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Usability Of "DFU Application" For Diabetic Foot Ulcer Prevention

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A B S T R A C T

Introduction: The development of smart detection software may help reduce the number of decubitus ulcer infections by enabling early identification and management. Ensuring the usability and effectiveness of such technology is essential before widespread adoption. **Objective:** This study aimed to explore prospective users' perceptions of the mobile app for detecting diabetic foot ulcer (DFU) infection, focusing on its usefulness, ease of use, and overall user satisfaction. **Methods:** The usability of the DFU app was assessed by experienced users. The evaluation included perceived usefulness, ease of use, and overall satisfaction. Standardized tools such as the System Usability Scale (SUS) and a specific app rating scale were used to collect user feedback. **Results:** The DFU app received usability ratings ranging from 0.50 to 0.88. The lowest rating was for performance quality (Mean = 0.50, SD = 0.12), while the highest was for integrity (Mean = 0.88, SD = 0.07). The overall usability score, as measured by SUS, was considered acceptable (Mean = 78.4, SD = 6.83). Most users reported no significant issues with using the app, except for difficulty understanding the language used in the interface, which was rated as a serious usability issue with a severity score of 3. **Conclusions:** Users perceived the DFU app as useful and efficient, particularly in detecting the risk of infection. Despite a noted language comprehension issue, the app demonstrated good overall usability and has the potential to support early intervention for decubitus ulcer prevention.

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1. INTRODUCTION

Diabetic foot ulcers (DFUs) are persistent consequences of diabetes characterized by open skin lesions that may be associated with localized tissue necrosis. Individuals with diabetic foot ulcers constitute roughly 12-15% of the total diabetic population, often affecting the lower limbs (American Diabetes Association). In Indonesia, the incidence of diabetic foot ulcers is around 13% among hospitalized patients and 26% among outpatients (National Institute of Health Research and Development, 2018). Diabetic foot complications arise from diminished sensation, further aggravated by impaired blood circulation in the legs due to endothelial damage in blood vessels, leading to reduced oxygen and nutrient delivery to the skin and other tissues, thereby prolonging the wound healing process (Lazzarini et al., 2022).

DFU is a lesion that is one of the most common complications in DM patients and has a significant impact on the duration of hospital stay and the cost of treatment (McLeod et al., 2020). According to (Armstrong et al., 2017), the global prevalence of DFU ranges from 9.1 to 26.1 million individuals. Symptoms of DFU include a decrease in pain, a loss of pressure sensation, increased dehydration of the feet, and flaking of the epidermis. The occurrence of incisions is facilitated by all of these conditions. When a wound develops, the patient's quality of life will be significantly impacted, and the risk of amputation will increase. This is due to the fact that the ability of special leukocytes to destroy bacteria is compromised by hyperglycemia and poor circulation in the lower extremities, which can lead to infection. In Indonesia, the incidence of diabetic ulcers in individuals with diabetes is approximately 15%. Amputation of the lower extremities is a potential consequence of UKD, which can lead to a decline in quality of life and even mortality (Jahromi et al., 2014; Onu et al., 2022). Therefore, it is imperative to implement early prevention initiatives that are both convenient and accurate for patients, allowing for the easy monitoring of the risk of infection in UKD.

Technological innovations, including mobile computing, sensor-based diagnostics, and artificial intelligence (AI), offer new opportunities for enhancing chronic disease management, including DFU care. For instance, Hsu and Yang (2019) developed an AI-based wound segmentation and infection assessment method using edge-detection and machine learning algorithms. Similarly, Toledo Peral et al. (2018) introduced a three-stage image-processing system using a wireless camera to characterize macules in diabetic patients. Other tools such as the AI-based platforms CekMata.com and Caredise.com in Indonesia allow users to classify wound types, namely normal, infected, or necrotic by uploading photos for remote analysis using deep learning (Li et al., 2021). While promising, these solutions typically rely on browser access, lack a dedicated mobile app, and face issues in accessibility and feature readiness (Rosyid et al., 2020).

