamlet, Sleman, Yogyakarta. The data collected in October to November 2022. A total of 50 respondents were recruited with purposive sampling. The inclusion criteria of the respondents were residents who do not suffer from type 2 diabetes mellitus with a minimum age of 18 years and who have a smartphone. Residents who were taking blood glucose control medication and had a history of psychosis or were diagnosed with a mental disorder were excluded from the study. Respondents who were willing to participate in the study were asked to complete the informed consent, a demographic data questionnaire and the Risk Perception Survey for Developing Diabetes (RPS-DD) questionnaire (14). Fasting blood glucose (FBG) of the all respondents were measure before they fill out the questionnaire. FBG levels were measured by the research team using a portable blood glucose meter and finger-prick capillary blood sampling. Participants were instructed to undergo an overnight fast of at least 8 hours before measurement. All measurements were performed following the manufacturer's operating instructions and standardized procedures for capillary blood glucose testing. After respondents completed the questionnaire, respondents were asked to install the DiaCal application. The American Diabetes Association (ADA) diabetes screening tool integrated in the Diacal to determine the risk score for developing type 2 diabetes of the respondents (15). Next, respondents fill out RPS-DD. Researchers summarized the diabetes risk score results for each respondent. Respondents were directed to read educational resources related to type 2 diabetes mellitus prevention through other features in the DiaCal app. The educational materials were tailored according the diabetes risk score of the respondents. The respondents classified as having low risk received education focusing on maintaining body weight, engaging regular exercise (3-5 times a week for 30-60 minutes), consume healthy food in balanced amounts, avoiding tobacco use and ensuring adequate rest. The respondents classified as having high risk received more comprehensive education including have regular medical check-ups, monitor blood glucose levels, maintain an ideal body weight, participate in exercise regularly (3-5 times a week for 30-60 minutes), discontinue smoking if the respondents smoke, avoid alcohol consumption, eat a healthy diet in balanced amounts, manage blood pressure and cholesterol, and ensure adequate rest (Figure 1). Participants were provided access to the DiaCal application and instructed to review the educational materials available within the DiaCaal over a two-week intervention period. To encourage engagement with the intervention, reminder messages were sent periodically throughout the study period. However, the DiaCal application did not include a usage-tracking feature;

DOI: http://dx.doi.org/10.35730/jk.v17i2.1591

therefore, the frequency of application use, duration of access, and adherence to reviewing educational materials were not objectively monitored. After 2 weeks, the respondents were asked to complete the RPS-DD again, and fasting blood glucose measurements were repeated to assess changes following exposure to the intervention. The Wilcoxon test used to analyze the data since the data not normally distributed. The ethical approval (IRB) obtained from STIKes Bethesda Yakkum Ethic Committee (IRB Number: No.150/KEPK.02.01/VIII/2022).

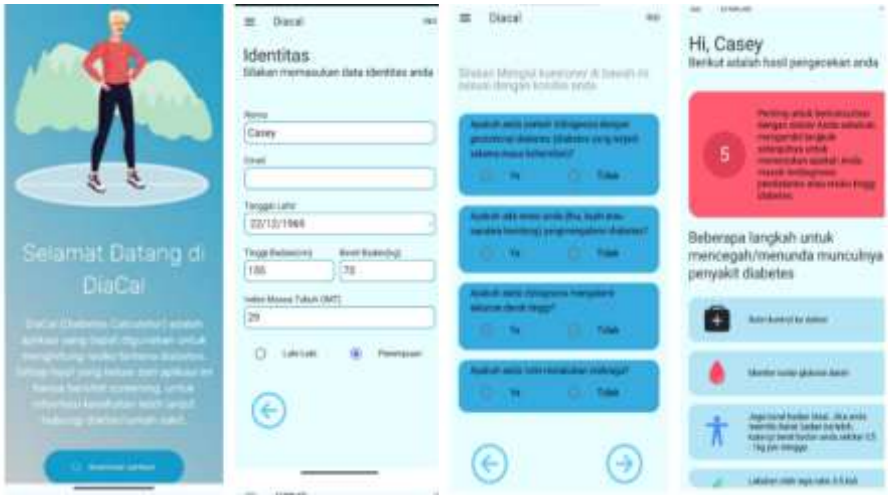

Figure 1. Diabetes calculator risk mobile application (DiaCal)

