

Mobile Application for Remote Patient Education and Follow-up for the Prevention of Diabetic Foot: M-DAKBAS

Abstract

Diabetic foot, a complication of diabetes mellitus, is a worldwide medical, social, and economic problem. Diabetic foot ulcers that are not included in the early treatment and care program can result in limb amputation and may be life-threatening. Early diagnosis is an important factor to prevent limb loss due to diabetic foot ulcer. The increase in diabetes-related complications has provided an opportunity for the development of different technological approaches to the management of these problems. The support of these technologies by international organizations increases the interest in diabetes technologies all over the world. The increasing use of smartphones has made the use of mobile health applications widespread in the self-management of diseases. Mobile health applications offer the individual the opportunity to be active 24 h a day, without experiencing time and place problems in matters related to their own health. The mobile diabetic foot personal care system (m-DAKBAS) allows the individual with diabetes to get information about the diabetic foot without going to the health center, to acquire the foot care behavior with its reminder and warning system, to take care of himself in an interactive way and it helps to regulate blood glucose, which is one of the important factors in the development of diabetic foot. In this article, the introduction, development purpose and features of the m-DAKBAS application developed for individual with diabetes, their relatives and health professionals are included.

Keywords: Diabetic foot, foot care, mobile application, mobile health application, nursing

Meryem Kılıç¹ , Ayişe Karadağ² 

¹Department of Nursing, SANKO University, Faculty of Health Sciences, Gaziantep, Türkiye

²Department of Nursing, Koç University, İstanbul, Türkiye

Introduction

Around the world, there are half a billion people who suffer from diabetes and one-third of those people are at risk of developing diabetic foot ulcers during their life. Infection is likely to occur in more than half of diabetic foot ulcers and amputation is likely to develop in 17% of diabetic foot ulcers.^{1,2} Furthermore, it has been seen that healed ulcers often relapse. More than 40% of diabetic foot ulcers may relapse within 1 year, 65% within 5 years and 90% within 10 years.¹ The mortality rates of individuals who have had lower limb amputation for diabetic foot ulcers during the last 5 years are worrisome when compared with the cancer statistics.³

More than one million diabetic individuals have been reported to have diabetic foot ulcers in Türkiye, and another half a million people have been diagnosed with diabetic foot infections.⁴ The Ministry of Health has drawn attention to the significance of the problem with the "Project for Home Follow-up, Treatment, and Follow-up of Cases Diagnosed with Diabetic Foot" by forming a diabetic foot study group in the fight against diabetes and its complications.⁵ Diabetic foot ulcer imposes a serious financial burden on both the patient and the national economy. The cost to the healthcare system of treating diabetic foot ulcers in patients is 5 times more than the cost of treating diabetic patients who do not have foot ulcers.⁶ In a study investigating diabetic foot expenditures in five developed European nations, it was found that the overall cost of an uninfected ulcer climbed from \$6.174 in 2002 to \$14.441 in 2005, while the direct cost of an infected ulcer increased from \$2.637 to \$2.957.⁷ According to Cavanagh, diabetic foot costs range from \$3.096 to \$107.900 per patient.⁸ In Türkiye, diabetic foot complications accounted for 16% of the 7.350.16 billion in the overall health cost for diabetes complications in 2012.⁵

The World Health Organization (WHO) highlighted in the results of the second global e-health survey that health expenditures are substantial in almost all countries and

This research article is a part of his doctoral thesis at Koç University Faculty of Nursing, Department of Nursing Fundamentals (Thesis number: 532446).

It was presented as an oral abstract at 14th National (International Participation) Wound Congress in Antalya between 12-15 December, 2019 and 5th National and 1st International Basic Nursing Care Congress in Antalya between 6-8 December, 2019.

Cite this article as: Kılıç M, Karadağ A. Mobile application for remote patient education and follow-up for the prevention of diabetic foot: M-DAKBAS. *J Educ Res Nurs.* 2023;20(4): 393-398.

