Original Paper

# Effect of Android-based Mobile Diabetic Foot Early Self-assessment on Diabetic Foot Prevention Behaviors of Indonesian Patients With Type 2 Diabetes

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## ABSTRACT

**Introduction:** Diabetes mellitus (DM) is a chronic disease with many complications. The most common complication is diabetic foot.

**Objective:** This study aimed to study the effect of Android-based mobile diabetic foot early self-assessment (M-DFEET) on diabetic foot prevention behaviors of Indonesian patients with type 2 DM.

**Materials and Methods:** This is a quasi-experimental study with a pre-test/post-test design that was conducted on 60 Indonesian patients with type 2 DM (30 in intervention group and 30 in control group) who met the inclusion criteria and were purposively selected from August to October 2021. The intervention group used the M-DFEET application, while the control groups did not use the application. Diabetic foot prevention behaviors were measured before using application and three months after using application. The data were analyzed using paired t-test and independent t-test.

**Results:** Most of the participants aged >55 years and most of them had DM for less than five years. After education, all participants in the intervention group (100%) were able to appropriately fill in the forms and use the application; however, only 10 (33.3%) participants had the ability to properly log in; which was probably due to an unstable internet connection. The result of paired t-test showed a significant difference in diabetic foot prevention behaviors before and after the M-DFEET use in the intervention group (P=0.016). Moreover, a significant difference in diabetic foot prevention behaviors was found between the intervention and control groups (P=0.02).

**Conclusion:** The M-DFEET application can significantly improve diabetic foot prevention behaviors of Indonesian patients with type 2 DM. In the future, the M-DFEET can be tested on more patients and be used in other populations.

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## Introduction

Diabetes mellitus (DM) is a chronic silent-killer disease with many complications. The most common complication of DM is diabetic foot, which is the most common cause of hospitalization in DM patients, resulting in increased treatment costs, disability, decreased quality of life, and risk of death [1]. Globally, the incidence of diabetic foot is relatively high and continues to increase along with the increase in the prevalence of DM. Diabetic foot mainly occurs in patients with type 2 DM for more than 10 years, where about 60% experience disability and leg amputation. The risk of amputation occurs every 30 seconds and is 15-40 times more frequent in DM patients worldwide [2]. In DM patients, 85% of amputations began with undetected foot ulceration and late treatment, which can turn into a severe infection [3-6]. Most diabetic foots occur due to late detection and poor management [7]. To prevent acute or chronic complications, early detection and appropriate treatments are needed [3].

Diabetic foot disorder is a preventable complication. Five key elements for diabetic foot prevention, include identifying the at-risk foot, examining the at-risk foot regularly, providing education to patients, families, and health workers, ensuring the use of appropriate footwear, and treating risk factors [8]. The assessment format is not specific for detecting diabetic foot, because it is still combined with the patient's general assessment. In addition, the existing instruments can only be used by health workers when patients visit health centres. They are also not accessible to patients and their families, making the instruments less effective in detecting the occurrence of diabetic foot. Hence, developing an innovative and efficient instrument for early detection of diabetic foot that is easy to use independently by patients and their families is required.

One strategy for developing such instruments is the use of mobile applications. One developed application for the diabetic foot screening is “Inlow’s 60-second diabetic foot screen” [9]. Another mobile application for the early detection of diabetic foot is “android-based mobile diabetic foot early self-assessment” (M-DFEET) which has simple features regarding patient identity, patient confidence in conducting foot examinations, assessment of foot conditions, conclusions on the results of the early detection, recommendations according to the early detection results, health education about foot examination at home, and automatic reminders. The M-DFEET application is in Indonesian language and has promising, valid, and reliable features that enable patients with type 2 diabetes to perform early self-assessment of their feet (Figure 1). It has been developed based on the software development life cycle (SDLC) principle which consists of five phases of inception, design, implementation, maintenance, and audit [10]. The M-DFEET has acceptable content validity (I-CVI=1.00) and good internal consistency (Cronbach's $\alpha$=0.74). The Android operating system has been chosen because of its widespread use and the accessibility of Android applications from Google Play. A survey in 2022 on the growth of internet users in Indonesia revealed that Android the largest smartphone platform in Indonesia, which is around 91% compared to other platforms [11].