RESULTS AND DISCUSSION

Results

Characteristic of the respondents

The characteristics of the respondents are presented in Table 1. At the beginning of data collection, 55 respondents were willing to participate in the study. However, five respondents dropped out of the study due to moving to another city, working outside the city, or resigning. Therefore, only 50 respondents were included in the analysis. Table 1 shows that the majority of respondents were female (72%), had a high school education or less (82%), were non-smokers (94%), and had no family history of type 2 diabetes (88%). More than 40% of the respondents had a body mass index of overweight to obese. The average age of all respondents was 55.6 years.

DOI: http://dx.doi.org/10.35730/jk.v17i2.1591

Table 1. Respondents' Characteristic

Variable	Category	n	Percentage (%)
Gender	Male	14	28
	Female	36	72
Education	Unschooled	7	14
	Senior high school	41	82
	below	2	4
Cigarette consumption	Higher education	47	94
	No	3	6
	Yes	44	88
Family history of diabetes	No	6	12
	Yes	28	56
Body Mass Index	Normal	16	32
	Overweight	6	12
	Obese	40	84
Risk for diabetes	Low risk	10	16
	High risk		
Variable	Mean (SD)	Minimum	Maximum
Age (yeas)	55,26 (13.44)	30	84

Diabetes mellitus risk perception scores were measured using the RPS-DD. The interval between pre-test and post-test data collection was 2 weeks after the intervention. RPS-DD subscale scores and the total RPS-DD range from 1 to 4. Items and subscales were coded such that higher scores indicated greater personal control, greater worry, or greater optimistic bias per RPS-DD assessment domain (16). A Wilcoxon test analysis showed there were differences in pre-test and post-test scores on personal control, worry and optimistic bias subscales ($p < 0.05$). Similarly, the total RPS-DD score also showed a difference between diabetes risk perception in the pre-test and post-test (Table 2). These findings suggest that exposure to DiaCal was associated with improved diabetes risk perception among the participants. Table 3 showed that the fasting blood glucose decreased after 2 weeks intervention.

Respondents' Risk Perception in Developing Diabetes

Table 2. Respondents' Risk Perception in Developing Diabetes

N = 50

No	RPS-DD dan RPS-DD Subscale	Median Pretest (IQR)	Median Posttest (IQR)	*p*-value
1	Personal Control	2.75 (2.50−3.00)	3.00 (2.75−3.00)	0.033[a]
2	Worry	2.50 (2.00−3.00)	3.00 (2.50−3.00)	0.047 [a]
3	Optimistic Bias	3.00 (2.87−3.00)	3.00 (2.50−3.50)	0.021 [a]
4	Total RPS-DD	2.75 (2.58−2.92)	2.87 (2.67−3.17)	0.010 [a]

DOI: http://dx.doi.org/10.35730/jk.v17i2.1591

Respondents' Fasting Blood Glucose

Table 3. Respondents' Fasting Blood Glucose

N = 50

No	Variable	Median Pre-test (IQR)	Median Post-test (IQR)	*p*-value
1	Fasting blood glucose	98 (94.75−113.75)	92.50 (82−109.75)	0.003[a]

Note:
a = Wilcoxon Signed Rank Test

DISCUSSION

Characteristic of the respondents

At the start of data collection, 55 respondents were willing to take part in the research. However, five respondents dropped out of the study because they moved to another city, worked outside the city, and withdrew from the study. Therefore, only 50 respondents were included in the analysis. Based on table 2, it was found that the majority of respondents were female (72%), had an educational background of high school or below (82%), did not have a smoking habit (94%), and did not have a family history of type 2 diabetes (88%). The average age of all respondents was 55.6 years. Most of the respondents had low risk of type 2 diabetes mellitus (84%). Even though most of the respondents had low risk of type 2 diabetes mellitus, some characteristic of the respondents could be potentially factors that increase the risk of type 2 diabetes mellitus such as female, age and body mass index.