Despite growing interest in AI-based DFU detection, many existing tools are not user-friendly, lack mobile app integration, and have not been systematically evaluated for usability among target users. Additionally, limited evidence is available on user perceptions regarding the usefulness and ease of use of these technologies in real-world settings, particularly in low- and middle-income countries such as Indonesia. This study aims to evaluate the perceived usefulness, ease of use, and user satisfaction of a newly developed DFU mobile application, with a focus on its potential to support early infection risk detection. The findings are expected to inform future refinements and promote wider adoption of AI-integrated mHealth solutions for DFU management.

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2. METHODS

Study design

This study employed a quantitative cross-sectional design to evaluate the usability, perceived usefulness, and acceptability of the Diabetic Foot Ulcer (DFU) mobile application. The study was conducted at the Diabetic Wound Care Centre in Bandung City between May and June 2024. A pilot usability test was conducted to assess the mobile app's effectiveness in a real-world setting among individuals with diabetic foot ulcers.

Apps development

The DFU mobile application was developed as an mHealth tool to provide education on diabetic foot ulcer prevention and management. The app integrates multimedia educational modules with thermal imaging capabilities to detect wound temperature, estimate wound depth and area, and support early infection risk detection. Photographs from both left and right extremities are used to quantify ulcer characteristics and provide feedback to users and caregivers. The application was built using Android Studio with Java and Kotlin programming languages and integrates a thermal imaging API compatible with FLIR sensors. A Firebase backend was used for data storage and authentication, ensuring secure and real-time access for both users and healthcare providers (Figure 1).

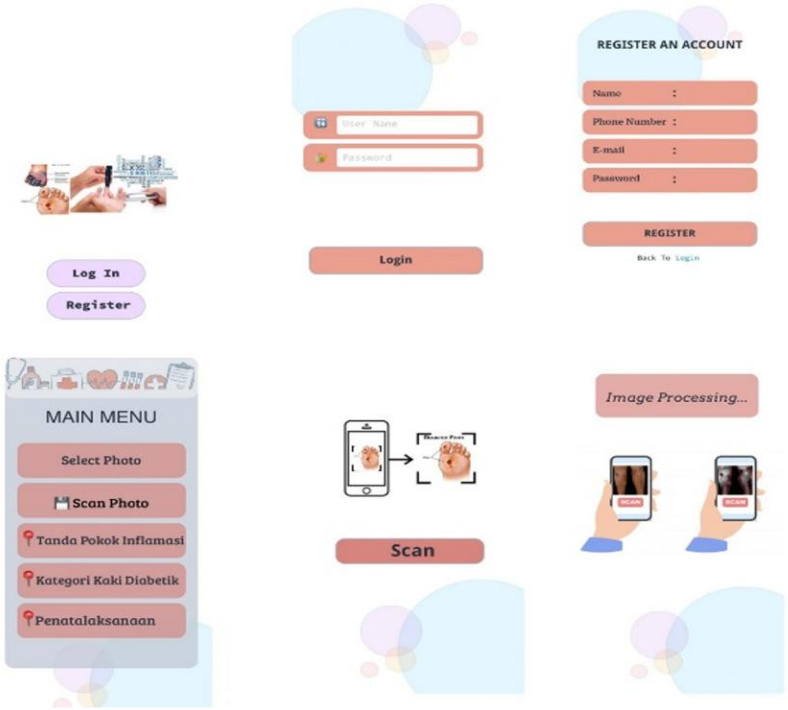

Figure 1. User interface of DFU mobile Application

Sample

A total of 30 participants were recruited through convenience sampling. Eligible participants were adults (aged ≥18 years) diagnosed with DFU grades 1 to 3 and residing in nursing homes across Bandung City. Inclusion criteria included being fully conscious, having the ability to communicate effectively, being free from significant visual or auditory

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impairments, and having the ability to operate a smartphone. Individuals without smartphone access or skills were excluded.