The health belief model (HBM) elucidates the impact of an individual’s perception of disease and health-promoting behavior. According to this model, if individuals perceive themselves as susceptible to severe complications of their disease, they are more likely to believe the benefits of taking necessary health measures and feel exposed to cues from internal or external sources that can trigger action [12, 13]. Based on this theory, this study aimed to assess the effectiveness of the M-DFEET application in Indonesian patients with type 2 DM.

## Materials and Methods

This is a quasi-experimental study with a pre-test/post-test design. The data were conducted from August to October 2021. The sample size was determined 26 per group using DanielSoper’s free sample size calculator, by considering a large effect size of 0.8, a test power of 0.8, and a type 1 error rate of 0.05 [14]. By accounting for a 10% sample dropout rate, the final sample size was 30 per group. In this regard, 60 patients with type 2 DM who met the inclusion criteria were purposively recruited from Puskesmas Blahbatuh Hospital, Gianyar, Bali. The inclusion criteria were a diagnosed type 2 DM, age 30-65 years, no diabetic foot complications, having a smartphone with Android operating system and being able to use these smartphones, attending socialisation and training on the use of the M-DFEET application, and willingness to participate in the study. On the other hand, the patients who already had diabetic foot were excluded. Sample selection was done based on assigning even and odd numbers to patient names. Even numbers were for the inclusion in the control group and odd numbers were for the intervention group. The flowchart of sampling allocation process is shown in Figure 2.

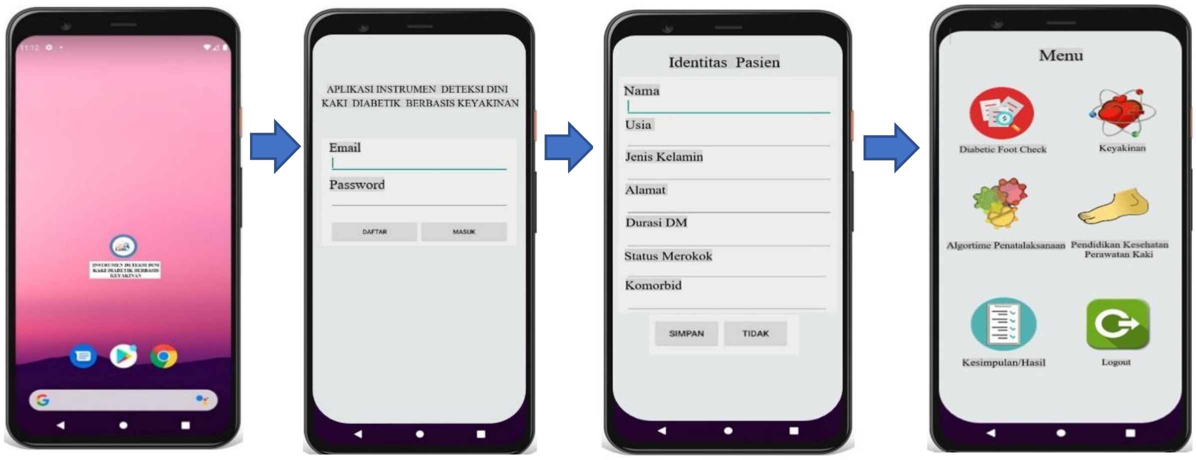


**Figure 1.** The M-DFEET application interface

A HBM-based questionnaire was used to measure patient's perceived severity, perceived susceptibility, cues to action, perceived benefits, and perceived barriers. Also, the Inlow's 60-second diabetic foot screen tool was used for screening and assessing the risk of diabetic ulcers so that appropriate prevention and treatment could be carried out [9]. It is a reliable and valid tool [15]. The diabetic foot prevention behavior was measured using a faith-based early detection instrument for diabetic foot through an Android application that had been developed. The M-DFEET has acceptable content validity (I-CVI=1.00) and good internal consistency (Cronbach's α 0.74). The Android operating system has been chosen because of its widespread use and the accessibility of Android applications from Google Play. A number of items included about routine foot examinations, routine diabetic foot exercises, routine foot cleaning, nail cutting, foot massage, and selection of appropriate footwear. The items rated on a scale as 0 (never), 1 (sometimes), 2 (often), and 3 (always). Based on the score, the prevention behaviors were categorized into three levels: Poor (≤50%), moderate (51-75%), and good (76-100%).

The research team provided socialization and training to the participants in the intervention group regarding the proper use of the application. They were trained to log in, register and fill the questionnaire. Diabetic foot prevention behaviors were measured before using application and three months after using application. The collected data were analysed using descriptive statistics, paired t-test to compare pre-test and post-test scores and independent t-test to measure the difference in the post-test scores between groups.