Corresponding author: Meryem Kılıç
E-mail: meryemcal@gmail.com

Received: December 01, 2021

Accepted: March 21, 2022

Publication Date: December 01, 2023



Copyright@Author(s) - Available online at www.jer-nursing.org
Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

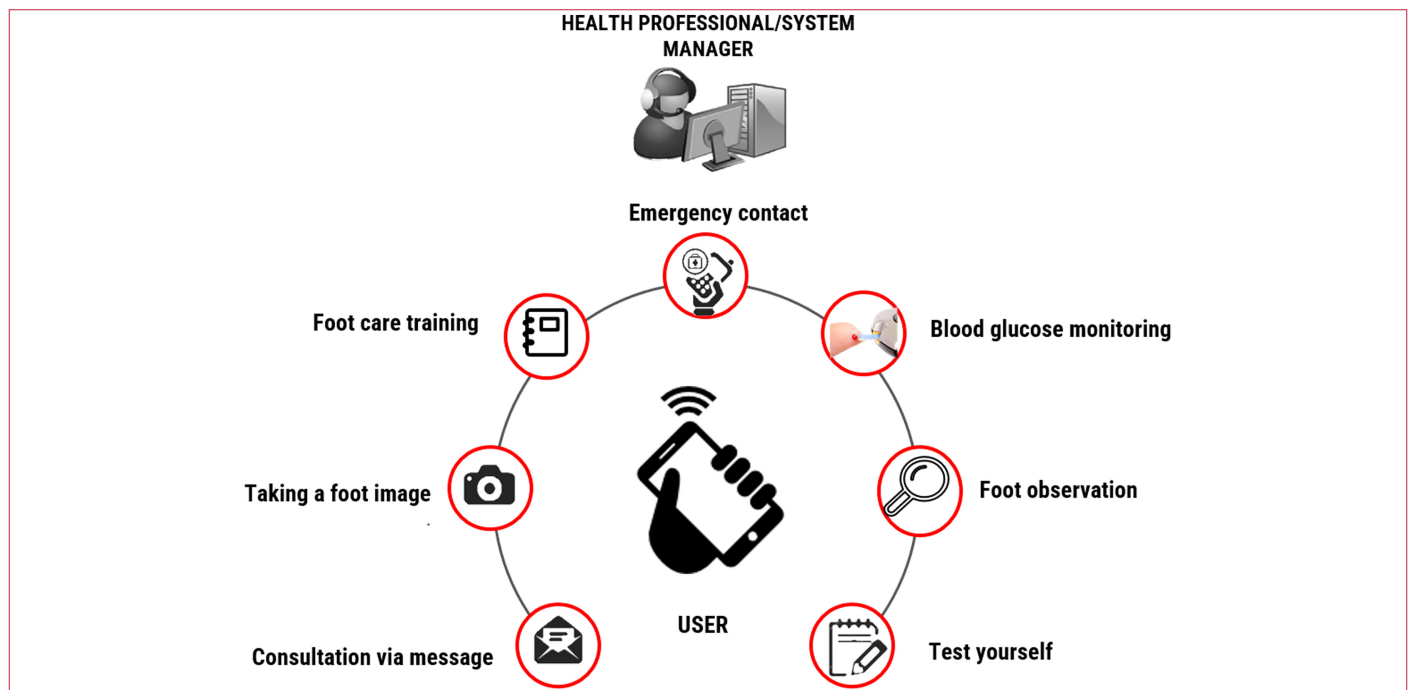


Figure 1. Framework of the present mobile diabetic foot personal care system.

access to services is not at the expected level. In addition, there is a low level of satisfaction among patients and healthcare professionals, as well as a shortage of physicians and nurses in almost every country. Concordantly, WHO stressed the need for innovative service approaches that include integrated care models for a society that is aware of and guided to protect and manage its own health, in which medical data from birth to death is processed and turned into information and the patient is Figure 1 at the centre.⁹

Communication technologies are essential instruments in these approaches. The existing status and forecasts for the size of the global mobile health market indicate that this market will expand dramatically over the next 7 years.¹⁰ It has been determined that the use of mobile health technologies has increased throughout the pandemic,¹¹ and innovative patient education approaches such as telecommunication and online technologies have been used in the management of diabetic foot ulcer.¹² The system of managing e-health, telemedicine applications, and remote patient follow-up, treatment, and care services, which responded promptly in practice to the COVID-19 pandemic, would be restructured in the aftermath of the pandemic. In this respect, it is anticipated that remote patient follow-up systems, which allow to increase compliance of diabetic individuals with treatment and monitor their physiological indicators, would become widespread after the pandemic.¹³

