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Development and usability testing of diabetes risk calculator (diacal): a health education application

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ABSTRACT

Despite the growing popularity of the mobile health application, the application that addressed to calculated diabetes risk is still limited. DiaCal was developed to prevent type 2 diabetes mellitus by screening and early detection approach. This study aimed to develop and examine the usability of DiaCal smartphone application-based education. This study was conducted with a cross-sectional approach. The framework of this application is based on the American Diabetes Association diabetes risk screening instrument. The development of the DiaCal was divided into three phases: preparation, design, and piloting. System Usability Testing (SUS) instruments used to examine the user-level acceptance of this application. DiaCal app developed in android platform core modules: a) data entry, b) conversion and calculation, c) output of the risk assessment, d) education. Twenty respondents were recruited in this study to evaluate DiaCal through SUS instrument. The average adjective range score is 85.25 which indicates that the DiaCal application is in the "excellent" category and the grade level scale is in "A+". This study showed a significant usability and acceptability of DiaCal in terms of effectiveness, efficiency, and satisfaction.

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1. INTRODUCTION

The prevalence is estimated increase to 783 million people in 2045 [1]. The increasing prevalence of diabetes could be due to insufficient prevention activities [2]. Indonesia was placed fifth highest ranked country with the highest cases of undiagnosed diabetes. IDF also reported that 73% of people in Indonesia do not recognize their condition [1]. People who do not aware that they are diabetic can have an increased risk of complications [3]. Therefore, beneficial strategies have been proposed for high-risk people to prevent the occurrence of diabetes[4].

Massive early detection is still important to reduce the number of undiagnosed diabetes [5]. Risk assessment questionnaires, laboratory tests, and combinations of the two can be used to identify or detect early type 2 diabetes mellitus. The American Diabetes Association recommends validated diabetes screening tools to assess asymptomatic people [6]. A previous study in Indonesia reported that the ADA screening tools are safe, noninvasive and easy to use [5]. If the screening for diabetes risk is followed by the perception that they

are at risk of getting this disease, prevention might be successful. However, perception of diabetes risk must be followed by modifying the risk factor behavior to increase success of diabetes prevention [7].

The mobile health application has been shown to be a promising intervention in terms of improving self-management, adherence to therapy [8], increasing awareness of healthy lifestyle and health outcomes [8], [9]. A systematic review was conducted to examine the effectiveness of mobile health. The findings indicated that the mobile application demonstrated a reduction in diabetes risk of at least small to moderate [10]. In addition to that, the mobile phone provides easy access to monitoring health condition [11]. This means that the mobile health application offers many potential benefits in the care of diabetes.

Although mobile health application offers great benefit, evaluation in the development stage still essential to achieve optimal conditions for successful implementation of the application. Evaluation of the mobile health application could be conducted in terms of its usability. Usability testing involves formally evaluating how effective, efficient and satisfactory user interactions with a product or system are perceived [12]. The previous study reported that about 95% of mobile health applications have not been evaluated in the term of usability [13]. Neglecting usability testing might increase the risk of unusable applications [14].

Some mobile application for diabetes prevention have been developed to prevent type 2 diabetes mellitus [15]. However, the number of these applications is still limited and is mostly in English version[10]. Meanwhile, the existing application with an English version may not be practical for Indonesian population. To our knowledge, there is no existing mobile application to prevent type 2 diabetes mellitus with the Bahasa Indonesia version. To simplify the early detection or screening for type 2 diabetes risk, the mobile application could be one of the alternative solutions. Therefore, the objective of this study was to develop a mobile health namely DiaCal (Diabetes Risk Calculator) to promote modification of life style as prevention of diabetes mellitus. We integrate the risk screening tools of the American Diabetes Association in mobile application with Bahasa Indonesia version and perform the usability test in general people.

2. METHOD

This study was conducted with a cross-sectional approach. The following development of the DiaCal was divided into three phases: preparation, design, and piloting.