Study indicated that females may have a higher risk of developing type 2 diabetes mellitus (T2DM) compared to males. A study highlighted that sex-specific factors including body fat distribution, differences in insulin sensitivity, hormonal factor, could significantly elevate the risk of T2DM in female (17). As age increases, the risk of someone developing type 2 diabetes mellitus also increases. Several studies have consistently demonstrated that increasing age is a significant risk factor for the development of Type 2 Diabetes Mellitus (T2DM). A large registry study involving nearly 300,000 individuals and found that the prevalence of T2DM rose markedly with age, even among participants with normal body mass index (BMI). This indicates that aging independently contributes to diabetes risk beyond the influence of obesity (18). Aging process (oxidative stress, chronic inflammation and mitochondrial damage) leads to progressive insulin resistance and impair glucose regulation all of which heighten susceptibility to T2DM (19).

People who are overweight or obese have a significantly higher risk of developing type 2 diabetes mellitus (T2DM) due to multiple interconnected mechanisms identified in recent research. Excess body fat promotes insulin resistance by causing chronic low-grade inflammation, lipid accumulation in non-adipose tissues such as liver and muscle, and disruption of insulin signaling and pancreatic β-cell function(20), (21). When fat cells reach their storage capacity, they cause fatty acids to spill over into tissues not designed for fat storage, leading to lipotoxicity that interferes with normal insulin action, contributing to insulin

DOI: http://dx.doi.org/10.35730/jk.v17i2.1591

resistance. Additionally, obesity-related disturbances cause mitochondrial dysfunction in the liver with overproduction of reactive oxygen species, further exacerbating insulin resistance and diabetes onset. Adipose tissue's role as an endocrine organ is altered in obesity, affecting metabolism and increasing the risk of β-cell dysfunction. In obese individuals, insulin secretion is increased at rest and after food intake, but chronic overproduction can exhaust pancreatic β-cells, worsening glycemic control and predisposing them to T2DM. Evidence shows that up to 85% of adults with T2DM are overweight or obese, and losing 10-15% of body weight can reduce the risk of diabetes by half, emphasizing the critical role of weight management in prevention. Thus, excess adiposity drives metabolic changes, inflammation, and cellular dysfunction that collectively increase the risk of type 2 diabetes, making weight control a key strategy for diabetes prevention and management (22).

Respondents' Risk Perception in Developing Diabetes

Perception is widely recognized as a primary determinant of behaviour. Accordingly, individuals' perceived susceptibility to disease and their level of awareness regarding diabetes are thought to influence their motivation and preparedness to adopt healthier behaviors (23). In this research the respondents' risk perception was examine using the RPS-DD. The RPS-DD subscale scores and the RPS-DD total range from 1-4. Items and subscales are coded such that higher scores indicate more personal control, more worry, or greater optimistic bias per the RPS-DD assessment domain (16). From the Wilcoxon test analysis, the results showed that there was a difference in pretest and post-test scores on personal control, worry and optimistic bias subscales ($p < 0.05$). Likewise, the total RPS-DD score indicates that a difference between the perception of diabetes risk on the pretest and post-test (Table 2). These findings indicate that exposure to the DiaCal intervention was associated with improved in participants' perceptions of diabetes risk. The meta-analysis study also emphasizes that education is effective to increase respondents perception (24). The higher the perception of health risks, the more people can recognize the dangers and importance of health risks (25). Although diabetes risk perception improved following the intervention, the one-group pretest–posttest design does not permit causal inference. The observed changes may have been influenced by factors other than the intervention itself, including knowledge of diabetes risk factors, previous health experience, and access to information (7). Therefore, changes in diabetes risk perception observed during the study period may not be solely attributable to exposure to the DiaCal application and randomized controlled studies are needed to establish causality and determine the extent to which the intervention itself contributed to these changes.