Patient Education and Follow-up in the Prevention of Diabetic Foot

Structured, organized and repetitive training plays an important role in the prevention of diabetic foot ulcers.¹⁴ On the other side, it has been determined that foot care is affected by the regular monitoring of diabetic persons' feet and shoes as well as their characteristics such as behaviors towards glycemic control,¹⁵ their health beliefs, ages, education, social support, and self-efficacy.^{16,17} It is important

for diabetic individuals to assume the necessary responsibility for their foot health, to remain active, and to make the right decisions for their foot health. The goal of the training, which is also the subject of this article, is to increase the patient's self-care knowledge, bring individual preventative foot care behaviors, and increase his motivation.¹⁴ The training content should include foot hygiene, wearing protective shoes, adopting protective foot self-care behaviors and seeking professional help for foot problems.¹⁸ Furthermore, high-risk diabetic individuals should identify the precursors of chronic wounds and learn exactly what interventions they should take in the case of a problem.¹⁴ Other important suggestions include structured training being reinforced in a few sessions and customized to the person, taking socio-cultural characteristics into consideration. Feedback should be taken to determine whether or not the patient completely understands the diabetes training and demonstrates adequate self-care abilities.¹⁸ In order to improve their abilities to deal with high-risk persons, health-care professionals who provide these trainings should receive regular and up-to-date training.¹⁴

Mobile Medical Applications

The use of smartphones and the Internet is constantly rising globally.¹⁹ This rise is a good choice since mobile technologies are one of important tools for promoting health. Mobile medical applications have usage areas such as information and time management, communication and consultancy, reference and information gathering, clinical decision-making, patient monitoring, medical training, medical research, preventive health-care services, health appointments, remote disease management, patient education, and awareness raising.²⁰⁻²⁴ Medical applications on smartphones can be used as future persuasion technologies due to their entertaining, facilitating, portable, and 24/7 service features, as well as reminder function, providing individualized data and social interaction, and guiding features.^{25,26}

Mobile applications aim to deliver the quality health-care services by reducing medical errors, making more efficient use of time, regulating clinical workflow, increasing sense of trust, and reducing costs.²⁷ The proper use of mobile medical applications helps patients to make conscious decisions regarding their health management and treatment.^{20,28} When combined with the correct design and communication strategies, these technologies may be effective in creating the behavioral change and ensuring sustainable behaviours.²⁵

There are many applications related to diabetes on the internet that are available to anyone. The integration of these technologies into the health-care system, nevertheless, leads to challenges in demonstrating their clinical effects, as well as in terms of safety, usability, and receiving feedback.²⁹ According to Eng and Lee,²³ mobile applications offer great potential in the management of chronic diseases and health. It is specifically stated that safe systems that can be employed inside the health-care system should be established. Türkiye is a country with a high prevalence of diabetes. Therefore, there is a need for the use of mobile health technologies in nursing care.

Purpose of the Mobile Diabetic Foot Personal Care System (m-DAKBAS) Application

Diabetes is a disease that is difficult to manage since it requires patients to make adjustments to their lifestyle, may cause complications, and lasts for the patient's whole life, and patients have to maintain their lives in a planned manner. Therefore, in order for patients to effectively self-manage their diabetes, they need specialized and sustainable care. The use of technology-based methods is suggested in this respect.³⁰

The goal of developing the mobile application examined in this article is to educate the individual on how to prevent diabetic foot ulcers, bring positive foot care behaviors, provide feedback specific to the individual, and reduce and prevent late admissions to the hospital as much as possible by identifying risky conditions early with remote patient follow-up. In the United Kingdom 2014–2016 National Diabetic Foot Audit report, it was stated that there was a significant increase in wound healing rates of diabetic foot ulcers diagnosed early in the first 2 weeks.³¹ In this context, early diagnosis of risky conditions would contribute to a rise in the healing rate of diabetic foot ulcers, amputation rate, and hospitalization duration, and a decrease in expenditures.

