Bölüm 1

Development of a Mobile-Accessible Web Application in Wound Management: A Pilot Study

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Abstract

Introduction and purpose: With the development of technology, new applications have started to deliver health services. These applications, which are described as mobile health applications, provide a systematic approach to managing chronic wounds and increase patients' quality of life and their compliance with treatment. In this direction, the study was carried out to develop an application that can be used by patients and healthcare professionals in chronic wound management.

Material and Method: To develop the application, first of all, the user panels and their contents were drafted, and the servers and infrastructure works were started. Interfaces were developed based on the page designs created, and separate pages were designed for patients and healthcare personnel. After the development of the main operation and management platform, the definition of services, the editing of image processing features, and the security tests, the mobile application was made ready for use. In the pilot

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study, eight patients with diabetic foot wounds were followed up with the application used on Android systems via web browsers, both tablets, and smartphones, via mobile application.

Results: In the study, it was determined that both the patients followed by the wound tracking system and the health personnel using the system were satisfied with the application.

Conclusion: Using mobile applications in the long-term treatment process of chronic wounds increases the patients' follow-up outside the hospital, their compliance with the treatment, and their comfort. In terms of health personnel, it also reduces the intensity and workload in the hospital and ensures that patient records are kept regularly. Patients with chronic wounds with no indication for hospitalization can be followed up with the mobile application.

Introduction

Chronic wounds, one of the most frequently encountered health problems in the world and in our country, are difficult to manage for both patients and healthcare professionals. Wound care and treatment requires a long time, and patients regularly apply to wound care outpatient clinics for control. The fact that these patients also have other chronic diseases can disrupt hospital visits due to economic and transportation problems [1].

Developing technology has positively changed many areas in today's society, including communication, transportation, and healthcare. With the widespread use of smartphones and the internet over the last three decades, the use of this new technology in healthcare services has started to take place in the lives of society as mobile health, or m-health. As of 2017, there are more than 80,000 smartphone applications for the Android operating system available for healthcare. These applications are used for the benefit of patients and healthcare professionals in many areas, such as ophthalmology, radiology, chronic disease management, and postoperative patient follow-up [2,3].

Digital technologies have also been used for wound treatment and follow-up, which is a common problem in the world. Examples of these are applications such as Wound Central, Wound Desk, Wound smart, Mobile Wound Care, and Immito Wound. These applications are compatible with Android and iOS smartphones. The use of this technology by patients and healthcare professionals in wound management has advantages such as preventing wounds, facilitating long-term follow-up in wound treatment, improving the quality of life of patients, and systematic collection of wound-related records [4]. During the COVID-19 pandemic, the use of mobile

applications for the follow-up of chronic wounds was recommended and became widespread [5].

When the literature is examined, it is seen that mobile-health applications developed for wound management are available in Europe, America, and China. These applications can generally be used in the language of the countries where they are produced and have an English language option. There is also a charge for use. In Turkey, where the elderly population is high and the incidence of chronic diseases is high, the treatment and care of individuals with chronic wounds is carried out in Wound Care Centre's, the number of which is limited. The majority of these patients are treated at home. Outpatient appointments are made for follow-up and regular hospital visits are required. Currently, there is no mobile-health application that covers all wound types and is widely used in Turkey. On the other hand, most of the wound monitoring applications used abroad are intended for physicians and do not include patients and wound care nurses.

This study was carried out to build an app for wound management in Turkey that may be used by patients and healthcare workers on mobile devices, in accordance with this demand. Wound monitoring app development and testing plans are discussed in this study.