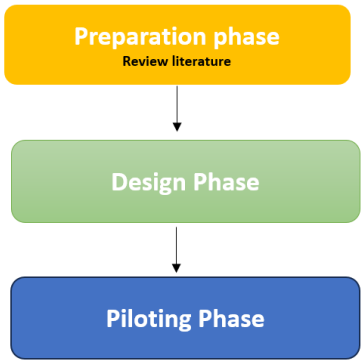

Figure 1. The development process of diacal

Preparation Phase

Review literature

In this phase, we conducted a literature review to identify an applicable instrument to calculate diabetes risk. We choose the ADA diabetes risk screening tool as our instrument. The ADA diabetes risk test score cut-off point is 5. The score 5 indicates high risk for type 2 diabetes [6]. We use the System Usability Scale (SUS) instrument to examine subjective user testing. The SUS instrument could be used to assess technological products, including the learning management system, mobile application, and website [16]. The SUS used in this study is a user-friendly tool for assessing the usability of mobile applications [17]. This instrument consists of 10 statements with a five-point scale that ranges from strongly disagreeing to strongly

disagreeing. The total SUS score ranging from 0-100. The SUS score have been translated to acceptability and adjective range such as good," "poor," or "excellent"[18], [19]. The formulas for calculating SUS scores are:

$$\text{SUS Score}=\{(S1-1)+(5-S2)+(S3-1)+(5-S4)+(S5-1)+(5-S6)+(S7-1)+(5-S8)+(S9-1)+(5-S10)\}*2.5$$

Note: Si = the-i item statement

Design Phase

Application core modules

We develop the application in the Android smartphone system since we believe that most Indonesians use android smartphone [20]. We designed the DiaCal for Android platform since the major Indonesian people user this platform. The core modules of the DiaCal including: a) data entry, b) conversion and calculating, c) output of the risk assessment, d) education. First, the user will input the data (name, email, date of birth, height and weight, and sex). The system will automatically calculate the body mass index (BMI). Then the user will determine their risk by answering the ADA diabetes screening tool. The risk score will appear in a short time, including the education based on that score (Figure 2). This application is simple and as user-friendly. In addition, it also uses less storage space on the mobile phone. During the development process, we also checked for errors. Then, we repaired and recoded it until the errors were eliminated.