Other contributions of the developed mobile application can be summarized as follows: Guiding the diabetic individual in foot care and taking safe, useful, and individualized feedback; raising the self-confidence of the individual; improving communication between patient and health-care professionals; making the individual free for use; being a system that patients may consult without having to visit a medical facility; preventing to forget important issues due to the reminder system; involving the diabetic individual in their own care in an interactive way; taking responsibility, and allowing home follow-up and care.

Development of m-DAKBAS

The development process of the m-DAKBAS consists of 4 stages: (1) Conceptual framework of the application (2) The text content and general framework of the application (3) Software phase (4) Pilot Study.

Stage 1: Conceptual Framework of the Application. Self-efficacy of individuals is important in converting self-care knowledge into behaviour.³² Self-efficacy is defined as “one's belief in own skill to execute and implement action plans necessary to attain some gains.”³³ For this reason, in this mobile application, it is aimed to improve the behavior and self-efficacy of the diabetic individual as well as their knowledge of foot care, and the technical details of the program are based on this approach.

Stage 2: The text Content and General Framework of the Application. At this stage, the authors developed the knowledge base/text content of the application in accordance with current evidence and guidelines.^{5,14,34} The content was put into final form with the opinions of six academic members with expertise in Endocrinology, Nursing, Underwater and Hyperbaric Medicine who have conducted studies on diabetes and diabetic foot. The general framework of the application was examined under the headings of blood glucose monitoring, foot care training, foot imaging, foot observation follow-up, self-test, counseling with a message and emergency communication (Figure 1).

Technical specifications of the m-DAKBAS application

The m-DAKBAS was designed as Web-based (Figure 2). There are two separate panels that can be used by the healthcare professionals/administrators and the diabetic individual/user. The application is available for download as a shortcut to the home screens of mobile phones running the iOS operating system and the Android operating system. The user panel of the diabetic individual has a main page, 8 interfaces and 8 sub-interfaces.

Information on the definition of diabetic foot, risk factors, and foot care is provided through the “Inform” and “Prevention” interfaces (Figures 3 and 4). Through the “Messaging” interface, individuals may communicate with healthcare professionals, as well as receive messages that are motivational, informative, and customized to the individual's needs. The “foot observation” interface is an essential one for the early diagnosis of diabetic foot. It was designed to identify possible risky conditions in the foot. The interface includes checkboxes for assessing dryness, swelling, ulcer, heat, callus, fissure, tingling, burning, unusual sensations, and pain on the foot skin. Using the interface, the user may share the findings of the self-foot examination with healthcare professionals by checking the appropriate boxes (Figure 5). The “Blood glucose” interface was created to help diabetic individuals in regulating their blood glucose levels. The individual may record their fasting and postprandial blood glucose levels in the morning, lunchtime, and evening and share them with healthcare professionals. Healthcare professionals may assess blood glucose values and provide customized feedback (Figure 6). The “Test yourself” interface enables the diabetic individual to test his/her knowledge and thus to have knowledge about foot care. Through the “Photo sharing” interface, the diabetic individual may share images of his feet with healthcare professionals. Possible foot problems may be diagnosed early by healthcare professionals, and positive foot care behaviors can be observed.

The admin panel allows healthcare personnel/system administrators to verify user records and update the information content of the application. It may keep track of any negative findings reported by diabetic individuals. It may send individual reminders and informative messages regarding his disease.



Figure 2. Main interface screenshot.

Stage 3: At this stage, the software process was completed. While developing the interfaces of the application, the researcher's experience with diabetic individuals was taken into consideration. The professionals who work in information technology developed the software of the application. A domain name and hosting were purchased for the researcher. An information technology specialist developed the software. Following the first introduction of the application, necessary adjustments were made, and it was offered to a small group of diabetic individuals (n=10). Following this preliminary implementation, the pilot study was started by making adjustments in the "Test yourself" and "Messaging" interfaces based on the feedback received.

Stage 4: At this stage, the pilot study of the application was carried out. The study was conducted based on a randomized controlled (experiment=44-control=44) experimental design. As a result of the study, it was determined that the training and follow-up made through the mobile application offered a better increase in the knowledge, behavior, and self-efficacy scores of diabetic individuals compared to routine verbal training. Following the completion of the study, it was determined that the knowledge score of the experimental group was significantly higher than the control group. Although there was no significant increase in the foot care behavior score, positive foot care behaviors were determined in the foot examination.³⁵



Figure 3. Information interface screenshot.