Measure

Demographic information collected included age, gender, educational level, occupation, and duration of diabetes diagnosis.

Usability and app evaluation were conducted using four standardized tools. The mHealth Evidence Reporting and Assessment (mERA) checklist was utilized to ensure comprehensive reporting of digital health interventions. The iSYScore index was applied to evaluate app transparency, perceived usefulness, and user engagement. Additionally, the Mobile App Rating Scale (MARS) and its user version (uMARS) were employed to assess the overall quality of the DFU application. These validated instruments measure key domains such as engagement, functionality, aesthetics, information quality, and subjective user experience. In this study, MARS was administered by expert reviewers, while uMARS was completed by end users. The rationale for selecting MARS and uMARS is based on their strong psychometric properties and their broad applicability in evaluating mHealth applications across various settings and populations.

Study procedures

Participants were provided with Android smartphones pre-installed with the DFU app, accompanied by detailed usage instructions. In-app feedback messages guided users through the app's interface. Following independent use, participants completed the uMARS questionnaire to evaluate their perceptions of the app’s functionality and usefulness. Expert reviewers assessed the app using MARS. Data were collected using structured forms and entered into a Microsoft Excel spreadsheet for further analysis.

Evaluation tool and analysis

Descriptive statistics were calculated using SPSS® software (IBM Corp., Armonk, NY, USA) to summarize participant demographics and evaluation scores. Mean, standard deviation, and frequency distributions were used to interpret the results. No inferential statistical analysis was performed, as the primary aim was to explore usability and acceptability rather than to test hypotheses.

3. RESULTS

Of the thirty participants, the majority (60%) were female. The mean age of participants was 48.9 years (SD = 4.75), and the average duration of diabetes was 6.66 years (SD = 2.48). Most participants (66%) reported being unemployed. Notably, all participants confirmed that they were capable of using a mobile phone.

The usefulness of the DFU mobile application was assessed by experienced users using standardized evaluation tools. The app received quality ratings ranging from 0.50 to 0.88. The lowest score was observed in the domain of performance quality (Mean = 0.50, SD = 0.12), while the highest score was recorded for integrity (Mean = 0.88, SD = 0.07). These findings suggest that the DFU app demonstrates a generally high level of quality and functional performance across most assessed domains (see Table 1).

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Table 1. Quantitative evaluation after using the DFU Application

	Mean ± SD
Content quality	0.60 ± 0.08
Performance quality	0.50 ± 0.12
Usability	0.70± 0.18
Application integrity	0.88 ± 0.07
User feedback	0.61 ± 0.05
Continuity	0.73 ± 0.10
Application form	0.57 ± 0.11
Terminology	0.67 ± 0.19

Following the intervention, approximately 60 end users completed the post-intervention usability questionnaire. As shown in Table 2, the most significant usability issue reported was related to language comprehension. Based on the System Usability Scale (SUS) scores, the DFU app demonstrated acceptable usability, with a mean score of 78.4 (SD = 6.83). Notably, no participants reported difficulties in operating the app. However, the only identified usability concern was the challenge in understanding the language used in the interface, which was classified as a serious issue with a severity rating of 3.

Table 2. Usability issues and severity (N=60).

Usability issues	**F**	**Severity**
Unclear buttons	10	2 to 3
Functionality with layout	35	2
Terminology interpretation issues	40	3
Finding and understanding suggestions	42	2

Table 3 presents the results of the quantitative assessment conducted after the intervention. Participants demonstrated improved understanding, more positive attitudes, stronger intentions to engage in preventive behaviors, and greater readiness to manage diabetic foot care. Notably, the vast majority of participants expressed willingness to recommend the DFU application to others. The observed changes following the use of the DFU app were statistically significant, as indicated by the McNemar test ($p < 0.05$).

Table 3. Quantitative evaluation after using the DFU App from end users (N=60).