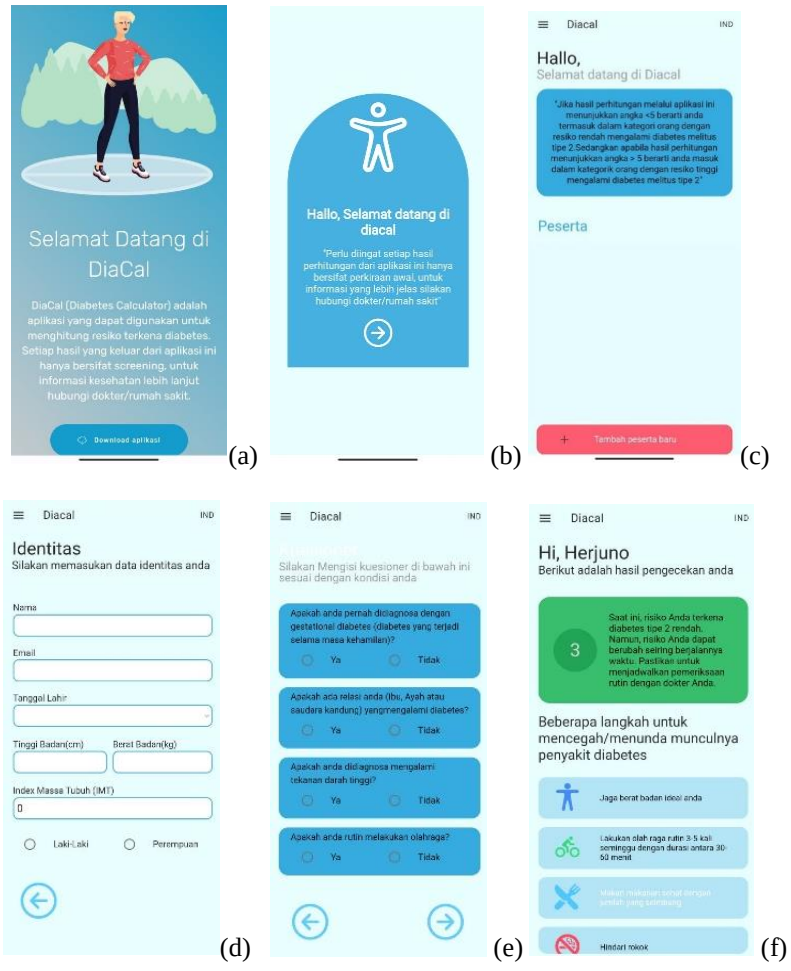

Figure 2. Diacal display design: (a) dan (b) application cover, (c) new input slots, (d) dan (e) identity and diabetes risk calculation, (f) risk score and education

Pilot phase

We conducted this study among residents of the Ambarketawang village in Yogyakarta, Indonesia. We recruited 20 residents as our participants with convenience sampling. Usability testing of the product could be performed in at least in five participants [21]. The inclusion criteria of the respondents were age 18-65 years, undiagnosed with type 2 diabetes mellitus, android and smart phone users and agreed to be respondents in this study. We contacted them individually and gave them information about DiaCal. We invite them to use DiaCal

and appraise it through the SUS instrument [18]. Participants were asked to download the application on their smartphone, register, and fill out the diabetes risk questionnaire and read the education based on their diabetes risk score. We also collect feedback regarding the application. The result of this usability testing was used to resolve and improve the application until we achieved an acceptable version.

Ethics approval

This study obtained an ethical statement from the STIKES BETHESDA YAKKUM Health Research Ethics Committee (approval number No.150/KEPK.02.01/VIII/2022).

3. RESULTS AND DISCUSSIONS

Characteristis of The Respondents

Table 1 Characteristic of the respondents

Characteristic	n		(%)
Gender			
Male	5		25
Female	15		75
Education			
Senior high school	18		90
College above	2		10
Employment			
Employed	14		70
Unemployed	6		30
Characteristic	Mean	Min	Max
Age	45,6	19	60

A total of 20 residents of the Hamlet Ambarketawang, Yogyakarta, Indonesia participated in this study. Most of the respondents were female (75%), had lower education (90%), and were employed (85%). The variation in education and employment of the respondents was necessary to be considered as it can help the researcher ensure the application understood and easy to use by any difference characteristic of the users [22].

Dical Outlook

The DiaCal outlook presented in Figure 1. The calculation of diabetes risk score appears in a short time. Meanwhile, the score displayed on the green icon that is categorized as ‘low risk’ and red icon as “high risk” [6] . It will make it easier for the user to determine their condition. Once the diabetes risk score appears, the system will provide educational information for the user based on the risk score. The educational feature using simple language as the target user of this application is general people. DiaCal could offer personalized feedback to users, providing them with beneficial individualized information.

Pilot Testing of DiaCal Usability

Conducting usability tests before releasing the app to a broader user base is crucial [14]. SUS is a global assessment of usability aspects (effectiveness, efficiency, and satisfaction) subjectively indicated by users and shows the level of user acceptance. Among all participants, the majority of participants indicated that the DiaCal application was accepted (95%) and was effective and efficient (Table 2). It means that participants found the DiaCal application usable and helped them prevent type 2 diabetes mellitus. Similar result found in the previous systematic review that indicated that application developed in Asia could be used effectively by the user as it develops considering the characteristic of the user [22].

Table 2. Distribution of the acceptability range (n=20)

	Category	n	%
Acceptability range	Unacceptable (0–50)	0	0
	Marginal (51–70)	1	5
	Acceptable (71–100)	19	95

The average adjective range score is 85.25 which indicates that the DiaCal application in the"excellent" category (Table 3) [18] and the grade level scale in “A+” category according newest SUS score range (Figure 3) [23].

