ORIGINAL ARTICLE

Usability and functionality of M-DFEET application for the independence of foot care in diabetes mellitus patients

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ABSTRACT

Introduction: Diabetes mellitus (DM) poses significant challenges in foot care management, often leading to severe complications if not properly addressed. Diabetic Peripheral Neuropathy (PND) is commonly associated with diabetic foot ulcer (DFU) and is a leading cause of hospital admissions and prolonged treatment durations. Therefore, this study aimed to determine the usability and functionality of the Mobile Diabetic Foot Early Self-Assessment (M-DFEET) application for the independence of foot care for DM patients in the South Denpasar Community Health Centre area.

Materials and Methods: This is a cross-sectional study with 60 DM patients, selected by simple random sampling. The instrument used consists of the DM patient observation sheet-based user view and the M-DFEET application. Categorical data were classified as frequency and percentage, while the numerical data were reported as mean and standard deviation (SD).

Results: The evaluation results show that all 60 participants (100%) rated the functionality of the M-DFEET application as excellent in helping with foot care. Furthermore, most participants, 55 (91.7%), assessed the efficiency of the application as good. Regarding the usability, 58 participants (96.7%) considered it good, while the remaining participants deemed it adequate. These findings underscore the application's potential to optimize time and effort for its users effectively.

Conclusions: The feedback on the M-DFEET application is overwhelmingly positive, with all participants rating its functionality as very good for foot care. The application is likely to be well-received by users especially T2DM patients, and holds potential as an evaluative tool in foot care management.

KEYWORDS:
Diabetes mellitus, foot care, functionality, M-DFEET, usability

INTRODUCTION

Diabetes mellitus (DM), often referred to as a silent killer, is associated with serious long-term complications.[1] It represents a significant global public health challenge and is one of the leading causes of mortality worldwide.[2,3] Among the most severe complications of DM is Diabetic Peripheral Neuropathy (DPN), a condition that significantly increases the risk of developing Diabetic Foot Ulcers (DFU). In addition to being a major cause of prolonged hospital stays.[4,5] DFU contributes to increased healthcare costs, higher disability rates, diminished quality of life, and an elevated risk of mortality.

DFU is one of the most preventable long-term complications of diabetes. Prevention is supported by five key elements: 1) identifying feet at risk, 2) regular inspection of feet at risk, 3) educating patients, family members, and healthcare providers; 4) ensuring proper footwear use, and 5) managing risk factors.[6] These five elements are important for preventing DFU, amputation, and maintaining the quality of life of patients. Diabetic foot is a severe consequence of chronic DM, characterized by deep tissue lesions associated with neurological impairments and peripheral vascular disease of the lower extremities.[7]

The increasing incidence of diabetic foot disease is closely linked to the global increase in DM prevalence and the prolonged life expectancy of patients. The prevalence of DFU in T2DM is relatively high, with most patients having lived with the condition for over a decade. Approximately 60% of these patients experience impairments, including a significant risk of leg amputation.[6,8] The risk of amputation occurs every 30 seconds and is 15-40 times more frequent in DM patients compared to non-DM patients. Furthermore, 85% of amputations in DM patients begin with foot ulceration, which often progresses to gangrene or severe infection.[3,8,9] Considering these alarming statistics, increasing awareness of DFU problems is very important. The challenges posed by this condition include increasing incidences of foot complications, extended waiting times for treatment, and difficulties in early detection. These issues underscore the need for creative, innovative, and effective solutions that patients can utilize independently. One such solution is by making an application that can facilitate families and DM patients to carry out foot examinations independently at home (M-DFEET Application, available at https://denpasarinstitute.com/M-DFEET_1_1.0.apk).[10,11]

This Android-based Mobile Diabetic Foot Early Self-Assessment (M-DFEET) application is designed using the "Inlow's 60-second diabetic foot screen tool" as its foundation.[12] The application includes a login menu, a main menu with patient information, a diabetes screening form, foot assessment items (visual, touch, sensation), early foot assessment results, recommendations, health education, and notifications. The visual evaluation included assessing the