This is similar to the results of previous research on groups of respondents with Gestational Diabetes Mellitus (12) and high school students (26), which stated that application-based education can increase risk perception in both groups of respondents. Increased perception of type 2 diabetes mellitus risk in the respondents of this study can change their lifestyle and result in preventive behaviour or adherence to prevention through increased sensitivity of the participants. This can reduce the prevalence of diabetes

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in the future. In addition, in this study, the optimistic bias score increased in the post-test. When situations are uncertain and risky, optimism is suggested to help people make better decisions. Optimism also affect belief updating and action selection, which can be beneficial for navigating a risky environment (27). Contrary, if optimistic bias exceeds a certain threshold, it can have negative consequences. It is characterized by individuals who underestimate personal health risks and refrain from exhibiting preventive health behaviors which potentially increase the risk of poor health outcomes (28).

The significant improvement in diabetes risk perception observed after the 2-week intervention is consistent with previous studies showing that risk perception can be modified shortly after educational interventions. A study on cardiovascular disease risk communication for type 2 diabetes patients found that the appropriateness of risk perception improved significantly at 2 weeks after the intervention, but the effect disappeared by 12 weeks. Patients appeared to recall their risk accurately only for a few weeks post-education, suggesting repeated communication during follow-up visits is advisable for lasting impact (29). Factors enhancing sustained risk perception include health literacy and emotional engagement such as fear of recurrence, which can strengthen motivation and health management awareness, but these effects are generally mediated and may decline over time without continuous support (30). In this research we also performed follow up 2 weeks after the intervention. The risk perception of the respondents may change after 2 weeks intervention. A qualitative study found that cues to action, such as social motivators and repeated health communication, are crucial to sustain risk perception and preventive behaviours in the long term, supporting the importance of reinforcement beyond the initial education (31). This highlights the importance of integrating periodic risk communication to maintain awareness and promote long-term behaviour change.

Respondent's fasting blood glucose

The fasting blood glucose of the respondents decreases after 2 weeks intervention ($p = 0.003$). This finding may suggest a favorable change in participants' glycemic status during the study period. However, the observed reduction in fasting blood glucose should be interpreted cautiously. The present study employed a one-group pretest–posttest design without a control group; therefore, the observed change cannot be attributed solely to the DiaCal intervention. Several factors that influence fasting blood glucose levels, including dietary intake, physical activity, sleep patterns, stress, and other lifestyle behaviors, were not monitored or controlled during the study period (32), (33), (34). Consequently, the contribution of these factors to the observed reduction cannot be determined.

Among all the respondents, ten respondents classified as having high risk to type 2 diabetes mellitus. Therefore, regular monitor allowed them to detect early change in blood glucose levels. Monitoring can reveal episodes of dysglycemia (either transient hyperglycemia or rising glucose trends) earlier than a single test, potentially providing an early signal for prompt preventive intervention and lifestyle modification (35).

DOI: http://dx.doi.org/10.35730/jk.v17i2.1591

Besides that, regular monitoring helps healthcare providers identify early detection of hyperglycemia in high risk people and adapt preventive interventions more quickly (36).

CONCLUSION

This study found an increase in diabetes risk perception and a decrease in fasting blood glucose levels following a 2-week intervention using the DiaCal application. This study only performed follow up after 2 weeks intervention, which may be insufficient to achieve sustained changes in perceived risk of diabetes. Future studies need to consider longer intervention durations and longer follow-up periods to better evaluate the sustainability of improved diabetes perceived risk and fasting blood glucose level.

AUTHOR CONTRIBUTIONS

Conceptualization, methodology, data collection, analysis, writing-original draft and editing and final approval of the manuscript (DHF). Writing-original draft and data collection (SFA).

ACKNOWLEDGEMENT

We extend our gratitude to Directorate General of Vocational Education, Ministry of Education, Culture, Research, and Technology, Republic of Indonesia who has funded this study

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