Figure 4. Prevention interface screenshot.

Figure 5. Foot observation interface screenshot.

Figure 6. Blood glucose monitoring interface screenshot.

Conclusion

We believe that m-DAKBAS is a diabetes-friendly system since it enables diabetic individuals to engage in the self-management in relation to foot care, raises self-confidence, establishes an early diagnosis of diabetic foot complications, enhances the relationship between individuals and healthcare professionals, is easy to access and use, is portable, gives patients the ability to consult without having to physically visit a health-care facility, allows home follow-up and care, and makes possible for individuals to be involved in their own care inter-actively and to take responsibility for their own health. Consequently, patient education is an essential component of a holistic and high-quality health-care service. It is recommended that mobile applications be further developed, improved, and tested to develop self-care competence in diabetic individuals, which is an essential subject of this component, reduce the risk of diabetic foot development, and diagnose diabetic foot ulcers and other potential complications early. It is suggested to assess the usability of the m-DAKBAS on larger patient groups by having to put it into routine use in clinics.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – M.K., A.K.; Design – M.K., A.K.; Supervision – M.K.; Literature Search – M.K.; Writing – M.K.; Critical Review – A.K.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The financial support of the research was provided by KOÇ University, Vehbi Koç Foundation (Foundation support number: DK.28,00012.09).

References

1. Armstrong DG, Boulton AJM, Bus SA. Diabetic foot ulcers and their recurrence. *N Engl J Med*. 2017;376(24):2367-2375. [CrossRef]
2. Lipsky BA, Senneville É, Abbas ZG, et al. Guidelines on the diagnosis and treatment of foot infection in persons with diabetes (IWGDF 2019 update). *Diabetes Metab Res Rev*. 2020;36(suppl 1):e3280. [CrossRef]
3. Armstrong DG, Swerdlow MA, Armstrong AA, Conte MS, Padula WV, Bus SA. Five year mortality and direct costs of care for people with diabetic foot complications are comparable to cancer. *J Foot Ankle Res*. 2020;13(1):16. [CrossRef]
4. Saltoğlu N, Kılıçoğlu Ö, Baktiroğlu S, ve ark. Diyabetik ayak yarası ve infeksiyonunun tanısı, tedavisi ve önlenmesi: ulusal Uzlaşma raporu. *Klimik Derg*. 2015;28:2-34.
5. Türkiye Diyabet pProgramı - TDP 2015-2020. Available at: https://extranet.who.int/ncdccc/Data/TUR_D1_T%C3%BCrkiye%20Diyabet%20Program%C4%B1%202015-2020.pdf.
6. International Diabetes Federation-IDF. *Diabetes Atlas*. 8th ed; 2017.
7. Tchero H, Kangambega P, Lin L, et al. Cost of diabetic foot in France, Spain, Italy, Germany and United Kingdom: a systematic review. *Ann Endocrinol (Paris)*. 2018;79(2):67-74. [CrossRef]
8. Cavanagh P, Attinger C, Abbas Z, Bal A, Rojas N, Xu ZR. Cost of treating diabetic foot ulcers in five different countries. *Diabetes Metab Res Rev*. 2012;28(suppl 1):107-111. [CrossRef]
9. World Health Organization. *Mhealth: New Horizons for Health through Mobile Technologies – Second Global Survey on Ehealth*; 2011.
10. 2016-2027 mobil sağlık pazarı büyüklüğü ve tahminleri. Available at: <https://www.grandviewresearch.com/industry-analysis/mhealth-market>. Accessed April 20, 2021.
11. Tyagi A, Prasad AK, Bhatia D. Effects of excessive use of mobile phone technology in India on human health during COVID-19 lockdown. *Technol Soc*. 2021;67:101762. [CrossRef]
12. Jaly I, Iyengar K, Bahl S, Hughes T, Vaishya R. Redefining diabetic foot disease management service during COVID-19 pandemic. *Diabetes Metab Syndr*. 2020;14(5):833-838. [CrossRef]
13. Najafi B. Post the Pandemic: how will COVID-19 Transform Diabetic Foot Disease Management? *J Diabetes Sci Technol*. 2020;14(4):764-766. [CrossRef]