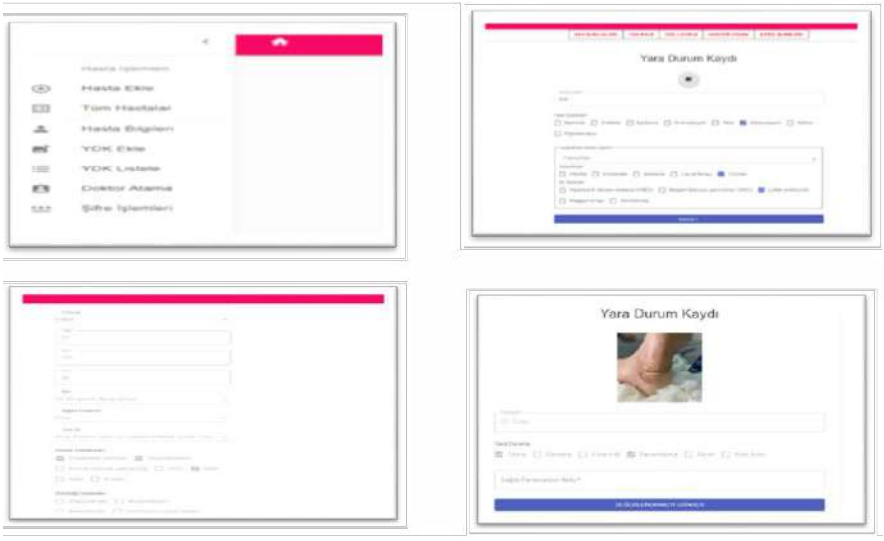
Materials and Methods

The wound monitoring system was developed as a functional, responsive web application prototype that can be used on Android, IOS, and Personal Computers by a multidisciplinary team of physicians, nurses, and computer engineers with expertise in academic research and clinical applications. First, user panels and content were created as a draft, and server infrastructure work began. In the design phase, physicians and nurses who are experts in the field of wound treatment created a list of the sections that should be included in the content of the application and the data that should be entered. This content draft, which was created based on the relevant literature and the needs of users (patients and healthcare personnel), information about the patient and the wound (patient's age, height, weight, chronic diseases, medications, diet, wound classification, photographs of the wound), and explanations about the treatment and care procedures applied to the wound. Computer engineering researchers developed interfaces based on the page designs created. Separate pages were designed for patients and medical staff. After the development of the main processing and management platform, the definition of services, the design of image processing features, and finally security tests, the mobile application was ready for use. In the pilot

study, only patients with diabetic foot wounds were followed up with the application, which can be used from web browsers on Android systems via mobile applications on both tablets and smartphones.

In order for the healthcare team working in wound care outpatient clinics and wards to use the application, they logged in to the application from their smartphones and web browsers on the computer. They can enter their own accounts in the application with the defined username and password. Then, for a new patient who applied to the outpatient clinic as an outpatient, the patient's record was created from the "add new patient" tab in the application, and then the first status record for the wound was added to the patient-related folder by the staff in charge at the hospital. The patient's chronic diseases, treatments, and surgeries; current laboratory results; medications; mobilization status; nutritional status; body mass index; location of the wound; wound type; dimensions; and other characteristics were recorded. The treatment and follow-up plan specific to the patient's wound were recorded in the application when the first wound status was recorded. In the next step, the patient or his/her relatives were informed about the use of the application. From the application login screen, the patient logged in to the application with the username and password created during patient registration and delivered to the patient. A day was set for the patient's follow-up at home, and on the designated control day, the patient or relative was asked to create a wound status record, including photographs and wound condition information, through the application. The created WSA was automatically transmitted to the responsible physician/nurse following the patient through the application. The patient submitted a photo of their wound to the doctor or nurse on the designated days using the WSA form; the doctor or nurse reviewed the photo and made a decision regarding the patient's treatment and follow-up plan before responding in writing to the patient (Figure 1).