	Mean (SD)
System Usability Scale Score	78.4 ± 6.83
Understand more about pressure ulcer prevention	58.5 ±6.95
Have a positive attitude towards using the app	45.9 ± 4.89
Have more intention towards using the app	72.7 ± 5.38
Readiness for using the app	40.2 ± 4.89
Will recommend the App to others, n (%)	56 (93.3)

4. DISCUSSION

This study revealed an overall positive user response to the DFU mobile application, with high ratings for usability, perceived usefulness, and user satisfaction. The quantitative assessment demonstrated statistically significant improvements in participants' knowledge, preparedness, attitudes, and intentions to manage diabetic foot ulcers after using the app. These findings are

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consistent with the growing body of literature highlighting the role of digital tools in enhancing chronic disease self-management (Otis et al., 2023; Azevedo et al., 2025).

A closer examination of each usability dimension provides more nuanced insight. Functionality scores indicated that users found the app responsive and stable during use. However, the main usability challenge identified during the pilot phase was difficulty navigating to the main menu, highlighting a need for interface simplification and improved information architecture. The information quality domain received consistently high ratings, suggesting that the educational content was perceived as clear and valuable. In terms of aesthetics, users appreciated the visual presentation, although some noted that text size and contrast could be improved for older users or those with visual impairments. Engagement scores were generally positive, though users suggested adding interactive features such as progress tracking or alerts for infection risk based on temperature monitoring.

Importantly, all users reported that they were able to operate the application independently, indicating acceptable ease of use. However, one serious usability issue was identified language comprehension. This barrier may stem from technical terminology or interface language not being sufficiently adapted for varying literacy levels. Addressing this issue will be critical in improving the accessibility of the final version of the app.

The current prototype, while promising, differs from a fully developed product. This distinction should be clearly acknowledged, as the findings primarily reflect user interaction with a pilot version rather than a market-ready application. Usability testing at this stage serves as a foundational step to refine features, enhance performance, and support broader acceptability (Nielsen & Budiu, 2013).

While the app has shown potential in supporting diabetic patients, especially in promoting wound self-monitoring and infection prevention, its design must better reflect the needs of high-risk subgroups. These include patients with diabetic neuropathy, impaired circulation, and poor glycemic control factors that significantly influence DFU development and healing (Zhou et al., 2025). Additionally, physical limitations, digital literacy, age, and access to technology may affect both usability and overall outcomes. For instance, older adults or those in low-resource settings may face challenges in smartphone-based interventions unless interfaces are simplified and culturally adapted. Another important limitation relates to the sample. Participants were volunteers and may have had higher mobile proficiency than the general population of patients with diabetes, possibly introducing selection bias. Furthermore, important clinical variables, such as angiography/angioplasty history, ulcer size progression, or the presence of infection were not integrated into this study, which limits the clinical applicability of the findings. Future research should include a more diverse sample, incorporate broader clinical indicators, and evaluate long-term engagement. Studies should also assess integration into clinical workflows, including how healthcare professionals can use the app to monitor patients remotely. Moreover, digital health tools like the DFU application should be framed within broader preventive healthcare approaches. By facilitating early detection and timely intervention, such tools can reduce complications and empower patients in chronic disease self-management (Pratiwi et al., 2023).

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5. CONCLUSION

In summary, the DFU mobile app prototype demonstrated high user satisfaction, ease of use, and educational value. While its functionality shows promise, refinement is needed to address interface clarity and accessibility barriers. With further development and validation in diverse populations, the app has the potential to support self-care and improve outcomes for individuals at risk of diabetic foot complications.

6. DECLARATION

Data Availability Statement

In response to a request from the relevant authors, the raw data used to draw these conclusions will be made public.

Ethics Statement

The linked university's Institutional Ethical Review Board examined and authorized the research involving human subjects. All individuals included in this study gave their written consent before taking part.

Conflict of Interest

The authors affirm that they had no financial or business ties that may be seen as a conflict of interest while they did the research.

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