## Results

The most of respondents in the intervention group were over 55 years of age (53.3%), while the majority of respondents in the control group aged 36-45 years (56.7%). Regarding gender, the majority of respondents in the control group were female (63.3%) while the percentage of females and males in the intervention group was equal (50%). The majority of respondents had DM for less than 5 years in both intervention (90%) and control (76.7%) group (Table 1).

The levels of ability to use the M-DFEET application in the intervention group are shown in Table 2. The results showed that one third of participants in the intervention group had a good ability to log into the M-DFEET application, while the rest had a moderate ability to log in.

At baseline, there were 18(60%) participants who had good preventive behaviors in the intervention group, while 12(40%) had moderate behavior. Meanwhile, in the control group, there were 10(33.3%) participants with good preventive behaviors and 20(66.7%) with moderate behavior (Table 3). After the intervention, there was an increase in the number of participants with good behavior in the experimental group from 12 to 27(90%), while 3 participants (10%) still had moderate behavior. Meanwhile, in the control group, there were 16 participants (53.3%) with good behavior and 14(46.7%) with had moderate behavior. Additionally, statistical analysis results showed a significance difference between control and experimental groups after intervention (Table 3).

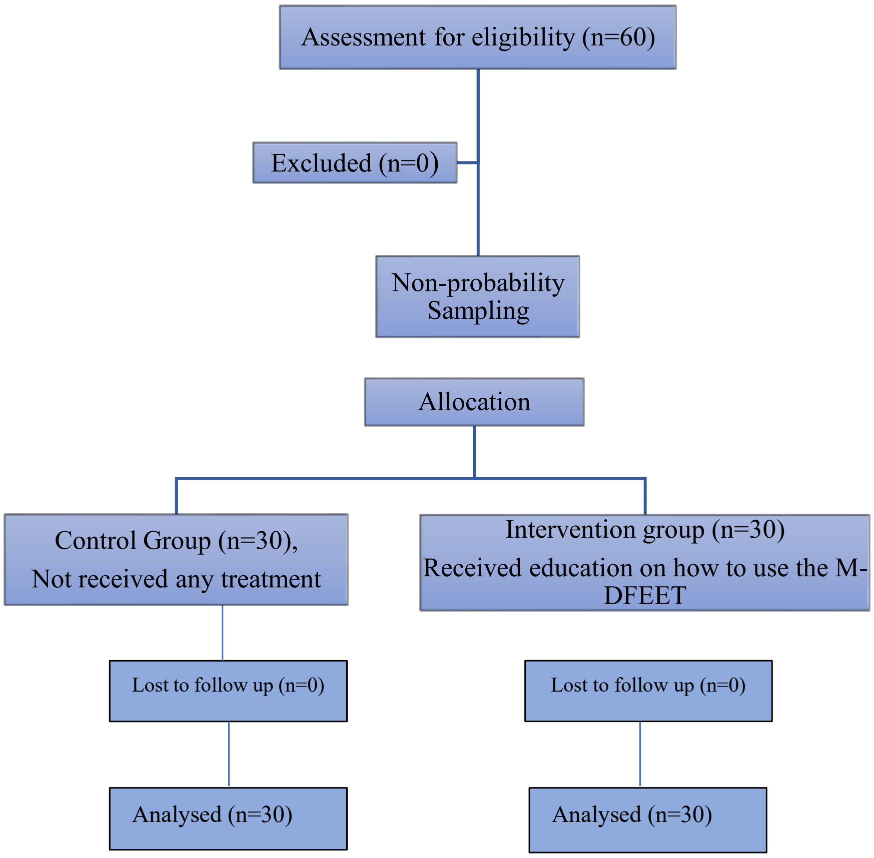


**Figure 2.** Flowchart of the sampling and allocation processes

## Discussion

The findings showed that the M-DFEET application had a significant impact on diabetic foot prevention behaviors in the experimental group. The application can increase the diabetic patients' knowledge of foot condition. Two previous studies had similar findings; they also showed that mobile applications can help diabetic patients to maintain their foot conditions [16, 17]. By using mobile applications, patients with DM do not need to go to healthcare centres; they can have easy access to related information anywhere and anytime. Development of the application with remote consultation is beneficial [18]. The M-DFEET is very easy to use. All age groups can use it according to the assessment results. Technology can help diabetic patients to understand their condition [19, 20]. It is very important for diabetic patients to take preventive measures to controlling glucose level and DM complications [21]. A previous study showed that many diabetes-related mobile applications could help diabetic people [22].