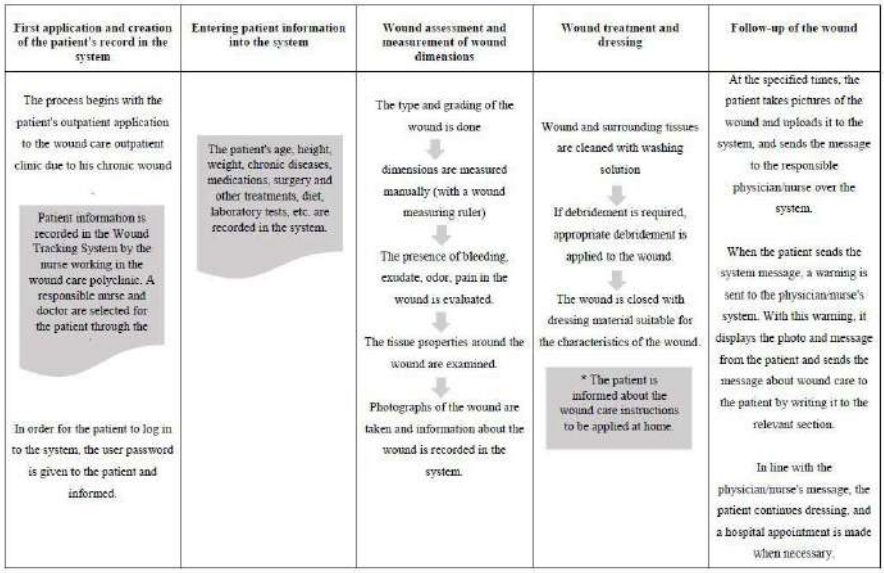
Figure 1. Screenshots of the interfaces of the Wound Monitoring System (A. View of the main page, B. The page where the treatment and care methods applied to the wound are recorded, C. The page where the patient's information is recorded, D. View of the wound photograph submitted by the patient on the healthcare staff screen)



The necessary permissions were obtained from the institution to which the Wound Care Outpatient Clinic was affiliated and the ethics committee before the study was started. For the pilot study, both written and verbal consent were obtained from the patients with an informed consent form before enrolment in the study. The sample of the study consisted of 8 patients who presented to the Wound Care Outpatient Clinic of a training and research hospital with diabetic foot wounds. Patients between the ages of 18 and 80 years, who had a smartphone or tablet, who could use the smartphone and application, and who did not have a diagnosis of cancer were included in the study. The use of the application was explained by the physician and nurse in the outpatient clinic to the eight patients who were selected among the patients who applied to the outpatient clinic and agreed to participate in the study. Since some of the patients were not competent at using smartphones, their relatives and caregivers were informed. The patient or relative logged into the system using their username and password via their own phones. For home follow-ups, taking a photograph of the wound and uploading it to the application and transmitting it to the physician or nurse was demonstrated through the application. Patients who were

followed up through this application for three months were called to the hospital for diagnostic tests and treatment when necessary. Patients and their family members were given an online survey to complete at the conclusion of the process in order to rate the mobile app. The ten-question survey was used to find out how happy patients were with the web application that can be used on mobile devices.

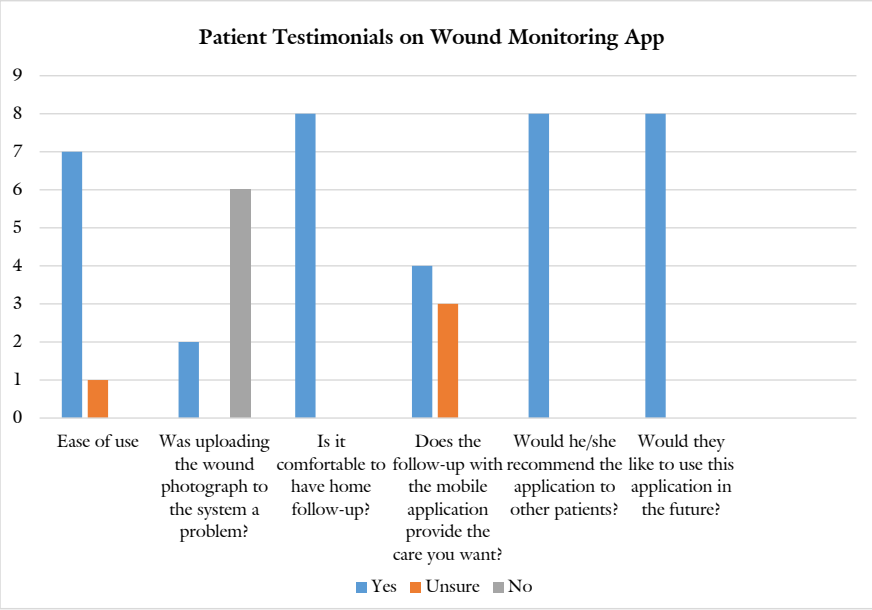
Figure 2. System workflow for diabetic foot ulcer wound management