Table 3. Distribution of the adjective range (n=20)

	Category	n	%
Adjective range	OK (52–72)	1	5
	Good (73–84)	6	30
	Excellent (85–99)	13	65

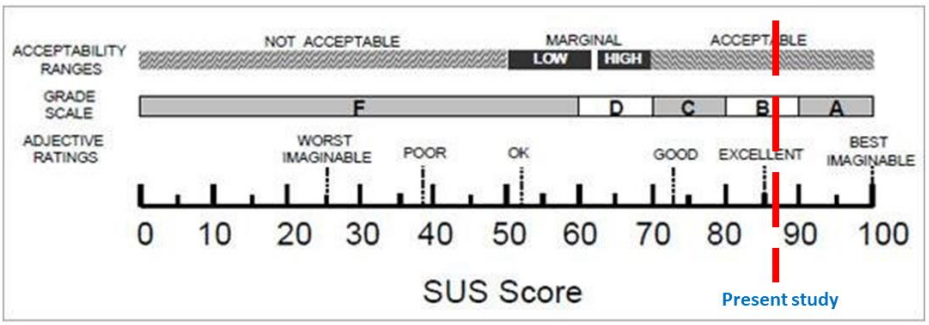

Figure 3. Provison for the SUS score of the diacal

Primary Finding

We developed an application that integrated the diabetes risk score and its relevant education. This application is expected to prevent type 2 diabetes mellitus among the general people in Yogyakarta, Indonesia. The role of the app makes the user aware of their condition and increases their perception of risk. Thus, the user will follow the education and engage in healthy behaviors. The intervention aimed at lifestyle modification showed positive impact on diabetes prevention [24]. A previous study that implemented a mobile health application also showed improvement in the perception of diabetes risk [25] and reduce the prevalence of diabetes [26]. On the other hand, mobile health can extend the reach and scale of behavior change at a low cost [27].

Previously, to obtain ‘Grade scale A’, the SUS score must be at least 90 [28]. Regarding usability testing, that participants indicated the DiaCal is classified as acceptable, excellent and grade A+ application (SUS score = 85.2) using the newest grading scale. The SUS score ranges from 84.1 to 100 categorized as grade A+ [23]. Participants stated that DiaCal was easy to download and use. The design was also simple due to which they could find the diabetes risk score and relevant information based on the risk score in a short time. The information in DiaCal provided in simple language. Using a simple language will accommodate people with any level of literacy and will help them to understand the provided material easily [29]. During the usability testing, we also collected feedback from participants to improve our application. Additionally, we do not consider DiaCal as a primary diabetes risk screening tool. We anticipate that participants will consider the result of the calculated score and seek the help of a healthcare professional for further examination. However, this application still needs to be evaluated and developed further, since DiaCal is only compatible with the Android platform.

Comparison With Previous Study

A previous study conducted in Brazil developed a mobile application to risk of diabetes [30]. They integrate The Finnish Diabetes Risk Score (FINDRISC) into eHealth. The difference from our application was their application only focuses on the risk screening in large population. A similar study utilized the mobile application to prevent diabetes mellitus [31]. Their application compiles multiple domains such as weight loss, diet modification, physical activity, and quality of life. The intervention differed from ours and targeted people with high-risk diabetes and diabetes risk screening not included in their apps. Other applications have also been developed to support daily self-management [20]. This application is only specific to patients who already diagnosed type 2 diabetes mellitus.

Strength and Limitation

This study had several advantages in the preventive field. The integration of ADA diabetes risk score instruments in the mobile application could help people be aware with their condition. Since the application was developed on the smartphone, people can access it anytime and anywhere. Some drawbacks of these apps

were only applicable for Android-based smartphones. The results of this study should be developed by conducting further research to identify the effectiveness of this application.

4. CONCLUSION

The usability testing of the app indicated that DiaCal is categorized as acceptable, excellent, and grade A+ application. This indicated that participants found DiaCal application usable and easy to use. The features of the DiaCal app can assist general people identify their risk for diabetes and help them modify their behaviors. Since this application only applies to android-based smartphone, further research needs to be conducted in other operating systems.

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Author1: Conception and design, data collection, data analysis and interpretation, manuscript writing. Author2: data collection and manuscript writing

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