14. Schaper NC, van Netten JJ, Apelqvist J, et al. Practical Guidelines on the prevention and management of diabetic foot disease (IWGDF 2019 update). *Diabetes Metab Res Rev.* 2020;36(suppl 1):e3266. [CrossRef]
15. McInnes A, Jeffcoate W, Vileikyte L, et al. Foot care education in patients with diabetes at low risk of complications: a consensus statement. *Diabet Med.* 2011;28(2):162-167. [CrossRef]
16. Oni D. Foot self-care experiences among patients with diabetes: a systematic review of qualitative studies. *Wound Manag Prev.* 2020;66(4):16-25. [CrossRef]
17. Huang M, Zhao R, Li S, Jiang X. Self-management behavior in patients with type 2 diabetes: a cross-sectional survey in western urban China. *PLoS One.* 2014;9(4):e95138. [CrossRef]
18. Bus SA, Lavery LA, Monteiro-Soares M, et al. Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF 2019 update). *Diabetes Metab Res Rev.* 2020;36(suppl 1):e3269. [CrossRef]
19. Research2Guidance. Mobile health market report 2013-2017. *The Commercialization of Mhealth Applications*; 2013.
20. de Jongh T, Guroi-Urganci I, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for facilitating self-management of long-term illnesses. *Cochrane Database Syst Rev.* 2012;12(12):CD007459. [CrossRef]
21. Ventola CL. Mobile devices and apps for health care professionals: uses and benefits. *P T.* 2014;39(5):356-364.
22. Demir H, Arslan ET, Mobil. Sağlık Uygulamalarının Hastanelerde Kullanılabilirliği: hastane Yöneticileri üzerine bir araştırma. *KMÜ Sosyal Ekon Araştırmalar Derg.* 2017;19(33):71-83.
23. Eng DS, Lee JM. The promise and peril of mobile health applications for diabetes and endocrinology. *Pediatr Diabetes.* 2013;14(4):231-238. [CrossRef]
24. Goyal S, Morita P, Lewis GF, Yu C, Seto E, Cafazzo JA. The systematic design of a behavioural mobile health application for the self-management of Type 2 diabetes. *Can J Diabetes.* 2016;40(1):95-104. [CrossRef]
25. Fogg BJ, Eckles D. *Mobile Persuasion.* Stanford CA: Stanford Captology Media; 2007.
26. Doğanıyigit SÖ. Exploring intention on continuous use of mobile health applications designed by persuasive technology: "Adimsayar" case study. In: Sezgin E, Yildirim S, Özkan-Yildirim S, Sumuer E, eds. *Current and Emerging Mhealth Technologies.* Cham: Springer; 2018:37-53.
27. Ağaç F. Mobil uygulamalar, sağlık sistemini kişiselleştiriyor. *Bilişim Derg.* 2015;174:42.
28. Turner J, Larsen M, Tarassenko L, Neil A, Farmer A. Implementation of telehealth support for patients with type 2 diabetes using insulin treatment: an exploratory study. *Inform Prim Care.* 2009;17(1):47-53. [CrossRef]
29. Caburnay CA, Graff K, Harris JK, et al. Evaluating diabetes mobile applications for health literate designs and functionality, 2014. *Prev Chronic Dis.* 2015;12:E61. [CrossRef]
30. American Diabetes Association. Prevention or delay of type 2 diabetes. *Diabetes Care.* 2018. *Diabetes Care*;41(suppl 1):S51-S54. [CrossRef]
31. National diabetes foot care audit (NDFCA, 2014-2016). Available at: <https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-footcare-audit/national-diabetes-foot-care-audit-2014-2016>. Accessed January 19, 2022.
32. Sloan HL. Developing and testing of the Foot Care Confidence Scale. *J Nurs Meas.* 2002;10(3):207-218. [CrossRef]
33. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev.* 1977;84(2):191-215. [CrossRef]
34. American Diabetes Association. Microvascular complications and foot care. *Diabetes Care.* 2018;41(suppl 1):S105-S118. [CrossRef]
35. Kilic M, Karadağ A. Developing and evaluating a mobile foot care application for persons with diabetes mellitus: a randomized pilot study. *Wound Manag Prev.* 2020;66(10):29-40. [CrossRef]