Findings

In the pilot study in which the wound monitoring application was tested, eight patients who agreed to use the application and complied with the instructions were studied. All eight patients who used the mobile wound care application were males with a mean age of 52.75 years (min: 25, max: 73). Seven patients were diagnosed with Type 2 diabetes and one with Type 1 diabetes, and 7 patients had hypertension, coronary artery disease, and/or peripheral arterial disease. All patients were admitted to the Wound Care Outpatient Clinic for diabetes-related lower extremity ulcers. When the opinions of the patients/caregivers regarding the use of the mobile application were obtained, the majority of the patients reported that they could use the application easily, that they did not have any problems uploading their wound photographs to the system, and that it was comfortable to reach the physician/nurse from home. All of the patients/caregivers stated that they would recommend this mobile application to other patients and that they

would like to use this application in the future. Three patients responded that they were undecided about providing the care. They wanted to follow up their wounds with the mobile application. Physicians and nurses who used the application reported that the system was useful in terms of collecting patient information and wound-related information in the same system, seeing the patient's course, and reducing the number of patients in the outpatient clinic by reducing outpatient visits. No wound complications developed during the follow-up of the patients with the mobile application.



Discussion

Mobile health applications affect the service delivery techniques of doctors, nurses, health workers, and health service providers (hospitals, mobile health organizations, pharmacies, etc.) and provide great advantages in the realization of this service [6]. The World Health Organization defines mobile health as public health applications supported by mobile technologies such as medical health applications, mobile phones, patient monitoring tools, and personal digital assistants [7]. Mobile devices and the internet, which have developed and become widespread with technology, have started to be used in a wide range of areas, from keeping health records to treatment-oriented uses. During the COVID-19 pandemic, the use of mobile health applications by patients and healthcare professionals has gained momentum. This study was carried out to develop a mobile health system that patients

and healthcare professionals can use for wound management. Especially with mobile technologies, remote monitoring of the patient and maintenance of the treatment provides great convenience in alleviating the burden on the healthcare system. For this reason, it is foreseen that the application, which includes patients and healthcare professionals in wound treatment and care, will bring great convenience to patients, physicians/nurses and the healthcare system by setting an example.

The use of a standardized and systematic technique helps the healthcare team with the accurate assessment of the wound [8] and the reliability of therapeutic interventions [9]. The use of online mobile health apps with different functionalities can provide the support healthcare providers need to care for their patients with chronic wounds. In parallel with the developing technology worldwide, mobile health applications are used in many branches of health services. One of the areas where these applications are used is the follow-up and treatment of chronic wounds [2, 10]. In studies on mobile health applications developed for wound care, it has been shown that they increase patient comfort, satisfaction, and adherence to treatment, reduce the workload of healthcare professionals, and provide standardization in terms of medical records and care methods [5,11-13]. In a meta-analysis study by Huang et al. (2021), 14 studies involving 1926 patients were analyzed, and it was found that the wound healing rate significantly improved in patients using telemedicine compared to traditional care [14]. In another study where wound follow-up was performed through a mobile application, it was reported that the majority of patients were satisfied with the follow-up with a smartphone-based application [15].