Table I: Characteristics of Research Participants (n = 60)

Characteristics		n	%
Age (year)	36-45	20	33,3
	46-55	16	26,7
	>55	24	40
Gender	Female	34	56,7
	Male	26	43,3
Duration of DM	< 5 years	50	83,3
	>5 years	10	16,7

Table II: Evaluate the patient's ability to use the M-FEET application (n = 60)

Variables	Category		
	Good n (%)	Enough n (%)	Not enough n (%)
Q1 Login capability	50 (83.3)	10 (16.7)	0 (0)
Q2 Identity filling capability	54 (90)	6 (10)	0 (0)
Q3 Confidence instrument filling capability	45 (75)	15 (25)	0 (0)
Q4 Capability of filling instruments for early detection of diabetic feet	53 (88.3)	7 (11.7)	0 (0)
Q5 Ability to understand the parameters and conclusions of early detection examination scores for diabetic feet	50 (83.3)	10 (16.7)	0 (0)
Q6 Ability to understand recommendations based on foot examination results	58 (96.7)	2 (3.3)	0 (0)

Table III: Evaluate patient opinions in using the M-DFEET application (n = 60)

Rated Aspect	Category			Score
	Good n (%)	Enough n (%)	Not enough n (%)	Mean (SD)
Functionality	60 (100)	0 (0)	0 (0)	33.95 (2.587)
Efficiency	55 (91.7)	5 (8.3)	0 (0)	45.58 (4.637)
Usability	58 (96.7)	2 (3.3)	0 (0)	44.90 (4.181)

foot's skin, toenails, deformity pressure, and footwear. The touch was used to assess skin temperature and detect pedal pulses, while sensation was assessed using a cotton tip. The quality of this application is also based on an assessment from the user's perspective such as functionality, reliability, efficiency, usability, and portability. However, the functionality and usability of this application still need to be tested on DM patients.[13] Therefore, this study aimed to investigate the usability and functionality of the M-DFEET application in promoting independent foot care for DM patients.

MATERIALS AND METHODS
This cross-sectional study focusing on the usability and functionality of an Android-based independent foot care application called M-DFEET application for DM patients was carried out from April to May 2023. This application contains patient information, a diabetes screening form, foot assessment items (visual, touch, sensation), early foot assessment results, recommendations, and health education. The NBR ISO/IEC 9126-1, a standard issued by the International Organization of Standardization and the International Electrotechnical Commission and later amended and translated by the Brazilian Association of Technical Standards was adopted. This standard defines a quality model for software products from two perspectives,

including internal and external quality,[14] which consists of a set of properties to fulfill the user's demands, such as functionality, usability, dependability, efficiency, maintainability, and portability.

The four qualities that define a usable quality are effectiveness, productivity, safety, and satisfaction. Usability focuses on evaluating the finished product from the user's perspective, measured by the performance attained by the target audience when using the program. In this context, software is considered usable when it is intelligible, comprehensible, and operable making it simple enough for the users to grasp, learn, and use. High usability is crucial to software success since it allows users to use the application's capabilities and resources quickly and efficiently. On the other hand, functionality refers to the application's ability to provide operations and tools to meet users' demands.

Participants
The DanielSoper independent sample size calculator determined that sixty beta testers were sufficient to evaluate the usability and functionality of this mobile application. The participants consisted of DM patients from South Denpasar Health Centre. The total number of beta testers was selected due to study findings suggesting that 10 participants in the usability test would detect 94.7% of all usability issues.[15,16] The participants were recruited using a simple

random sampling method from among T2DM patients. Eligibility criteria included having either a history of DM for more than five years or a diagnosis within the past six months accompanied by symptoms, particularly neuropathic disorders. Participants were also required to have an Android device, such as a smartphone or tablet.

Materials
In this study, the instrument used was an observation sheet-based user view to evaluate the patient's ability to use the M-DFEET application and the patient's opinion regarding the application. The abilities assessed include log-in, fill-in identity, features about trust instruments, features about early detection of diabetic feet, features about parameters and conclusions about early detection of diabetic foot examination scores, and understanding recommendations. An opinion evaluation includes functionality, efficiency, and usability.