We employed the HBM model [23] in this study. This model measures patient's perceived severity, perceived susceptibility, cues to action, perceived benefits, and perceived barriers. When diabetic patients perceive themselves to be susceptible to serious complications of diabetic foot and have a heightened knowledge of benefits, they are more likely to adopt essential health-related measures [24]. The cues to action from internal or external sources can help patients take health actions, such as early detection of diabetic foot [25].

The M-DFEET application uses a theoretical approach that builds trust in patients with type 2 DM, prevent diabetic foot complications, or reduce deaths. The success of controlling the complications of diabetic foot depends on patients' self-care behaviors since more than 95% of DM-related treatments are done by the patients themselves based on beliefs, ability, and adherence to health guidelines. By the M-DFEET application, diabetic patients can conduct early diabetic foot detection test independently anywhere and anytime. The application also has proper quality based on functionality, reliability, efficiency, usability, and portability. This application is projected to contribute to evidence-based nursing practice to reduce DM-related disability and death. However, the application, which was developed only

**Table 1.** Sociodemographic characteristics of study participants

| Variables | | No. (%) | |
|---|---|---|---|
| | | Intervention | Control |
| Age (y) | 36-45 | 3(10) | 17(56.7) |
| | 46-55 | 11(36.7) | 5(16.7) |
| | >55 | 16(53.3) | 8(26.6) |
| Sex | Female | 15(50) | 19(63.3) |
| | Male | 15(50) | 11(3.7) |
| Duration of DM (y) | ≤5 | 27(90) | 23(76.7) |
| | >5 | 3(10) | 7(23.3) |

**Table 2.** Ability of diabetic patients to use the M-DFEET application in the intervention group (n=30)

| Assessed Criteria | No. (%) Ability | |
|---|---|---|
| | Good | Moderate |
| Ability to log in | 10(33.3) | 20(66.7) |
| Ability to fill in the identity form | 30(100) | 0(0) |
| Ability to fill in the HBM-based instrument | 30(100) | 0(0) |
| Ability to fill in the diabetic foot early detection instrument | 30(100) | 0(0) |
| Ability to understand the parameters and make conclusions of the diabetic foot examination scores | 30(100) | 0(0) |
| Ability to understand recommendations based on the foot examination results | 30(100) | 0(0) |

Notes: Poor ability was not observed and was omitted in table.

**Table 3.** Diabetic foot prevention behavior scores and levels in diabetic patients before and after the intervention

| Behavior | | No. (%)/Mean±SD | | | |
|---|---|---|---|---|---|
| | | Intervention Group (n=30) | | Control Group (n=30) | |
| | | Pre-test | Post-test | Pre-test | Post-test |
| Level | Good | 18(60) | 27(90) | 10(33.3) | 16(33.3) |
| | Moderate | 12(40) | 3(10) | 20(66.7) | 14(46.7) |
| | Poor | 0(0) | 0(0) | 0(0) | 0(0) |
| Score | | 30.87±3.76 | 32.37±1.65 | 29.3±2.84 | 30.37±4.19 |
| | Minimum | 24 | 29 | 23 | 24 |
| | Maximum | 37 | 35 | 35 | 36 |
| Before intervention | | P=0.016* | | P=0.276* | |
| After intervention | | P=0.02** | | | |

*Paired t-test, **Independent t-test.

for Android users and use the Indonesian language, is highly dependent on the stability of the internet connection. Furthermore, the application has yet to be tested extensively with a larger number of participants. In addition, the application needs to be upgraded to be used offline and save data for online processing when internet is reconnected.

## Ethical Considerations

### Compliance with ethical guidelines

This study received ethical approval from the Research Ethics Committee of STIKES Buleleng (Code: 085/EC-KEPK-SB/IX/2021) on September 20, 2021.

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### Authors' contributions

Conceptualisation and methodology: Ni Wayan Suniyadewi, Nursalam, Yuni Sufyanti Arief, Ninuk Dian Kurniawati; Data collection: Ni Luh Putu Inca Buntari Agustini, I Dewa Ayu Rismayanti, and Virgianti Nur Farida; Data analysis: Arifal Aris and Resti Utami; Writing the original draft: Ni Wayan Suniyadewi, and Yuni Sufyanti Arief; Final approval: All authors.

### Conflict of interest

The authors declared no competing interest.

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