The main factors affecting traditional wound care practices are measurement of wound dimensions, records of wound assessment and treatment, and personalized treatment plans. In wound care outpatient clinics, taking wound photographs of outpatients and archiving and keeping comprehensive records constitute a significant workload [5]. Current clinical practice for wound assessment uses rulers, photography, computer-based visual inspection, and subjective measurements. Although the methods used are numerous, there is no standardized practice. In contrast to rapid developments in clinical information systems such as hospital information systems, electronic medical record systems, and laboratory information systems, wound care management still lacks an effective digital solution. Institutions' patient record systems often do not have a dedicated space to record photographs, measurements, and other information about the wound. However, time needs to be allocated for taking photographs and

measurements of the wound at each patient visit [2]. Since the follow-up and treatment of chronic wounds requires a long period of time, keeping patient records organized and being able to view them from a single source provides important support to healthcare professionals. The previous condition of the wound and its condition during the treatment process can be compared, the patient's response to treatment and other data of the patient (blood sugar, CRP level, etc.) can be seen and the treatment can be directed with this information. The wound monitoring system developed in this study has advantages such as making patient assessments and records in an objective and standardized manner, organizing data, and collecting them in a single source.

When the literature is examined, it is seen that the elderly patient group has low compliance with mobile-health applications that require uploading photos to the system [13,15,16]. This may be due to limitations in the use of smartphones, cameras, and internet/technology in the relevant age groups, as well as difficulties in accessing the internet and equipment such as smartphones/tablets. In this study, considering the elderly patient population with chronic wounds, the mobile application was designed with simple content and was easy to use. In the patient user panel, there is only a section for uploading photos, a section where wound-related features and notes can be written, and an area where the doctor's answer can be seen. However, it was observed that the patients included in the pilot study used the mobile application with their caregivers. In this situation, patients who live alone and have trouble using mobile apps can have a different care plan made for them.

The fact that technology provides healthcare services with remote access brings some negativities with it. It has been shown in some studies that the classical health professional-patient relationship is reduced in the mobile method, so the expectations of the patients cannot be met. On the other hand, health professionals are also concerned that remote assessment of the patient will lead to deficiencies in physical assessment [17-20]. Considering this issue in the developed wound follow-up application, the initial evaluations of the patients were made during the hospital admission and the subsequent follow-ups were carried out through the application. In the follow-up performed by the physician/nurse through the application, if deemed necessary, it directs the patient to re-apply to the Wound Care Outpatient Clinic. In addition, when laboratory and other diagnostic tests or complicated treatments such as VAC applications are required, an appointment is created for patients to follow up with the application and they are invited to the hospital.

Results

The development of a mobile application that can be used by patients and healthcare professionals in wound management has advantages such as preventing wounds, facilitating long-term follow-up in wound treatment, improving the quality of life of patients, and systematic collection of wound-related records. With this application, which enables wound care and follow-up of patients at home, it is aimed to reduce the number of hospital admissions of patients, alleviate the workload of healthcare personnel, and reduce the circulation in hospitals in the COVID-19 pandemic and thus reduce the risk of possible transmission. It is envisaged that patient-related problems in wound follow-up can be eliminated with this application, thus accelerating wound healing, reducing costs, and increasing the patient's quality of life. Another advantage is that it is possible to keep records of patients with wounds in a systematic way, to have a common application that can be used by all healthcare professionals, to provide documents about patients and wound types, and to use this data in future healthcare planning.

Ethical Approval and Consent to Participate

Before conducting the study, written permission was obtained from the Sakarya University Clinical Research Ethics Committee where the study would be conducted (Date:11.10.2021, Research Code No: E-16214662-050.0104-67854-151). Before administering the survey forms, the patients were informed about the study's purpose, reason, and data collection process. It was explained to the participating patients that no personal data would be used in the study findings and that their identity information would be kept confidential.

Human and Animal Ethics

The study forms were administered to the patients who volunteered to participate in the study and gave their written consent. The investigation conforms to the principles outlined in the Declaration of Helsinki.

Consent for publication

The patients were informed about the writing and publication of the patient data obtained in the study. Patients who agreed to participate in the study gave written and verbal consent to submitting other data in the article, keeping their personal information confidential.

Availability of supporting data

The data that support the findings of this study are available from the corresponding author Ayşe Çelik Yılmaz upon reasonable request.

Competing interests

The authors declare no conflict of interest**.**

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Limitations of the Study

The study was meant to be a pilot study, so it only took place in one place and with a small number of people.

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