Procedures
Participants were first instructed to install the M-DFEET application on their respective Android devices. Once installed, they were asked to use the application for two months. After this period, participants provided feedback on the user interface, focusing on its usefulness, functionality in providing warnings, and effectiveness in early detection of diabetic foot conditions.

Statistical analysis
The data was entered and analyzed using IBM SPSS Statistics Version 24. Subsequently, categorical data were presented in frequencies and percentages, whilst numerical data were presented as mean and standard deviation (SD).

Ethical statement
The ethical clearance of this study was obtained from the health research ethics commission of the Institute of Technology and Health Bali with the protocol number: 04.0295/KEPITEKES-BALI/IV/2023. Participants provided written informed consent after being thoroughly briefed on the aim of this study.

RESULTS
Respondent characteristics
Most of the participants were over 55 years old (40%), of female gender (56.7%), and had suffered from DM for <5 years (83.3%).

Evaluation of T2DM patient's ability to use the M-DFEET application
The success of implementing the Android-based M-DFEET application was evaluated using an observation sheet. The results showed that the majority of 50 participants (83.3%) have good abilities when logging in to the M-DFEET application. However, 10 (16.7%) participants had a good ability to log in to the M-DFEET application. Most participants, 54 (90%), had good abilities in filling in personal identity features. Most participants, 45 (75%), were able to understand features about confidence instruments, 53 (88.3%) understood features about early detection of diabetic feet, and 50 (83.3%) understood features about parameters and conclusions of examination scores for early detection of

diabetic feet. Most participants, 58 (96.7%) also had good abilities in understanding recommendations based on the results of foot examinations.

Evaluate the opinions of T2DM patients when using the M-DFEET application.
The success of implementing the Android-based M-DFEET application was also evaluated through patient feedback, measured using an observation sheet. All 60 participants (100%) reported that the M-DFEET application functioned very well in supporting foot care. Most participants (55, 91.7%) rated the application's efficiency as good, while five participants (8.3%) found it satisfactory. Regarding usability, 58 participants (96.7%) rated it as good, while the remaining two participants considered it satisfactory.

DISCUSSION
The M-DFEET application was developed as an early screening tool to prevent diabetic foot problems and has been validated as a reliable and trustworthy resource.[17] Designed with the specific needs of T2DM patients in mind, the application enables users to perform foot inspections independently, at their convenience, and from any location.[10] The M-DFEET application also assesses the patient's confidence in carrying out routine and autonomous foot examinations. This study used the Health Belief Model (HBM) theoretical approach, which is the most extensively used theory to explain health behaviour.[18] This theory describes how a perceived or individual belief in sickness influences health behaviour. The HBM suggests that an individual's perceived susceptibility to illness, its severity, and the perceived benefits and barriers to action influence health behavior. Individuals who perceive a higher risk of severe disease complications are more likely to take appropriate health measures. The chosen course of action is typically the one offering the greatest benefits with the least resistance or difficulty. Health behaviors, such as the early diagnosis of diabetic foot conditions, are motivated by internal and/or external cues to action.[19]

The quality of the produced application is determined by the user's perception of its usefulness, dependability, efficiency, usability, and portability.[20] A trial application of the development of an Android application-based early detection instrument for diabetic feet was carried out on 60 DM patients. In line with M-DFEET application usability testing, this study showed that 100% of the participants considered the mobile application easy to use. A user-friendly mobile application such as M-DEET encourages adoption even among those who are unfamiliar with it or have no immediate.[21] All participants unanimously agreed that the different functionalities of the M-DFEET application were nicely integrated. In the modern era, a single mobile application was expected to perform several functions in order to accelerate access to information. Additionally, using a single mobile application to access multiple features is more time-efficient than relying on several separate applications. The universal ease of use reported by participants can be attributed to M-DFEET's familiar and consistent design, which simplifies navigation and functionality.

All participants were found to have good understanding and skill in using the Android-based application developed for early detection of diabetic foot. After the activity of familiarizing with the application was completed, its reliability and trustworthiness was established by getting Type 2 diabetes (T2DM) patients to conduct their own foot examination using this Android application.[22] The process included instructions on how to download the application, log in, fill out the application, and interpret the results and recommendations according to the scheduled timeline. To ensure that the application meets its objectives and provides clinical benefits, patient comprehension was evaluated through behavioral changes in self-care practices, such as an increased frequency of foot exams, more consistent foot hygiene routines, and adherence to clothing recommendations. Direct observations by researchers over the course of two months of data collection showed no diabetic foot problems, such as ulcers or infections, as well as an improvement in overall foot health. However, some participants often face challenges in accessing the application due to internet network costs, especially for those who live in remote areas.

M-DFEET application offers a cost-effective alternative to in-person clinical examinations by reducing the need for frequent clinic visits. The application is free, ensuring accessibility for a wide range of users, particularly in resource-limited settings. Its availability anytime and anywhere enables patients to monitor their foot health without scheduling clinic appointments. This feature is particularly beneficial for individuals in remote areas or those with This feature is especially advantageous for individuals in remote areas or those with limited mobility, as it helps eliminate barriers to care. To identify risk factors and symptoms of diabetic foot issues, M-DFEET application uses evidence-based questionnaires. Key questions include: Do you experience pain, tingling, or numbness in your feet? Have you noticed any sores or changes in the temperature or color of your skin? Do you regularly examine your feet for sores? Additionally, the application integrates advanced features, such as image analysis and symptom tracking, to improve diagnostic accuracy. Based on user responses, the application categorizes individuals into low-, medium-, or high-risk groups, providing tailored recommendations. For instance, low-risk users receive preventive care tips, while high-risk users are advised to seek immediate clinical evaluation. By promoting self-management and patient education, the M-DFEET application empowers users to take proactive steps, facilitating early intervention and reducing the risk of complications.

Developing effective applications requires a strong emphasis on validity to ensure they accurately measure the intended outcomes.[14,16] This process involves aligning the application's content with the study objectives while maintaining relevance to the target population.[13] In this regard, precise operational definitions play a critical role to guide the design of the application to ensure that it can capture the variations among users effectively. For example, in this study, the application should be able to differentiate different individuals (e.g. patient with high risk versus those with low risk) based on the responses they enter into the application.

When designing instruments for mobile applications such as the M-DFEET application, usability is another key consideration to optimize functionality and enhance the user experience. Clear and concise questions tailored to the target population are essential for gathering reliable data. Understanding how users interact with the application will further enhance its continuous improvement and effectiveness in both clinical and non-clinical settings.

Reliability is crucial in ensuring consistent results across repeated assessments. For example, the M-DFEET application has been adapted to meet the needs of T2DM patients and tested for reliability.[10] The application has shown potential for integration into existing healthcare services, enabling early detection of diabetic foot issues and supporting preventive care strategies. Future enhancements to the M-DFEET application could include features such as personalized foot care guidance for DM patients. Additionally, further study is needed to assess the long-term impact of M-DFEET application on patient behavior and its effectiveness in preventing diabetic foot ulcers. These studies should include larger, more diverse populations and extended follow-up periods to provide comprehensive evidence of the application's benefits.

CONCLUSION

application is specifically designed to assist users, especially individuals with T2DM, in performing foot examinations independently, anytime, and anywhere, thereby eliminating the need for frequent visits to healthcare facilities. By prioritizing user accessibility and ease of use, the application empowers patients to take a proactive role in managing their foot health. The M-DFEET application incorporates patient-centered features and is supported by a theoretical framework building confidence in early detection and routine, independent foot care. This approach enables T2DM patients to monitor their foot health effectively while enhancing their self-efficacy in preventing complications. The implementation of the M-DFEET application has the potential to advance evidence-based nursing practices by significantly reducing disability and mortality associated with diabetic foot complications. By focusing on early intervention and preventive care, the M-DFEET application contributes to better clinical outcomes and improved patient quality of life.

CONFLICT OF INTEREST
The authors declare they have no conflicts of interest.

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